Larger Foraminifera from the Philippine Archipelago

Kuniteru Matsumaru
Innovation Research Organization, Professor Emeritus, Saitama University, Saitama 338 8570, Japan
matsumar@mail.saitama-u.ac.jp

ABSTRACT: Nineteen successive larger foraminiferal assemblage zones of Late Cretaceous to Quaternary age are recognized in 265 stratigraphically positioned samples from 15 islands of the Philippine Archipelago, based on the biostratigraphic relationship of 192 age-diagnostic larger foraminifera species, including 19 new species and 8 new genera, together with 64 species of associated planktonic foraminifera. The following new taxa are described herein: *Orientorbitoides*, n. gen., *Paleobaculogypsinoides*, n. gen., *Hashimotoina*, n. gen., *Eopellatispira*, n. gen., *Mindoroella*, n. sp., *Baculogypsinella*, n. gen., *Luzonella*, n. gen., *Quasibaculogypsinoides*, n. gen., *Orientorbitoides cebuensis*, n. sp., *Pseudorbitoides philippinensis*, n. sp., *Paleobaculogypsinoides catanduanensis*, n. sp., *Calcarina catanduanensis*, n. sp., *Asterocyclina pinugayensis*, n. sp., *Assilina philippinensis*, n. sp., *Hashimotoina mindanaoensis*, n. sp., *Alveolina luzonensis*, n. sp., *Glomalveolina reicheli*, n. sp., *Pseudolituonella mindanaoensis*, n. sp., and *Pfendericonus mindanaoensis*, n. sp., *Eopellatispira mindoroensis,* n. sp., *Mindoroella mindoroensis,* n. sp., *Baculogypsinella eocenica,* n. sp., *Luzonella trochidiformis,* n. sp., *Quasibaculogypsinoides primitiva,* n. sp., *Boninella negroensis,* n. sp., *Orbitogypsina mindoroensis,* n. sp., and *Borelis fusiformis,* n. sp. These zones can be correlated with larger foraminiferal assemblages in Japan, India, and Turkey as the basis for an advanced Letter Stage system, for the foraminiferal record in latest Mesozoic and Cenozoic shallow-water environments of the Tethyan realm extending from the western Pacific to the Mediterranean. A total of 181 species of larger foraminifera from the Philippines are illustrated and described based on re-examined and new samples.

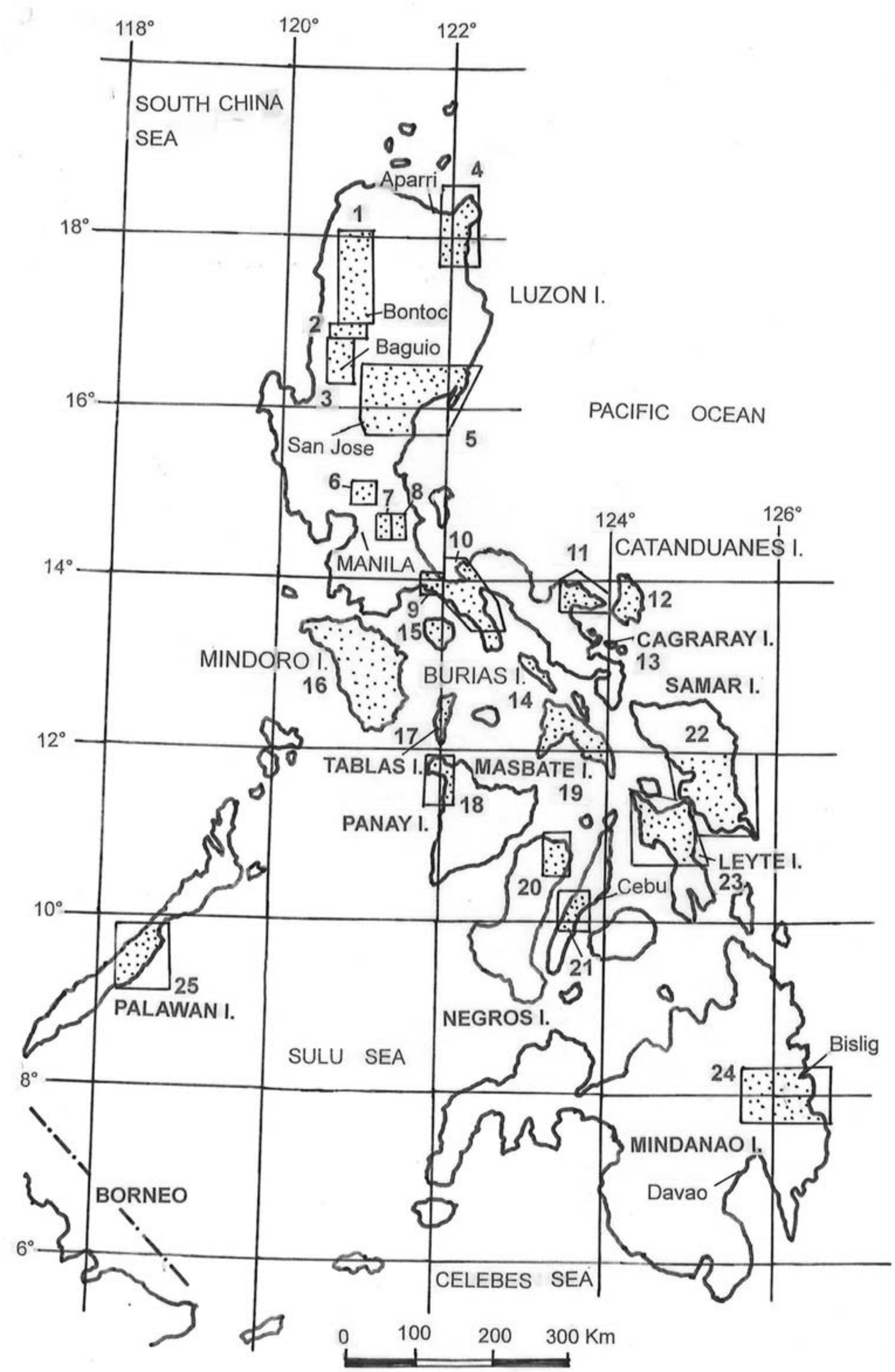
INTRODUCTION

Decades of study of the biostratigraphy and classification of larger foraminifera from the Cretaceous and Cenozoic of the western Pacific and Tethys realms, including the Philippine Archipelago, Indonesia, Micronesia, Taiwan, Japan, India, Turkey and other areas, permits the application across this wide region of the letter classification and letter stages first employed in the Dutch East Indies (now Indonesia) by Van der Vlerk and Umbgrove (1927) and Leupold and Van der Vlerk (1931). For many years the Indonesian letter stages were not fully recognized due to inadequate data for the stage boundaries, while the significance of the range and environmental meaning of larger foraminifera was obscured by the dominance of standard planktonic foraminiferal zones (Adams 1985; Chaproniere 1984). Nevertheless, the letter stages are still very relevant in studies of the distribution in space and time of the shallow, largely carbonate strata in these regions, where planktonic foraminiferal zones are unknown or poorly represented.

In order to recognize the Indonesian letter stages in the Philippines, the author previously reviewed these units in terms of the local biostratigraphy (Matsumaru 2005, unpubl.; Matsumaru 2011), resulting in significant clarification of their definition because of information from intervals that are not well represented in the sequences studied by Van der Vlerk and colleagues. During this research, although many specimens have been degraded by volcanic activity and reworked specimens are more common than usual due to tectonics and submarine slumping, it was still possible to recognize several new genera and species as well as many species known elsewhere in the Tethys domain, in order to provide new information on the larger foraminiferal biostratigraphy in the Philippine Archipelago.

Many of the samples studied here were collected by the Republic of Philippines-Japan Cooperative Mineral Exprolation Project, or RP-Japan Project, during 1972 to 1976. Others are the result of reconnaissance work by members of APRSA (Association of Palaeontological Research of Southeast Asia) during 1972 to 1985. The author has also receieved numerous samples in cooperation with colleagues from 1972 until today.

Standard references: In the discussions that follow, the reader should understand that the reference to the name and age of chronostratigraphic units follows the GTS 2012 time scale of Gradstein et al. (2012), as adopted by the International Commission on Stratigraphy (ICS). Similarly, all references to planktonic foraminiferal zones are to Blow (1969, 1979) for the Cenozoic, and Sliter (1989) for the Cretaceous, as amplified by Postuma (1971), Berggren and Van Couvering (1974), Caron (1985), Toumarkine and Luterbacher (1985), Bolli and Saunders (1985), Berggren et al. (1995), and Anthonissen and Ogg (2012). These sources are not further cited in the text.



TEXT-FIGURE 1
Index map of study areas: **1, 2,** N Luzon, Bontoc (tfs. 2, 6); **3**, Baguio (text-fig. 6); **4**, N. Luzon, Palanan (text-fig. 3); **5**, NE Luzon, Caraballo Mts. (tfs. 4, 6); **6**, Mid Luzon, Sibul (text-fig. 6); **7, 8**, Mid Luzon, Binangonan - Pinugay Hill (tfs. 5, 6); **9**, **10**, SE Luzon, Atimonan - Bondoc Peninsula (tfs. 7, 8); **11**, SE Luzon, Caramoan Peninsula (text-fig. 9); **12**, Catanduanes (text-fig. 10); **13**, Cagraray (text-fig. 11); **14**, Burias (text-fig. 12); **15**, Marinduque (text-fig. 13); **16**, Mindoro (text-fig. 14); **17**, Tablas (text-fig. 15); **18**, Panay (text-fig. 16); **19**, Masbate (text-fig. 17); **20**, Negros (text-fig. 18); **21**, Cebu (text-fig. 19); **22**, Samar (text-fig. 20); **23**, Leyte (text-fig. 21); **24**, E. Mindanao (text-fig. 22); **25**, Palawan (text-fig. 23).

PART 1: LATE CRETACEOUS TO MIDDLE EOCENE

Samples from 57 stations on 7 islands of the Philippine Archipelago provide 82 age-diagnostic species of larger foraminifera in 43 genera of Late Cretaceous (Maastrichtian) to Middle Eocene (Bartonian) age. Of these, 35 genera and 55 species including three new genera and 11 new species are systematically described here. Five larger foraminiferal assemblage zones can be recognized, based on the biostratigraphic occurrences of age-diagnostic larger foraminifera and associated planktonic foraminifera, and which can be correlated with larger foraminiferal assemblages in India, Turkey and other regions in the Tethyan realm.

In this part, seven distinguishing points are recognizaed: (1) Identification of *Pseudorbitoides philippinensis*, n. sp. of Maastrichtian age; (2**)** Occurrence of Paleocene *Orbitosiphon tibetica* in the Philippine Archipelago; (3) Evidence of westward migration from the Caribbean bio-province to the Philippine Archipelago during the Late Cretaceous and late Paleocene (Thanetian) based on presence of *Asterorbis rooki* Vaughan and Cole*, Sulcorbitoides pardoi* Brönnimann*, Sulcoperculina dickersoni* (Palmer)*, Vaughanina cubensis* Brönnimann, and *Coleiconus* spp; (4) Establishment of the pre-Tertiary ms1 Letter Stage and the lower Tertiary a0 stage in the larger foraminifera of Philippine Archipelago (Matsumaru 2011, 2016); (5) Correlation of Philippine larger foraminiferal assemblages to five latest Cretaceous (Campanian-Maastrichtian) faunal assemblages in the Haymana and Black Sea regions of Turkey (Matsumaru 2016, table 17); (6) Assignment of 43 genera and 82 species of age-diagnostic larger foraminifera in the Late Cretaceous-middle Eocene strata of the Philippines to five distinct assemblages of larger foraminifera in a detailed biostratigraphy of species from different lithofacies and ecological environments; and (7) Use of the new taxonomic information to allow the Letter Stages in the Philippine Archipelago to be correlated internationally with the other faunal assemblage zones in the eastern and central Tethys.

SAMPLES AND STUDIED SECTIONS

A total of 57 samples of Maastrichtian-middle Eocene age (table 1) were investigated in this part of the study, collected from Philippine Study Areas on seven islands: Luzon (27 stations), Catanduanes (6 stations), Cagraray (3 stations), Marinduque (6 stations), Mindoro (2 stations), Cebu (5 stations) and Mindanao (8 stations). More than 2,000 random thin sections of fossiliferous rock together with oriented thin sections for the more important species have been made. Free specimens isolated from the matrix are very rare.

NOTE: In regard to the following discussion, the location of Philippine Study Areas is shown in text-figure 1. The chronostratigraphic position of the samples are shown in Table 1, and the distribution of studied species in the samples is summarized in Table 2.

Caraballo Mountains, Nueva Visaya Province, Northeast Luzon, Study Area 5

The Caraballo Group, of pumpellyite-prehnite schist and green schists of Late Cretaceous to Eocene age, contains three limestone formations, exposed in the Mt. Palali-Upper Cagayan-Baler Section (Hashimoto et al. 1980), in which Formnation II has a fauna indicative of Assemblage 3 of Thanetian age to Assemblage 5 of Bartonian age (tables 1, 2), while samples from Formation III yield fauna representative of Assemblage 6 of Priabonian age (tables 3, 4). Succeeding upper Oligocene to Quaternary samples are noted in tab. 3 and their contents itemized in tables 5-14.

Pinugay Hill and Tanay-Daraitan sections, Luzon, Study Areas 7 and 8

Pinugay Hill, about 35 km east of Manila in Rizal Province is entirely composed of gray limestone with a thin intraformational conglomerate. Reyes and Ordonez (1970) identified the "K-T boundary" here for the first time in the Philippines, but a lower Paleocene (Danian) hiatus exists between their sample G42-44, with Maastrichtian *Pseudorbitoides* Douvillé and *Omphalocyclus* Bronn, and their overlying sample G36, carrying the Thanetian *Miscellanea* spp. and calcareous algae *Distichoplax biserialis.* Hashimoto et al. (1978) tentatively identified 4 limestone samples in an 18-m section of Pinugay Hill as probably belonging to the Pinugay Hill Limestone of the Kinabuan Formation, and located the K-T Boundary of Reyes and Ordonez in the intraformational conglomerate that is within this section. Subsequently, these authors (Hashimoto et al. 1979) found that only their two lower samples (7451105d and c) were in the Upper Cretaceous Pinugay Hill Limestone , and that the upper two (7451105b and a) were in the Paleocene Masungit Limestone (*Disticoplax biserialis* algae bearing limestone) of the Maybangain Formation. The thin sections of these 4 samples as well as additional thin sections have confirmed that the two lower samples contain a larger foraminiferal fauna (table 2) of Assemblage 1, together with planktonic foraminifera of the *Gansserina gansseri* Zone or Sliter's Zone KS 30 that substantiate Late Cretaceous (Maastrichtian) age. The upper 7451105b sample yields larger foraminifera of Assemblage 2 or Letter Stage a0, while the planktonic foraminiferal fauna indicates Zones P3-4, of middle Paleocene (Selandian) age. The uppermost Sample 7451105a, however, yields a larger foraminifera fauna (table 2) belonging to Assemblage 3 or Letter Stage a1, and the planktonic foraminiferal fauna indicates the Zones P4-5, both regarded as late Paleocene (Thanetian).

The thin sections of Hashimoto et al. (1979, figs. 1-3), taken from the south side of Pinugay Hill and the Tanay-Daraiton Section (text-fig. 5, right square) are all from the Eocene Masungit Limestone of the Maybangain Formation. The lowermost, Sample 7451215, yields larger foraminifera indicating Assemblage 4 of early to middle Eocene, or Letter Stage a2 (table 2) (Matsumaru and Sarma 2010). The overlying strata yield foraminifera (table 2) indicating Assemblage 4 of Ypresian-Lutetian age.

NOTE: for the Oligocene to Quaternary sequence in this study area see text-figures 2-4, 6.

Bondoc Peninsula, SE Luzon, Study Areas 9, 10

Hashimoto and Matsumaru (1981, fig. 4) described three limestone samples, 31055, 31056 and 31057, which are located along the Pitogo-Gumaca road as well as stations PTG-5 and PTG-8 of Matsumaru and Barcelona (1982, fig. 2). These samples are gray tuffaceous limestone with fragments of greenish Unisan Volcanics (BMG 1981), which also occurs in the shear zone of the Gumaca Fault bounding Cretaceous shales.

Caramoan Peninsula, SE Luzon, Study Area 11

Eleven samples from the Maastrichtian Pagsangahan Formation, mid Paleocene Garchitorena Formation and lower to mid Eocene Guihalo Formation are re-examined here. Station 6611806 and stations CR36 and CR35, dark gray limestone on the coast of Guijalo Bay were originally assigned to the Guihalo Formation (Takizawa et al. 1996, fig. 2; text-fig. 8), but the localities CR36 and CR35 are now assigned to the preceding Garchitorena Formation due to the occurrence of *Ranikothalia nuttalli* (tabs. 16, 18). On the other hand the dark gray limestone pebbles sampled at Station CR42 as well as stations 6611806, CR75, CR51 and Station CR44 belong to the clastic member of the Guihalo Formation, with a fauna of Assemblage 4 with characteristic *Nummulites atacicus, N. globulus,* and *N. millecaput* (table 2). Station CR37, samples Garchitorena Formation, *Disticoplax biserialis*-bearing dark gray limestone containing *Miscellanea primitiva* and *Kathina selveri* of Assemblage 2.

At the stations in the eastern cape of the Caramoan Peninsula (CR 56, CR 61 and CR 63) Maastrichtian (Letter stage MS1; table 1) Bonagbonag Limestone with both typical Tethys species such as *Lepidorbitoides* spp., *Simplorbitoides papyraceus, Orbitoides tissoti*, and *Omphalocyclus macroporus,* and charcteristic Caribbean taxa such as *Pseudorbitoides* (cf. *P. mindanaoensis*, n. sp.) and *Sulcoperculina dickersoni* (table 2) can be found.

Catanduanes Island, Study Area 12

The Cretaceous Bonagbonag Limestone member of Pagsangahan Formation is also exposed here, beneath the Eocene Payo Formation with its upper member Sipi Limestone (BMG 1981, pp. 74-75). Six samples are re-examined in this study. Hashimoto and Matsumaru (1981, fig. 2) considered the limestones at Station 121006 and Station 120902 (text-fig. 10) to be Eocene based on the occurrence of *Fabiania* sp., *Asterocyclina stellata,* and *Nummulites* cf. *N. pengaronensis,* but re-examination of sample 121006 yields a middle Paleocene assemblage due to occurrences of *Idalina sinjarica* and *Rotalia trochidiformis* (tab. 2). Only sample 120902 yields a middle Eocene fauna that is typical of the Eocene Sipi Limestone (tab. 2).

Hashimoto and Matsumaru (1981) previously found a Maastrchtian assemblage with *Omphalocyclus macroporus* and *Lepidorbitoides minor* at Station 121002 (text-fig. 10), in Bonagbonag limestones that had been wrongly assigned to the Eocene Sipi Limestone, and in fact at the presumed type locality of the Sipi Limestone, Station 6Z1120 at Bato City, the author found only Bonagbonag limestone with *Omphalocyclus macroporus* and *Pseudorbitoides philippinensis*, n. sp., which indicates that the Bonagbonag Limestone ranges from Late Cretaceous to middle Paleocene. The typical Bonagbonag Maastrichtian fauna at Stations CT 22 and CT29 on Bonagbonag Point contains Tethyan larger foraminifera such as *Lepidorbitoides minor, L. bisambergensis,* and *Omphalocyclus macroporus,* together with Caribbean taxa such as *Pseudorbitoides*, *Sulcorbitoides pardoi, S. dickersoni*, and *Vaughnia cubensis* (table 2).

Cagraray Island, Study Area 13

Three samples from the Paleocene-Eocene Sula Formation (text-fig. 11) which is composed mainly of limestones and coal measures are re-examined here. Station 7681902, on the seashore of Batas City, and Station 7682301 about 500 m south of Port Sula City, are respectively the same as Stations L-DB264 and Station L-DB263 of Corby et al. (1951), with an upper Paleocene fauna. Station 7682302, on the coast near Batas Point, is in the same as Corby et al.'s Station L-DB262, and yields a nummulitic fauna of early to middle Eocene age. (table 2)

Marinduque Island, Study Area 15

Four samples (MQ22, 23, 25 and 29) along the Boac River road are from the Boac Limestone, interbedded with volcanics in the Marinduque Basement Complex, and yield large foraminifera together with planktonic foraminifera indicating the *Gansserina gansseri* Zone KS 30, of Late Cretaceous (Maastrichtian) age (text-fig. 13; tabs. 1, 2). Two samples were re-examined from the *Nummulites*-bearing Eocene limestones intercalated with volcanics and fine turbidites which Hashimoto (1939) named the Mangamnam Formation and Gervacio (1970) re-defined as the Taluntunan-Tumicob Formation. Station MQ28 yielded specimens correlated to the Japanese Ogasawara Islands middle Eocene Assemblage I and II, or Letter Stage a3 (Matsumaru 1996) according to occurrence of *N. gizehensis* and *N. perforatus* (table 2). The foraminifera of Station MQ2 in the middle course of the Mangamnan River, indicate Zones P4-5, or Thanetian. These are essentially different from the late Eocene *Nummulites* and *Discocyclina* fauna reported by Hanzawa and Hashimoto (1970), and indicate that the Taluntunan-Tumicob Formation ranges in age from late Paleocene (Thanetian) to middle Eocene (Bartonian) and perhaps to late Eocene as well.

Mindoro Island, Study Area 16

In the Bulalaco region of southeastern Mindoro (text-fig. 14) sample WR154 from Pocanil Point consists of reddish purple massive limestone that was attributed to either the Bandao Limestone or Pocanile Limestone by Corby et al. (1951, p. 84). According to the RP-Japan Project (1982), this sample from the Abra de Iog Formation of the Mamburao Group dated to Upper Cretaceous, but the recorded fauna (table 2) indicates late Paleocene, Thanetian, Letter Stage Tertiary a1 (Matsumaru and Sarma 2010; Matsumaru 2011). This suggests that the Abra de Ilog Formation was deposited in a wide time range from Late Cretaceous to late Paleocene. Station YR2-025 in central southern Mindoro, on the foot path to Liberty Ranch from the Tomalo River, samples brownish calcarenite of the Caguray Formation of Bartonian age, with *Asterocyclina stellata* and *Fabiania cassis* (table 2).

Cebu Island, Study Area 21

Five samples from Central Cebu are all from limestones interbedded with pyroclastic deposits of the Pandan Formation in the Central Highland (see detail, text-fig. 19). Samples CB1, Cebu 5 and 6, as well as sample 744725 yield *Lepidorbitoides* spp. and *Sulcorbitoides pardoi,* together with planktonic foraminifera indicating the *Gansserina gansseri* Zone or KS 30 of Late Cretaceous (Maastrichtian) age. Station 6Y1906-2 north of Tabunoc City has a more prolific larger foraminifera fauna of the same age.

TABLE 1
Samples yielding Upper Cretaceous to middle Eocene Assemblages 1 to 5 in the Philippine study areas (text-fig. 1) correlated to Tertiary letter stages. For sample locations, see text-figures 2-23.

EPOCH	AGE / STAGE	PLANKTONIC FORAMIFERA ZONE	Luzon NE - Caraballo Mts. *Formation II*	Luzon - Pinugay Hill, Tanay-Dareiton *Pinugay Hill, Masungit limestones*	Luzon SE - Bondoc Peninsula *Unisan Volcanics limestone*	Luzon SE - Caramoan Peninsula *Pagsangahan, Garchitorena, Guihalo fms.*	Catanduanes *Bonagbonag, lower Sipi limestones*	Cagraray *Sula Formation*	Marinduque *Boac Limest., Taluntunan-Tumicob Fm.*	Mindoro *Abra de Ilog, Caguray formations*	Cebu *Pandan Formation*	Mindanao E *Barcelona, Koban groups limest.*	ASSEMBLAGE	LETTER STAGE
EOCENE	PRIAB.	P16-17, P15	(continued on Table 3)										6	b
EOCENE	BARTONIAN	P15, P13-14, P12	H502 J310				120902		MQ28	YR2-025		F578	5	a3
EOCENE	LUTET., YPRESIAN	P10-11, P9, P6-8, P5	A138 A408	7451212 7451209 7451213 7451215	31055	CR42 CR44 CR51 CR75 6611806		7682302					4	a2
PALEOCENE	THANET.	P5, P4	A422	7451105a	31056 31507	CR35 CR36		7682301 7681902	MQ2	WR154		F538, I-6 E12, I-3	3	a1
PALEOCENE	SELAND.	P4, P3		7451105b		CR37	121006					G316 I-4, EN	2	a0
PALEOCENE	DAN.	P0-2												a0
CRETACEOUS	MAASTRICHTIAN	KS31												ms2-3
CRETACEOUS	MAASTRICHTIAN	KS30		7451105c 7451105d		CR56 CR61 CR63	CT22 CT29 121002 6Z1120		MQ22 MQ23 MQ25 MQ29		CB1, 5, 6 6Y1906-2 7442725		1	ms1

East Mindanao, Study Area 24

Eight samples from three fossiliferous horizons in the Taon River-Bislig River composite section above Cateel Bay (text-fig. 22), collected by RP-Japan Project in 1972 (Matsumaru 1974) are re-examined (table 2). In the lower limestone beds intercalated in the lavas and shales of the Cretaceous-Paleocene Barcelona Group horizon, Stations G316, EN and I4 yield large foraminifera of Assemblage 2 and planktonics of Zone P1-2, suggesting a Danian age except for the presence of *Coskinon rajikae* (table 2), which is restricted to Zone P3. In the upper limestone, Stations I3 and I6 nearby yielded larger foraminifera of Assemblage 3 of Thanetian age, as did Stations F538 and E12 (table 2) on Cateel Bay. Finally, Station F578 from the limestone intercalations in of the largely volcanic Koban Group yielded *Nummulites ptukhiani* Kacharava, which is also known from the middle Eocene of Meghalaya, NE India (Matsumaru and Sarma 2010).

TABLE 2
Distribution of larger foraminifera and planktonic foraminifera in the samples yielding Assemblages 1-5.

Species / Stations	Assemblage 1																		Ass. 2						Assemblage 3														Assemblage 4													Ass. 5					
	7451105d	7451105c	CR56	CR61	CR63	121002	6Z1120	CT22	CT29	MQ22	MQ23	MQ25	MQ29	CB 1	Cebu 5	Cebu 6	7442725	6Y1906-2	7451105b	CR37	121006	G316	EN	I4	A422	7451105a	31056	31057	CR35	CR36	7681902	7682301	MQ2	WR154	F538	E12	I6	I3	A138	A408	7451215	7451213	7451209	7451212	31055	CR42	CR44	CR51	CR75	6611806	7682302	H502	J310	120902	MQ28	YR2-025	F578
Alveolina amarassiensis																																									X																
A. ellipsoidalis																															X	X									X																
A. luzonensis, n. sp.																															X			X	X						X	X	X			X											
A. subpyrenaica																																				X	X				X																
A. vredenburgi																															X	X		X			X	X			X	X				X		X									
A. spp.																																X			X	X																					X
Assilina exponens																																																				X			X		
A. philippinensis, n. sp.																																									X		X														
Asterocyclina incisuricamerata																											X	X														X	X	X										X			
A. pinugayensis, n. sp.																																										X	X	X													
A. stella																											X	X	X												X	X	X	X	X					X		X					
A. stellata																												X				X									X	X	X	X					X	X				X		X	
Asterorbis rooki								X																																																	
Borelis spp.																																																									
Broeckinella arabica																					X	X	X	X										X			X	X																			
Calcarina catanduanensis, n. sp.																					X																																				
Chrysalidina spp.																						X	X																																		
Pseudolituonella mindanaoensis, n. sp.																						X	X	X	X									X	X																						
Coleiconus spp.																							X												X																						
Coskinon rajkae																						X	X																																		
Daviesina danieli																													X			X	X			X							X				X										
D. khatiyahi																																														X											
D. langhami																										X			X																												
D. spp.																											X			X						X																					
Discocyclina spp.																																							X	X																	
Fabiania cassis																																									X												X			X	
F. spp.																					X																																				
Glomalveolina reicheli, n. sp.																																X																									
G. levis																																									X																
Hashimotoina mindanaoensis, n. gen., n. sp.																						X		X																																	
Idalina sinjarica																			X		X	X	X		X	X					X			X	X			X			X																
Kathina major																									X	X	X	X																													
K. selveri																				X						X	X			X																											
K. spp.																														X																											
Lepidorbitoides campaniensis		X				X																																																			
L. bisambergensis		X				X		X	X																																																
L. minor		X						X	X			X						X																																							
L. spp.				X	X			X				X		X	X	X	X	X																																							
Lockhartia conditi																											X						X																X								
L. haimei																											X		X	X			X																								
L. spp.																											X																														
Miscellanea globularis																																X			X																						
M. miscella																																	X								X																
M. primitiva																			X	X						X				X		X																									
M. spp.																			X												X											X															
Nummulites amakusensis																																								X																	
N. atacicus																																							X	X	X	X	X	X	X	X	X	X	X	X	X						
N. burdigalensis																																									X	X	X		X					X	X						
N. distans																																									X	X	X	X	X					X							
N. gizehensis																																																				X			X		
N. globulus																																							X		X	X	X	X		X	X	X			X						
N. hongoensis																																								X																	
N. junbarensis																																								X									X								
N. millecaput																																							X	X	X		X	X	X	X			X	X							
N. perforatus																																																							X		
N. ptukhiani																																																									X
N. striatus																																																				X	X	X			

TABLE 2
Continued.

Species / Stations	Assemblage 1																	
	7451105d	7451105c	CR56	CR61	CR63	121002	6Z1120	CT22	CT29	MQ22	MQ23	MQ25	MQ29	CB 1	Cebu 5	Cebu 6	7442725	6Y1906-2
Omphalocyclus macroporus	X	X		X	X	X	X	X										X
Operculina custugensis																		
O. schwageri																		
O. spp.																		
Opertorbitolites douvillei																		
Orbitoclypeus ramaraoi																		
Orbitoides tissoti					X													
Orbitosiphon tibetica																		
Orientorbitoid. cebuensis, n.g, n.sp.			X															X
Paleobaculog. catanduanensis, n.g.,n.sp.						X												
Pfendericonus mindanaoensis, n. sp.																		
Pseudochrysalidina spp.																		
Pseudorbit. philippinensis, n.sp.	X	X	X		X	X	X	X		X	X	X	X					X
Ranikothalia nuttalli																		
Praerhapydionina boninensis																		
Peneroplis spp.																		
Rotalia trochidifomis																		
Siderolites calcitrapoides						X						X						
Simplorbites papyracea			X		X													
Sorites orbiculus																		
Sulcorbitoides pardoi		X				X		X				X		X				
Sulcoperculina dickersoni			X					X										X
Vaughanina cubensis								X				X						
Acarinina mckannai																		
A. nitida																		
A. primitiva																		
A. soldadoensis soldadoensis																		
A. broedermanni																		
A. spp.																		
Contusotruncana fornicata	X	X									X			X	X			
C. contusa	X					X				X	X			X		X	X	
Gansserina gansseri										X		X	X					
Globanomalina compressa																		
G. ex gr. *G. chapmani*																		
Globigerina ex gr. *G. lozanoi*																		
Globotruncana arca	X																X	
G. ex gr. *G. linneiana*	X			X					X	X							X	
G. ex gr. *G. falsostuarti*	X	X				X					X					X	X	
G. ex gr. *G. stuartiformis*	X													X				X
Globotruncanita stuarti	X			X					X	X						X		
G. elevata	X									X				X				
G. conica	X										X	X				X		
Igorina pusilla																		
Morozovella ex gr. *M. angulata*																		
M. ex gr. *M. conicotruncata*																		
M. velascoensis																		
M. ex gr. *M. aequa*																		
M. ex gr. *M. subbotinae*																		
M. spp.																		
Parasubbotina ex gr. *P. pseudobulloides*																		
P. trinidadensis																		
Praemurica uncinata																		
Rugoglobigerina rugosa		X										X			X			
Subbotina triloculinoides																		

Species / Stations	Ass. 2						Assemblage 3													
	7451105b	CR37	121006	G316	EN	I 4	A422	7451105a	31056	31057	CR35	CR36	7681902	7682301	MQ2	WR154	F538	E 12	I 6	I 3
Omphalocyclus macroporus																				
Operculina custugensis																				
O. schwageri																				
O. spp.													X	X				X		
Opertorbitolites douvillei																				
Orbitoclypeus ramaraoi							X	X	X		X	X	X	X	X			X		
Orbitoides tissoti																				
Orbitosiphon tibetica							X													
Orientorbitoid. cebuensis, n.g, n.sp.																				
Paleobaculog. catanduanensis, n.g.,n.sp.																				
Pfendericonus mindanaoensis, n. sp.				X	X															
Pseudochrysalidina spp.					X												X			
Pseudorbit. philippinensis, n.sp.																				
Ranikothalia nuttalli							X	X			X	X			X	X				
Praerhapydionina boninensis																				
Peneroplis spp.																				
Rotalia trochidifomis	X		X				X	X												
Siderolites calcitrapoides																				
Simplorbites papyracea																				
Sorites orbiculus																				
Sulcorbitoides pardoi																				
Sulcoperculina dickersoni																				
Vaughanina cubensis																				
Acarinina mckannai								X			X	X								
A. nitida																				
A. primitiva																				
A. soldadoensis soldadoensis																				
A. broedermanni																				
A. spp.															X					
Contusotruncana fornicata																				
C. contusa																				
Gansserina gansseri																				
Globanomalina compressa	X							X												
G. ex gr. *G. chapmani*												X								
Globigerina ex gr. *G. lozanoi*																				
Globotruncana arca																				
G. ex gr. *G. linneiana*																				
G. ex gr. *G. falsostuarti*																				
G. ex gr. *G. stuartiformis*																				
Globotruncanita stuarti																				
G. elevata																				
G. conica																				
Igorina pusilla								X			X	X								
Morozovella ex gr. *M. angulata*								X				X								
M. ex gr. *M. conicotruncata*	X							X			X	X								
M. velascoensis								X			X	X			X					
M. ex gr. *M. aequa*											X	X			X					
M. ex gr. *M. subbotinae*																				
M. spp.								X							X					
Parasubbotina ex gr. *P. pseudobulloides*	X			X				X			X									
P. trinidadensis	X			X				X												
Praemurica uncinata											X				X					
Rugoglobigerina rugosa																				
Subbotina triloculinoides								X												

Species / Stations	Assemblage 4													Ass. 5					
	A138	A408	7451215	7451213	7451209	7451212	31055	CR42	CR44	CR51	CR75	6611806	7682302	H502	J310	120902	MQ28	YR2-025	F578
Omphalocyclus macroporus																			
Operculina custugensis					X	X						X							
O. schwageri															X	X			
O. spp.																X	X		
Opertorbitolites douvillei			X																
Orbitoclypeus ramaraoi			X		X	X		X											
Orbitoides tissoti																			
Orbitosiphon tibetica																			
Orientorbitoid. cebuensis, n.g, n.sp.																			
Paleobaculog. catanduanensis, n.g.,n.sp.																			
Pfendericonus mindanaoensis, n. sp.																			
Pseudochrysalidina spp.																			
Pseudorbit. philippinensis, n.sp.																			
Ranikothalia nuttalli																			
Praerhapydionina boninensis																			
Peneroplis spp.																			
Rotalia trochidifomis																			
Siderolites calcitrapoides																			
Simplorbites papyracea																			
Sorites orbiculus																			
Sulcorbitoides pardoi																			
Sulcoperculina dickersoni																			
Vaughanina cubensis																			
PLANKTONIC																			
Acarinina mckannai						X													
A. nitida					X														
A. primitiva					X	X						X							
A. soldadoensis soldadoensis					X	X													
A. broedermanni					X	X						X							
A. spp.																			
Contusotruncana fornicata																			
C. contusa																			
Gansserina gansseri																			
Globanomalina compressa																			
G. ex gr. *G. chapmani*																			
Globigerina ex gr. *G. lozanoi*						X													
Globotruncana arca																			
G. ex gr. *G. linneiana*																			
G. ex gr. *G. falsostuarti*																			
G. ex gr. *G. stuartiformis*																			
Globotruncanita stuarti																			
G. elevata																			
G. conica																			
Igorina pusilla																			
Morozovella ex gr. *M. angulata*																			
M. ex gr. *M. conicotruncata*																			
M. velascoensis																			
M. ex gr. *M. aequa*					X														
M. ex gr. *M. subbotinae*					X	X													
M. spp.																			
Parasubbotina ex gr. *P. pseudobulloides*																			
P. trinidadensis																			
Praemurica uncinata																			
Rugoglobigerina rugosa																			
Subbotina triloculinoides																			

MAASTRICHTIAN TO MIDDLE EOCENE FAUNAL ASSEMBLAGES

The studied sections in the eastern Philippine Archipelago are calibrated to the standard time scale and global planktonic foraminiferal zonation, and to the Vlerk letter stages as recognized in the Philippines (Matsumaru 2011), as shown in table 1. Five larger foraminiferal assemblage zones derived from these samples, shown in Table 2, can be correlated to assemblages in the Jaintia Hills, Meghalaya, NE India, in the Ogasawara Islands of Japan and in the Bey Dağlari Autochton and Haymana-Black Sea region of Turkey (table 17).

Assemblage 1, defined by *Lepidorbitoides campaniensis* Gorsel, *L. bisambergensis* (Jaeger), *L. minor* (Schlumberger), *Omphalocyclus macroporus* (Lamarck), *Pseudorbitoides philippinensis,* n. sp. and *Sulcorbitoides pardoi* Brönnimann, is found in 18 samples (table 1). The Assemblage 1 fauna based on type sample 7451105c in ther Pinugay Hill section (text-fig. 5) is equivalent to the Pinugay (PNG) Fauna that was correlated to the upper Maastrichtian *Globotruncanita stuarti* Zone (Hashimoto and Balce 1977; Hashimoto et al. 1977; Hashimoto and Matsumaru 1984), but it is more accurately correlated to the early Maastrichtan *Gannserina gansseri* Zone, KS30. In fact, no uppermost Maastrichtian fauna is known from the Philippines. The included species *Sulcorbitoides pardoi, S. dickersoni, Asterorbis rooki, Vaughanina cubensis,* and genus *Pseudorbitoides* are also found in the Caribbean region, while *Lepidorbitoides campaniensis* and *L. bisambergensis* are known from the upper Campanian in Western Europe (Gorsel 1975; Bignot and Neumann 1991); these may or may not be reworked into the Maastrichtian Stage in the Philippines. Assemblage 1 is partially correlated to Assemblage 2 in the Haymana-Black Sea, Turkey, due to co-occurrence of *Omphalocyclus macroporus* (Matsumaru 2016; table 17). Assemblage 1 fauna is also found in Maastrichtian (*Gansserina gansseri* Zone) sequences in Hole 462, Nauru Basin, Micronesia, and Hole 165 and Hole 315 on Line Islands Ridge, Polynesia (Beckmann 1976; Premoli Silva and Brusa 1981).

Late Cretaceous, Maastrichtian ms1.

Assemblage 2 is defined by *Broeckinella arabica, Coskinon rajkae, Idalina sinjarica, Miscellanea primitiva, Pseudolituonella mindanaoensis*, n. sp. and *Rotalia trochidiformis,* based on two co-type samples, 7451105b in the Pinugay Hill section (text-fig. 5), and G316 of Minndanao Island (text-fig. 22), in order to reflect different environments. It is established as a new division, Letter Stage Tertiary a0 (Matsumaru 2011, p. 238), and Assemblage a0 lacks the defining taxa of the younger Letter Stage (Vlerk letter stage) a1 of Leupold and van der Vlerk (1931) in the Letter Classification of van der Vlerk and Umbgrove (1927). This assemblage can be correlated to Assemblage 7 in the Haymana-Black Sea, Turkey, due to the co-occurrence of *Coskinon rajkae, Idalina sinjarica, Miscellanea primitiva* and *Rotalia trochidiformis* (Matsumaru 2016; table 17).The faunas of Assemblage 2 occur together with planktonic foraminifera (table 2) indicative of Zone P3. No samples with early Paleocene Danian (Zone P0-2) fauna, representing lower Stage a0, have yet been recognized in the Philippines. As in Assemblage 1, Caribbean connections such as *Coleiconus* sp. document a mixed large foraminiferal fauna from both the Tethys and Caribbean regions.

Middle Paleocene (Selandian), Tertiary a0 upper.

Assemblage 3 is defined by *Daviesina danieli* Smout, *Kathina selveri* Smout, *Orbitoclypeus ramaraoi* (Samanta), *Lockhartia haimei* (Davies), *Miscellanea miscella* (d'Archiac), *Ranikothalia nuttalli* (Davies), *R. sindensis* (Davies), and *Alveolina vredenburgi* Davies, combined from sample 7451105a in the Pinugau Hill section, 7682301 on Cagraray Island; and sample MQ2 of Marinduque Island to include different environments. The characterizing *Ranikothalia nuttalli* was previously identified as *Ranikothalia bermudezi* in defining the late Paleocene larger foraminiferal fauna MSG1, or Masungit Fauna (Hashimoto and Matsumaru 1984). Assemblage 3, equivalent to Letter Stage Tertiary a1, correlates to Assemblage 1 and 2 of Meghalaya, NE India (Matsumaru and Jauhri 2003; Matsumaru and Sarma 2010) due to occurrences of *Miscellanea miscella* and *Ranikothalia nuttalli*. Assemblage 3 is also correlated to Assemblage 8 of Haymana-Black Sea, Turkey due to co-occurrence of *Kathina selveri* and *Ranikothalia nuttalli* (table 17). The associated planktonic foraminifera (table 2) indicate Zones P4-5.

Late Paleocene (Thanetian), Tertiary a1.

Assemblage 4 is defined by *Alveolina subpyrenaica* Leymerie, *Nummulites atacicus* Leymerie, *N. burdigalensis* (de la Harpe), *N. globulus* Leymerie, *N. millecaput* Boubée and *Opertorbitolites douvillei* Nuttall, from the type sample 7451215 of the upper Masungit Limestone, Pinugay Hill (text-fig. 5). The presence of *Nummulites atacicus, N. burdigalensis* and *N. globulus* identify Letter Stage Tertiary a2. This assemblage can be correlated to the interval of Assemblages 3-1 to 4-2 in Meghalaya (table 17) due primarily to co-occurrence of the index species *Nummulites atacicus, N. burdigalensis*, *N. globulus,* and *N. millecaput.* Also Assemblage 4 is correlated to Assemblages 9 to 11 in the Haymana-Black Sea, Turkey, due to the co-occurrence of *Nummulites atacicus* and *N. globulus* (Matsumaru 2016; table 17). The associated planktonic foraminifera (table 2) indicate that Assemblage 4 is reliably correlated to the interval from Zone P6 to Zone P10, if not all of P5 or P11.

Late Early Eocene (Ypresian) to Middle Eocene (Lutetian), Tertiary a2.

Assemblage 5 is defined by *Nummulites gizehensis* (Forskål), *N. perforatus* (Montfort), *N. ptukhiani* Kacharava, *N. striatus* (Bruguiere) and *Assilina exponens* (Sowerby) in a composite fauna from three type samples: H502 in Formation II of Caraballo Group, MQ28 from Taluntunan-Tumicob Formation, Marinduque Island, and F578 from the Koban Group, East Mindanao (table 1). It is correlated to Letter Stage Tertiary a3, based on similarity to Assemblage I and II from Haha-Jima, Ogasawara Islands (Matsumaru 1996, fig. 13), the lower part dated to 42.5 Ma by Kaneoka et al. (1970) and the upper part with planktonic foraminifera of Zone P13, securely linking Assemblage 5 to Lutetian-Bartonian Zones P12 to P15. Assemblage 5 can also be correlated to Assemblage 4-2 and in part to Assemblage 5 of Meghalaya, NE India (Matsumaru and Sarma 2010).

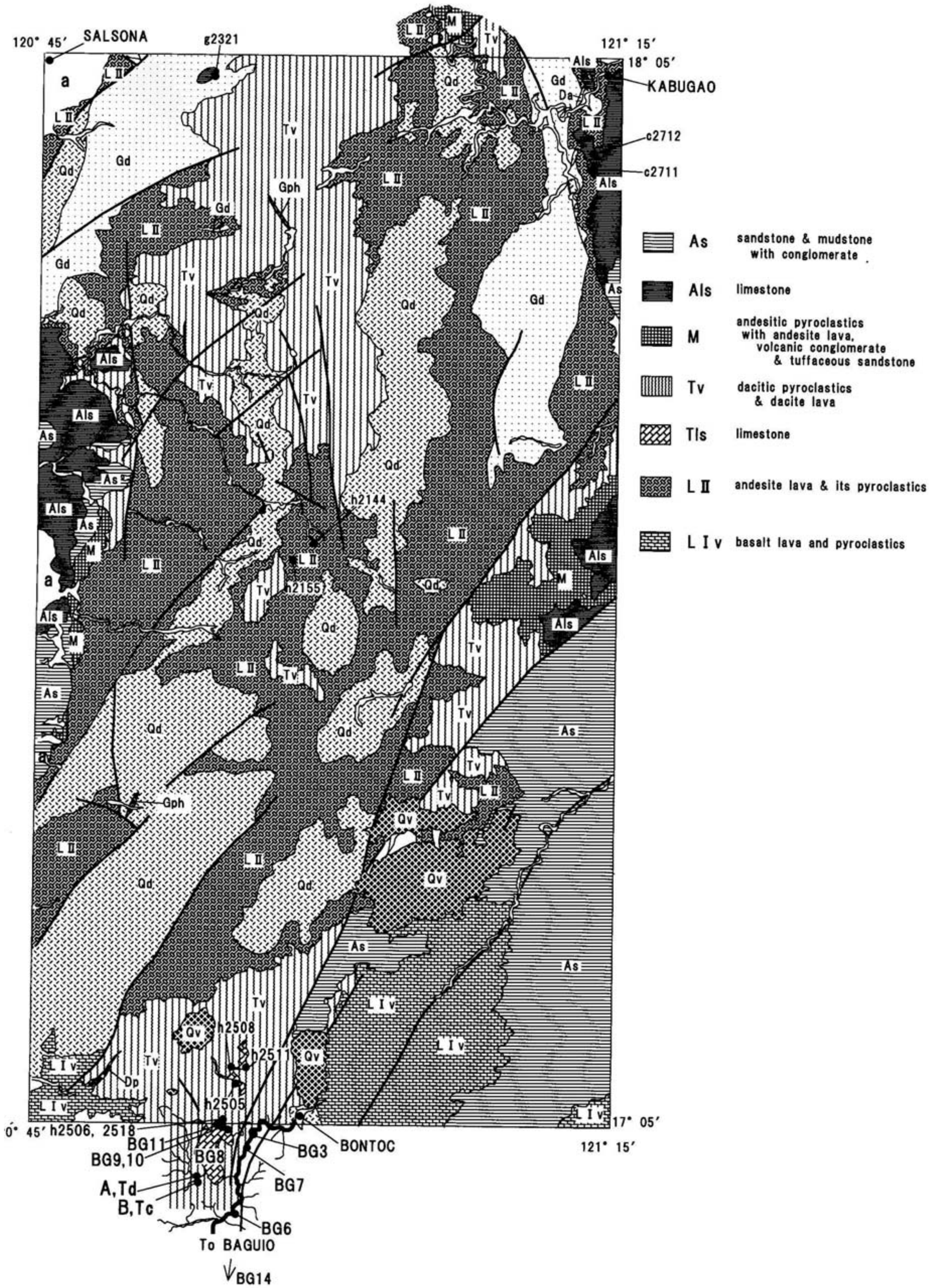
Middle Eocene (Lutetian- Bartonian), Letter Stage Tertiary a3.

SYSTEMATIC DESCRIPTIONS

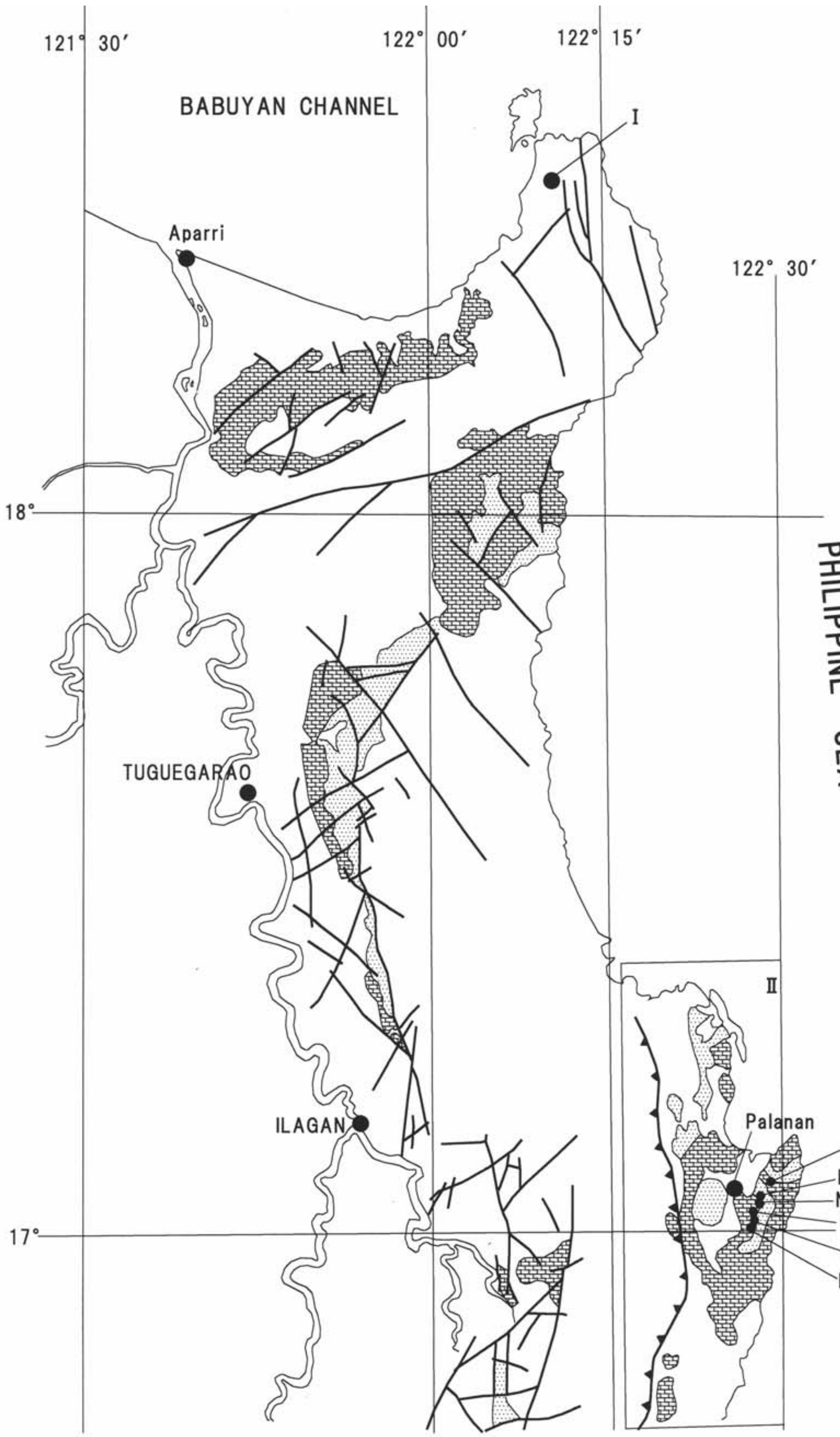
Table 2 provides the known occurrences of each species described below, in the samples shown in Table 1 that were stud-

TABLE 3
Samples yielding Upper Eocene to Pleistocene Assemblages 6 to 19 in the Philippine study areas (tf. 1) correlated to Tertiary letter stages. For faunal content of samples, see tables 4-15; for sample locations, see tfs. 2-23.

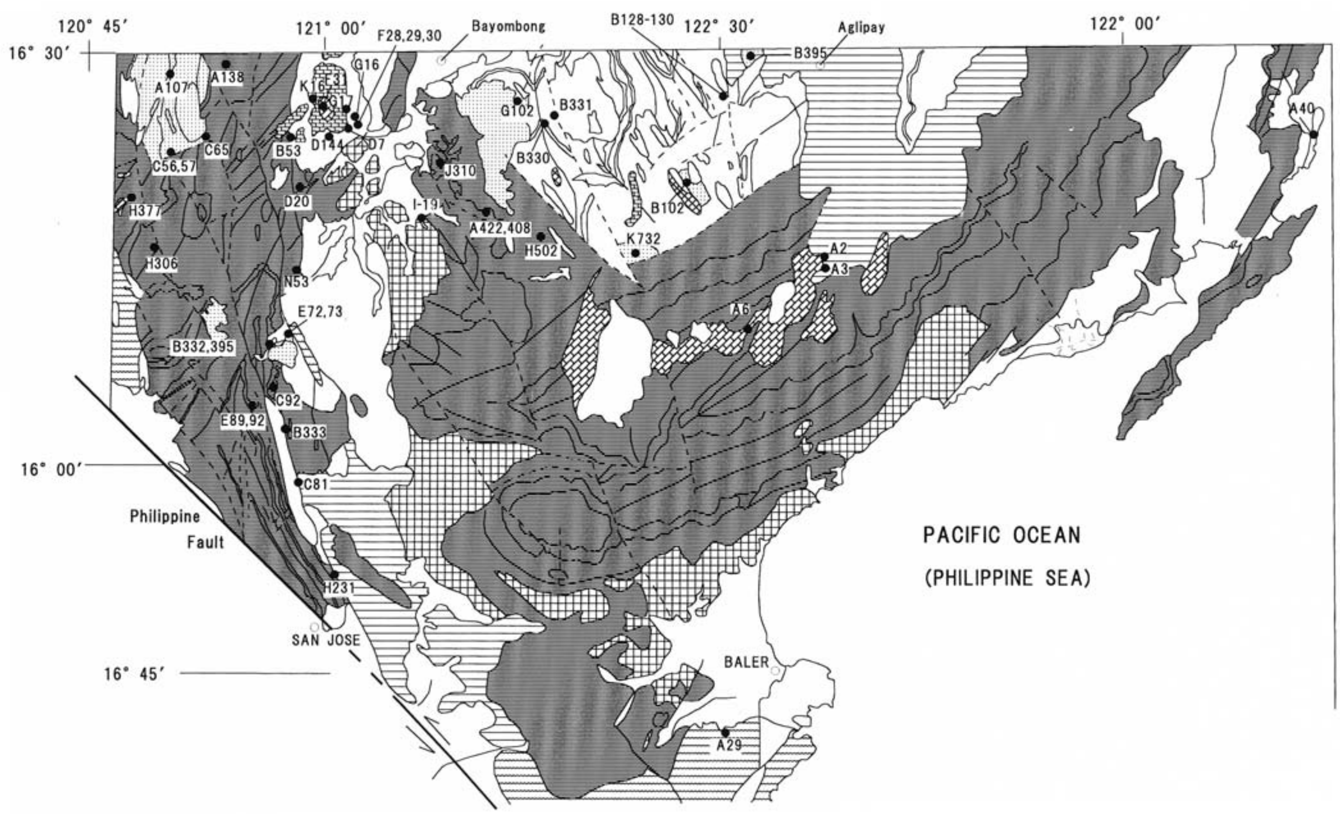
EPOCH	AGE / STAGE	PLANKTONIC FORAMINIFERA ZONE	Mid Luzon - Areas 1 to 3, 6, 7 Licua n Gr., Tineg F., Binangonan Lss. Angat Fm., Zigzag, Kennon. Mirador Iss. Alaba F.	Luzon N - Palanan Palanan limestone	Luzon NE - Caraballo Mts. Fm. III, Mamparang, Columbus, Palali, Macde fms	Luzon SE - Bondoc Peninsula Gumaca, Atimonan, Hondagua, Malumbang fms.	Catanduanes Upper Sipi limestone, Payo Fm.	Cagraray Coal Harbour limestone	Burias, Marinduque San Pascual Fm, Torrijos Fm	Mindoro NE Sablayan Gr., Tangon Fm.	Mindoro SW Caguray, Banda, Tangon fms, Sablayan Gr.	Mindoro - Bugton Peninsula Buguton, Paclasan limestones	Tablas Bagoliano, Colasi limestones	Panay Fragante Fm., Sta. Cruz Fm.	Masbate Masbate Fm., Mt. Maido, Masbate Iss.	Negros Trankalan limestone, Escalante Fm.	Cebu Lutac Hill Is., Calagasan, Cebu, Malubog, Mt. Uling, Toledo, Maingit, Barili fms.	Samar Tertiary d Fm., Daram Fm.	Leyte Pangasugan Fm., Dolores limestone	Mindanao East Mangagoy, Bislig, Agtuucanon fms., Kalagutay Gr.	Palawan Tert. d Fm., St. Paul Is., Alfonso XIII Fm.	ASSEMBLAGE	LETTER STAGE
PLST.		N22-23				BYG 3,4 BHK 7 PRS7							TB17	PN21 PN23					BHY5,6 VLB12 AGM3			19	h
PLIO.		N19-21				BYG 1									PWC16		Cebu 2, 44, 46		BHY2 VLB9 LMN10		QZ10-3	18	g
MIOCENE	MESSIN	N17-18	W9			BHK 4									MBG2		Cebu 25 Cebu 27					17	f3
	TORTON.	N15-16																					
		N14																					
	SERR.	N11-13	BG2		F28 B53 D20 K 16						MD106		TB 42		PWC 5		Cebu 29 Cebu 30					16	f2
	LANG.	N10	120		F31				MH5 MH6						MBG1 MSG-10						QZ10 -1, 2	15	f1
		N9																					
	BURDIGAL.	N8/M5				A9 MA11 SML10			MQ6 MQ10 MQ19-2				TB35, 45, 55				CB9, 18, 28, 38, 51, 52, 54			E10 E28 BTF2 H93		14	
		N7/M4																					
		N5-6 M2-3	AG3 BG15	2, 6	C57				MQ28? MQ19-1						PLN2						PP61	13	e5
	AQUIT.	N4 /M1	19 BG1	3, 4	A29 C56 B102 K732 B395			7681-905, 908	MQ12 MQ14 MQ20	TR2-127, 137	HR206 MD112 MD113 MD118			PN20	PLN8	7683-001	Cebu 23	7450-608, 609		C58 E25		12	
OLIGOCENE	CHATTIAN	P22	RZ3 c7211 c2712	1	A107 A2	PTG 5		7681-903 7681-904	MQ15 MQ16 MQ17		WR201 MD7	7212-101				7682-905, 906		7450-713		F498,		11	e4
			RZ4 BG9 h2518		A3	PTG9 31058 CLG1 At8										7682-902, 904 7683-003	CB7 CB8 CB15 CB20			F27 F28		10	e3
					A6 H377	CLG7 GMC18						11467 11468					21760					9	e1-2
		P21	h2506		B128						WR 203	11469, 73,74, 75,77, 78,83					74426 74427	7450-707		H14	QZ4	8	d
	RUPELIAN		A BG6B								WR 204												
		P18-20	B h2505		B130						WR 202	11479					CB2 CB3 74426-23, 24					7	c
EOCENE	PRIABON.	P15-17	BG7, 8,12, 6A, h2155, h2144		G102 I19		CT18 CT19 CT38 CT39				MD115-17 MD70 MD77 MD83 MD111 WR41 TR-2005 YR-2024											6	b



TEXT-FIGURE 2
North Luzon, Bontoc (Areas 1, 2). Samples are from the Dalpirip Schist (LIv), Licuan Group (LII), late Eocene, Tertiary b; Tineg Limestone (Tls) and Tineg Formation (Tv), lower to upper Oligocene, Tertiary c to e4; Mabaca Formation (M, not studied; RP-Japan Project, 1976) and Alaba Formation (Als), upper Miocene, Tertiary f3, which includes Station W9 outside the map (Hashimoto and Matsumaru 1981, fig. 15).



TEXT-FIGURE 3
North Luzon, Palanan (Area 4) Samples are from Palanan Limestone, upper Oligocene to lower Miocene, Tertiary e4 to e5 (Hashimoto and Matsumaru 1975, figure 2).



TEXT-FIGURE 4
NE Luzon Caraballo Mountains (Area 5). Main fossiliferous formations are upper Paleocene- lower Oligocene Caraballo Group (dark shade), middle to upper Oligocene Columbus Formation (square), lower Miocene Palali Formation (lower Palali, dotted; upper Palali, horizontal), and middle Miocene Natbang (inclined brick) and Macde (horizontal brick) formations (RP-Japan Project 1976, geological map; Hashimoto et al. 1980, fig. 3).

ied from the upper Cretaceous (Maastrichtian) to middle Eocene (Bartonian) of the Philippine Archipelago.

Phylum PROTOZOA Goldfuss 1817
Class RHIZOPODA von Siebold 1845
Order FORAMINIFERIDA Eichwald 1830
Suborder ROTALIINA Delage and Herouard 1896
Superfamily ORBITOIDACEA Schwager 1876
Family ORBITOIDIDAE Schwager 1876
Subfamily OMPHALOCYCLINAE Vaughan 1928
Genus *Omphalocyclus* Bronn 1853

Omphalocyclus macroporus (Lamarck 1816)
Plate 3, figure 10 left; plate 4, figures 4 upper, 5

Orbulites macropora LAMARCK 1816, p. 197
Omphalocyclus macroporus (Lamarck) – NEUMANN 1958, p. 65-66, pl. 6, figs. 1-8, pl. 35, fig. 2, fig. 16. – NAGAPPA 1959, p. 178, pl. 2, fig. 1. – HASHIMOTO, MATSUMARU and KURIHARA 1978, p. 69, pl. 8, figs. 5-6. – MATSUMARU 1997, p. 344, pl. 1, fig. 5.

Description: Test discoidal, biconcave and compressed in the center and thickest at the periphery. The central portion is formed by a single equatorial layer. Subspheric protoconch and reniform deuteroconch are surrounded by arcuate periembryonic and equatorial chambers. Chambers are connected through marginal stolons and in later stage divided into two or three layers of lateral chambers, similar to equatorial chambers. The wall is calcareous, lamellar and perforate.

Dimensions: Diameter of test = 3.9 to 4.1 mm, thickness = 0.94 to 1.10 mm, diameter/thickness ratio = 3.86 to 4.26; diameter of protoconch = 114 × 105 µm, diameter of deuteroconch = 254 × 105, ratio of deuteroconch diameter/protoconch diameter = 1.32 to 2.23. Distance across both protoconch and deuteroconch = 219 to 250 µm, thickness of embryonic chambers wall = 20 µm; dimension of equatorial arcuate chamber = 180 × 160 to 198 × 136 µm in tangential and radial diameters.

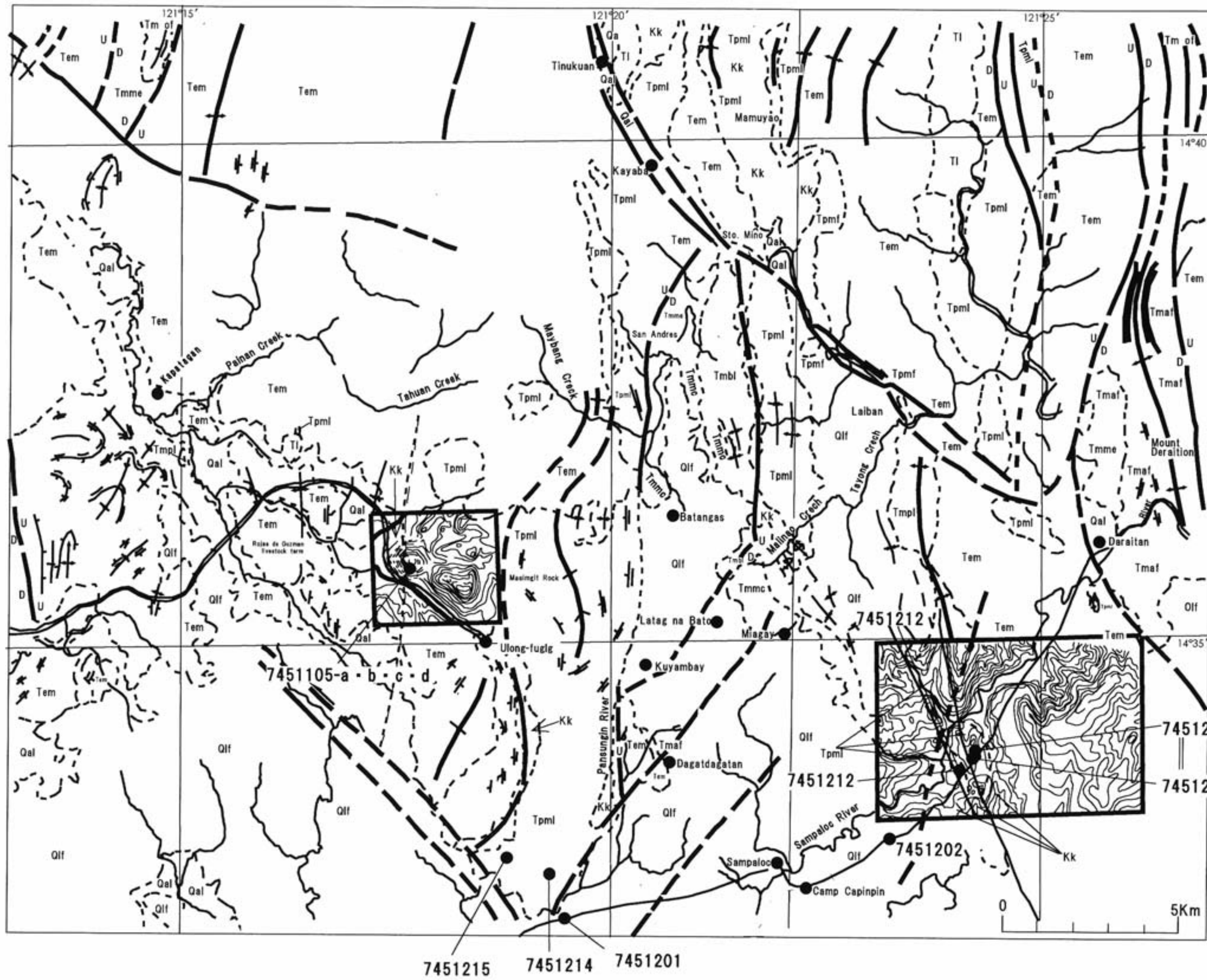
Remarks: Omphalocyclus macroporus occurs in Assemblage 1 faunas noted in table 2.

Late Cretaceous, Maastrichtian ms1.

Subfamily ORBITOIDINAE Schwager 1876
Genus *Orbitoides* d'Orbigny 1848

Orbitoides tissoti Schlumberger 1902
Plate 3, figures 9, 10 center

Orbitoides tissoti SCHLUMBERGER 1902, p. 259-260, fig. 3, pl. 8, figs. 21-25. – NEUMANN 1958, p. 58-60, fig. 13, pl. 1, figs. 1-3, 6-9; pl. 2, figs. 1-4; pl. 35, fig. 1. – NEUMANN 1993, p. 304-311, figs. 2-4, 16-19, pl. 1, figs. 1-3; pl. 4, fig. 2.



TEXT-FIGURE 5
Mid Luzon, Pinugay Hill (Area 7) and Tanay-Daraitan (Area 8). Part 1. Area 7 is left square (Hashimoto et al., 1978, fig. 2) and Area 8 is right square (Hashimoto et al., 1979, fig. 1). Samples in table 1 are from Pinugay Hill (Kk) limestone, upper Cretaceous Maastrichtian ms2; Masungit (Tpml) limestone, middle and upper Paleocene Tertiary a0 to a1; and Lower Eocene beds (Tem) with Tertiary a2 fauna, also identified as Masungit limestone. See text-figure 6, for younger beds.

Description: Test lenticular. In megalospheric specimens subspherical protoconch and reniform deuteroconch are embraced by two intra-embryonic chambers. These four embryonic chambers are surrounded by a thick perforated wall and connected to the surrounding auxiliary chambers by stolons. The later arcuate equatorial chambers are connnected with diagonal stolons. The lateral chambers are differentiated from the equatorial chamber layer. The wall is calcareous, lamellar and perforated.

Dimensions: Diameter of test = up to 1.5 mm, thickness = 0.8 mm, sum of longest and shortest internal diameter of embryonic chambers (Van Hinte 1965's, Li + li parameter), Li + li = 412 µm, Thickness of embryonic chambers wall = 16 to 20 µm, number of peri-embryonic primary auxiliary chambers = 4.

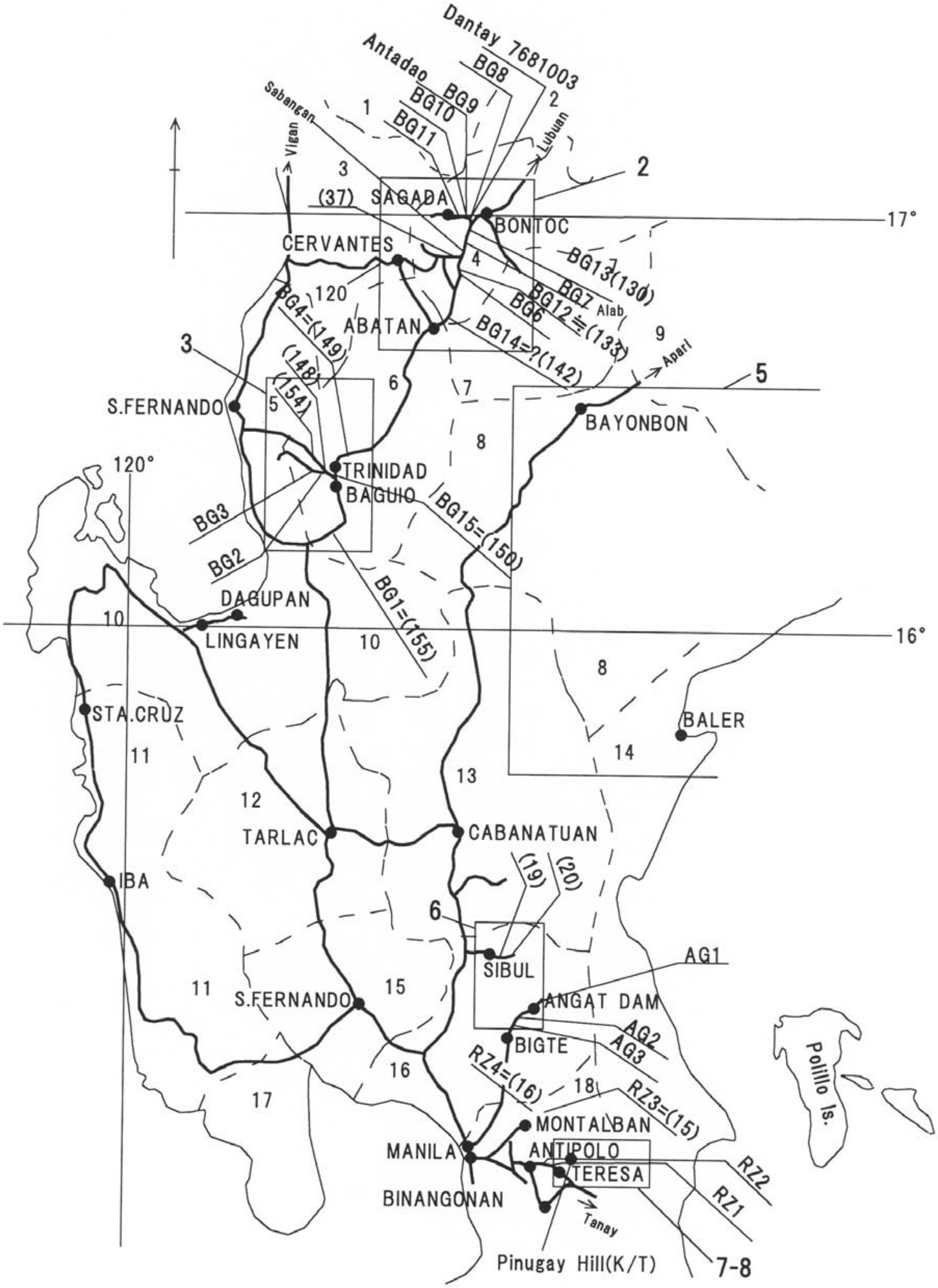
Remarks: Glaessner (1960) described *Orbitoides tissoti* and *Pseudorbitoides israelski* from the Campanian sandstone near Port Moresby, Papua New Guinea, but the embryonic chambers of *Orbitoides tissoti* from the Philippines are larger (Glaessner's specimen: Li + li = 380 µm).

Upper Cretaceous, Maastrichtian ms1.

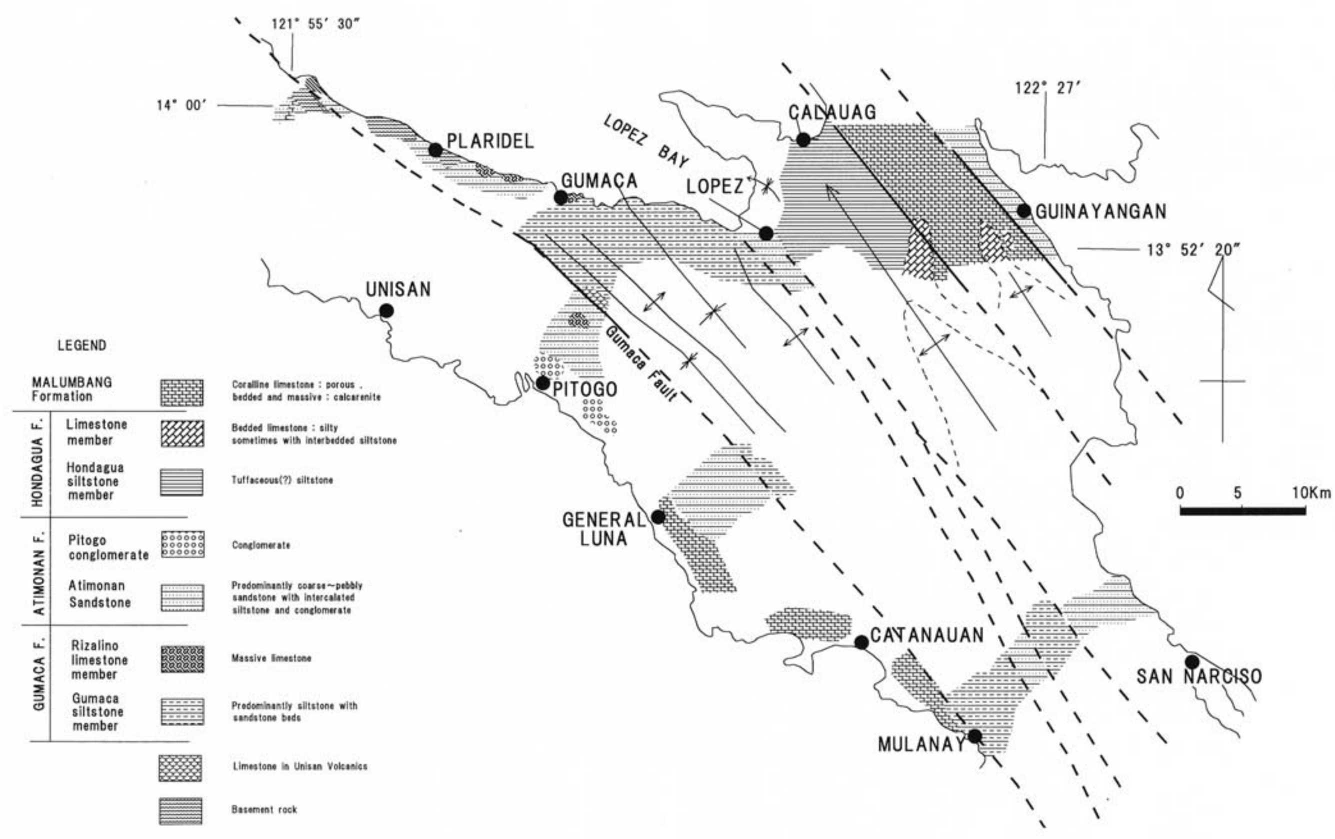
Genus ***Orientorbitoides*** Matsumaru, **n. gen**.
Type species: *Orientorbitoides cebuensis* Matsumaru, n. sp.

Etymology: Refers to orbitoids found in the Orient or Eastern Hemisphere.

Diagnosis: Orbitoid foraminiferal genus characterized by regularly arranged rectangular lateral equatorial chambers on the ventral side of test and two more slit-like cavities or a few rect-



TEXT-FIGURE 6
Mid Luzon, Bontoc (Area 2), Baguio (Area 3), Sibul (Area 6), Pinugay Hill (Area 7) and Tanay-Daraitan (Area 8), Part 2. Samples are from Binangonan limestone (RZ23, 24), upper Oligocene, Tertiary e3 to e4; Angat Formation (19, AG3) and Zigzag limestone (BG1, BG15), both lower Miocene, Tertiary e5; Kennon limestone (120), middle Miocene, Tertiary f1 upper; Mirador limestone (BG2), upper Miocene, Tertiary f2; Alaba Formation (W9, not shown), upper Miocene, Tertiary f3 (Hashimoto and Sato 1969, fig. 22).



TEXT-FIGURE 7
SE Luzon, Bondoc Peninsula (Areas 9, 10). The geological map shows Unisan Volcanics, upper Paleocene-lower Eocene, Tertiary a1 to a2; Gumaca Formation, late Oligocene, Tertiary e1 to e4; Antimonan Formation, early Miocene, lower Tertiary f1, Hondagua Formation, upper Miocene, Tertiary f3; and Malumbang Formation, Pliocene-Pleistocene, Tertiary g-h (Matsumaru and Barcelona 1982, fig. 1).

angular and spacious lateral chambers located over the dorsal side of the central test. Subsequent lateral chambers developed over the dorsal side of test create a lamellar thickening in the mature test. Monospecfic.

Age: all known occurrences are in Upper Cretaceous, early Maastrichtian.

Comparison: Genus *Orientorbitoides* resembles the genus *Orbitoides* d'Orbigny 1848 in its general features, but is distinguished by lamellar thickening of the dorsal side of test and an asymmetric test. *Orientorbitoides* is similar to the genus *Ilgazina* Erdogan 1995, from the upper Maastrichtian Ödemis Formation, Turkey, in the asymmetric test of the type species *Ilgazina unilateralis* which occurs with *Orbitoides apiculata* and *O. medius*. *Orientorbitoides,* however, has a few lateral slit-like cavities in the dorsal side of the test, large round diagonal or basal stolons in equatorial chambers.

Orientorbitoides cebuensis Matsumaru, **n. sp**.
Plate 3, figures 11-12

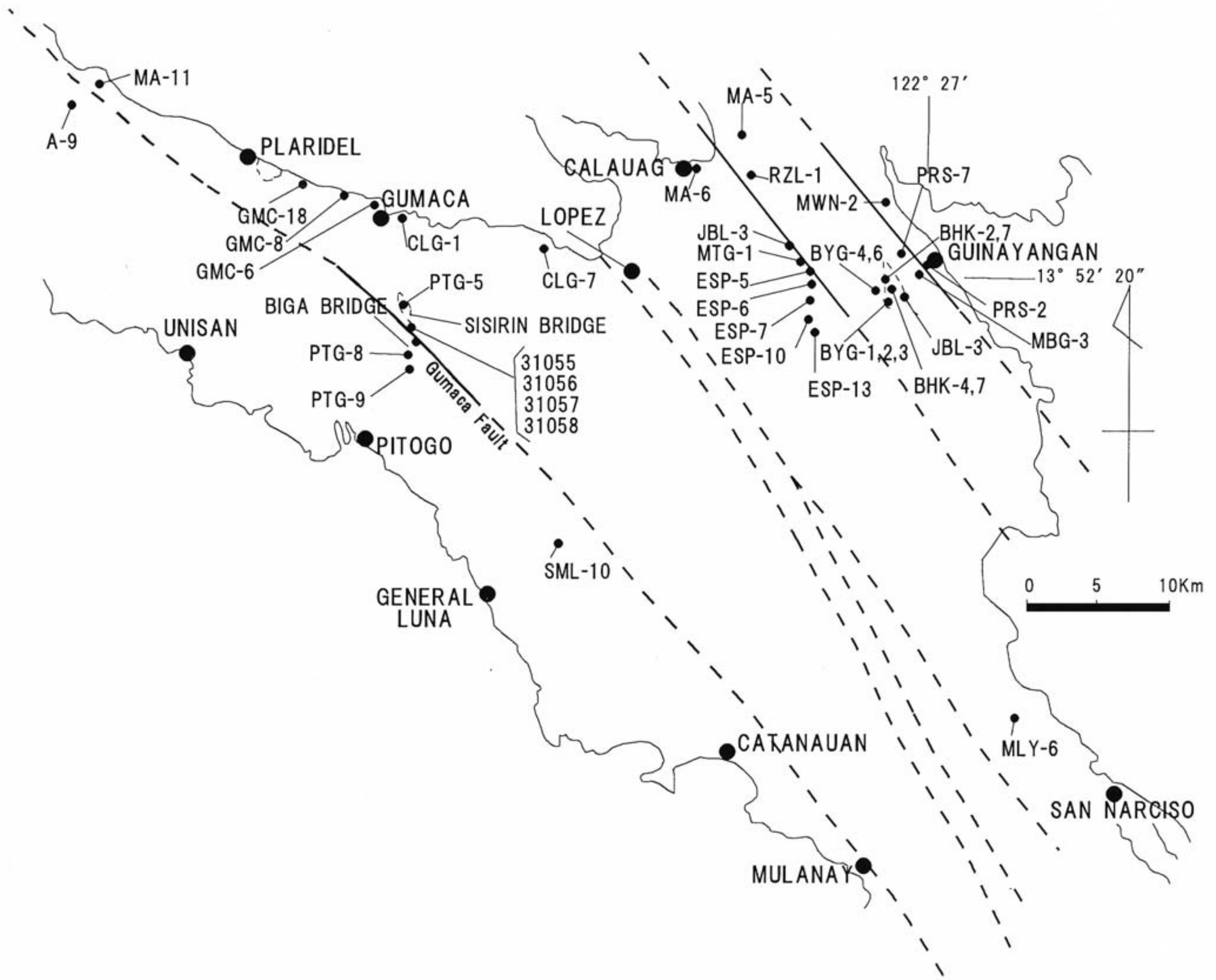
Etymology: Refers to type locality.

Type locality: Station 6Y1906-2, 7 km north of Tabunoc City, Cebu Island (text-fig. 19).

Holotype (fig. 11): Saitama University Coll. no. 8866.

Description: Test thin, lenticular, slightly convex on dorsal and concave on ventral side. In megalospehric forms,the embryonioc chambers in the axial section are embraced by a thick perforated wall, connected to the surrounding auxiliary chambers by stolons. Equatorial chambers are arranged rather regularly and connected with those of the proximal and distal cycles by big round diagonal or basal stolons. Lateral chambers on ventral side are arranged in regular rectangular tiers over embryonic and equatorial chambers, but are only partially present on the dorsal side as polygonal or vermicular slit-like or open cavities. Pillars are present in the ventral side of test. The wall is calcareous, lamellar and perforate.

Dimensions: Diameter of test = up to 1.5 mm to 3.1 mm, thickness = 0.35 to 0.59 mm; diameter/thickness ratio, 8.70; embryonic chambers = 105 × 154 and 175 × 210 µm in radial diameter and height; distance across both embryonic chambers = 280 µm; thickness of embryonic chamber wall = 38 to 74 µm; main auxiliary chamber radial diameter and height = 42 × 115 and 87 ×



TEXT-FIGURE 8
Bondoc Peninsula (cont.). Sample stations in the Bondoc Peninsula. Most of the samples shown on this map were not further re-examined here. (Matsumaru and Barcelona 1982, fig. 2).

147 µm; equatorial chambers radial diameter × height and tangential diameter × radial diameter = 42 × 50 to 83 × 140 µm and 80 × 34 to 87 × 52 µm; diameter of large round diagonal or basal stolons, 28 to 35 µm; lateral chambers radial diameter × height = 38 × 8 to 62 × 10 µm on ventral side, and = 43 × 12 to 50 × 14 µm on dorsal side. There are 12 lateral chambers in tiers over embryonic chambers, and 15 near the periphery. Thickness of roofs and floors = 5 to 12 µm; thickness of pillars = 16 to 26 µm.

Upper Cretaceous, Maastrichtian ms1.

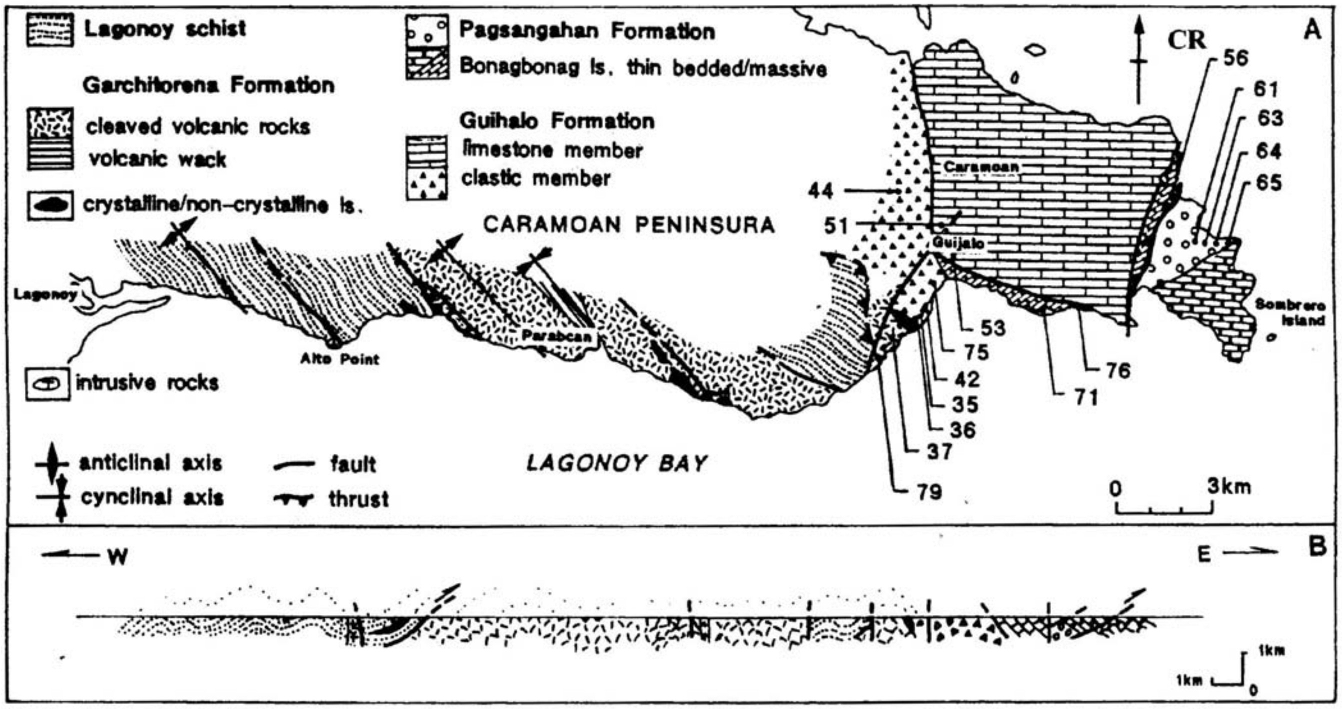
Family LEPIDORBITOIDIDAE Vaughan 1933
Subfamily LEPIDORBITOIDINAE Vaughan 1933
Genus *Lepidorbitoides* Silvestri 1907

Lepidorbitoides pembergeri Papp 1954
Plate 1, figure 5

Lepidorbotoides minima pembergeri PAPP 1954, p. 163-164, pl. 1, figs. 3-4.
Lepidorbitoides pembergeri Papp. – GORSEL 1975, p. 74-76, pl. 4, figs. A-b; fig. 2e. – MATSUMARU 2016, p. 14, 16, fig. 5B, pl. 2, figs. 8-9.

Description: A single megalospheric specimen was found in the Pinugay Hill Section (table 2). The small embryonic chambers has a protoconch diameter = 50 × 46 µm, and deuteroconch diameter of = 70 × 50 µm. There are 9-10 long nepionic spires from the primary auxiliary chambers (Papp's Heuptspirale; Gorsel's primary spirals in the helicolepidine manner) are counted 9 or 10, except the PAC. There are 2-3 secondary short spires. The equatorial chambers are arranged in open arcuate form, with tangential and radial diameters are 40 × 20 to 50 × 30 µm.

Remarks: The illustrated specimen is assigned to *Lepidorbitoides pembergeri* Papp because of the small embryonic chambers, biserial long (helicolepidine) and short nepionic spires,



TEXT-FIGURE 9
SE Luzon, Caramoan Peninsula (Area 11). Samples are from Bonagbonag limestone, Maastrichtian ms2, Garchitorena formation, mid to upper Paleocene Tertiary a0 to a1, and Guihao Formation, lower to mid Eocene, Tertiary a2. Station 6811806 (Hashimoto and Matsumaru, 1981) is not shown, but is located near Station CR36. (Takizawa et al. 1996, fig. 2).

and open arcuate equatorial chambers. Gorsel (1975) regarded Papp's (1954, p. 164, pl. 1, fig. 2) *Pseudorbitoides* cf. *P. trechmanni* Papp to also belong to *Lepidorbitoides pembergeri* with reduced uniserial nepionic spirals. This form, however, does not have any retrovert aperture in PAC as Papp (1954) indicated. This is the first *Lepidorbitoides pembergeri* reported from the Philippines, and this specimen is probably reworked from the upper Campanian.

Upper Cretaceous, Maastrichtian ms2.

Lepidorbitoides campaniensis Gorsel 1973
Plate 1, figures 6-10

Lepidorbitoides campaniensis GORSEL 1973, p. 263-267, pl. 1, figs. 1-6; pl. 2, figs. 1-4; pl. 3, figs. 1-3; pl. 4, figs. 1-3; fig. 3. – MATSUMARU 2016, p. 14-15, fig. 5B, pl. 2, figs. 10-11.

Description: Test is lenticular without a pillar, with sherical to subspherical protoconch and reniform deuteroconch. One primary auxiliary chamber originates from the deuteroconch through a stoloniferous aperture. A long primary spiral along the protoconchal wall and a short secondary spiral along the deuteroconchal wall are developed from biserial periembryonic arrangement. The equatorial chambers are almost arcuate with the basal stolon and lateral chambers arranged in regular tiers on both sides of the equatorial layer. The wall is calcareous, lamellar and perforate.

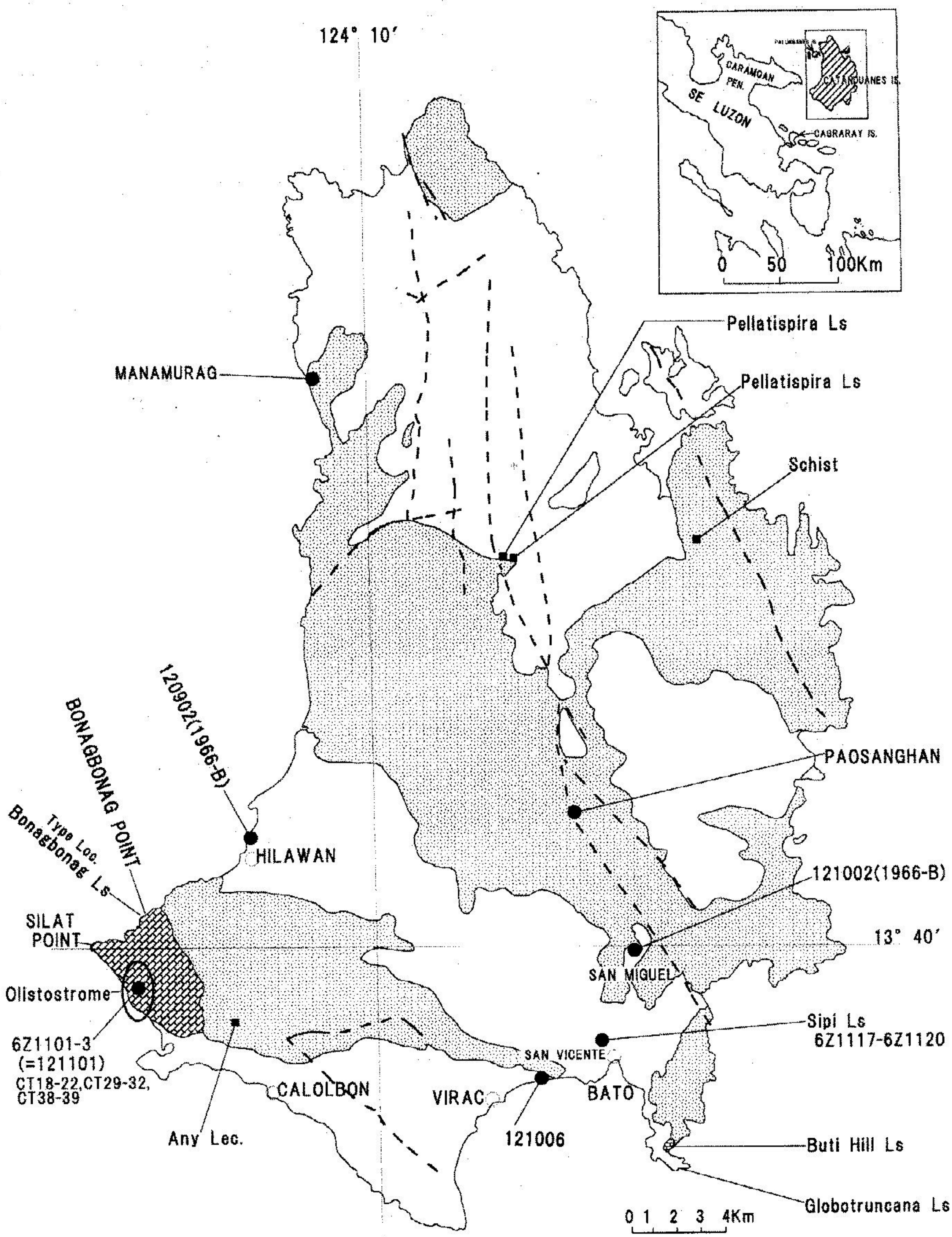
Dimensions: Diameter of test = 1.50 to 1.65 mm, thickness = 0.56 to 0.58 mm, diameter/thickness ratio = 2.40 to 2.80. In three measured specimens, protoconch diameter = 64 × 56, 80 × 80 and 88 × 76 µm, deuteroconch diameter = 80 × 56, 86 × 72 and 96 × 76 µm, ratio of deuteroconch/protoconch diameters = 1.25, 1.08 and 1.09, distance across both protoconch and deuteroconch = 112, 152 and 152 µm. Thickness of embryonic chambers wall = 12 to 20 µm. In four specimerns, primary auxiliary chamber tangential diameter × radial diameter = 40 × 17, 44 × 30, 50 × 34 and 60 × 30 µm, equatorial chamber tangential × radial diameter = 50 × 50 to 60 × 60 µm. Lateral chamber radial diameter × height = 40 × 10 to 60 × 10 µm. Thickness of roofs and floors = 4 to 7 µm, and number of lateral chambers = 11 to 13.

Remarks: A biserial periembryonic arrangement with one primary auxiliary chamber, a long primary spiral and a short secondary spiral is distinctive of *Lepidorbitoides campaniensis* Gorsel. This species is described from the Philippines for the first time, where it is restricted to Assemblage 1 in samples of Late Cretaceous age (table 2).

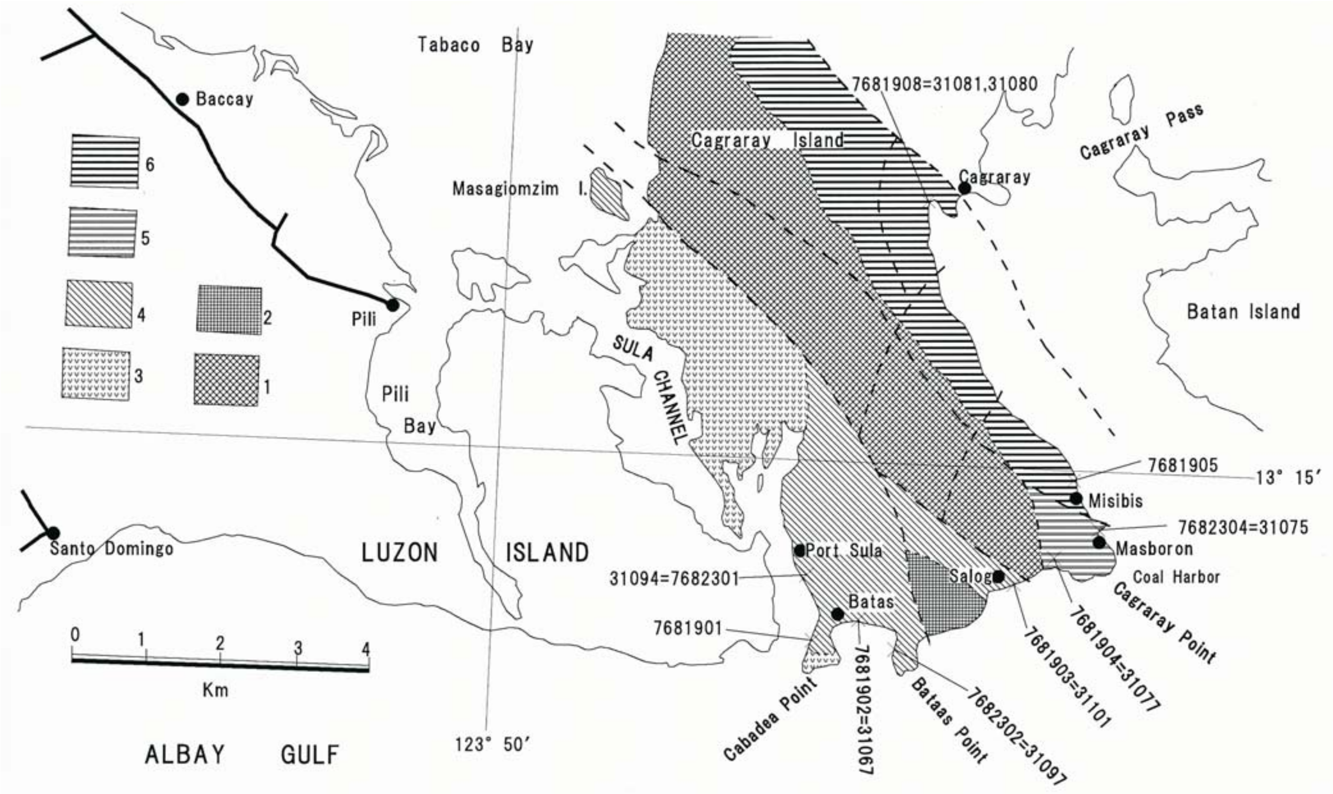
Upper Cretaceous, Maastrichtian ms1.

Lepidorbitoides bisambergensis (Jaeger 1914)
Plate 2, figures 1-4 upper

Orbitoides (Lepidorbitoides) socialis Leymerie var. *bisambergensis* JAEGER 1914, p. 160, pl. 4, figs. 3-3a.
Lepidorbitoides bisambergensis (Jaeger). – PAPP and KUPPER 1953, p. 77-79, pl. 1, figs.10-12; pl. 3, figs. 3-4. – PAPP 1954, p. 166, pl. 1, figs. 7-8. – PAPP 1956, p. 135, figs.2-3. – GORSEL 1975, p. 76-82, figs. 21-j, pl. 7, figs. A-b; pl. 8, figs. A-d; pl. 9, figs. A-c.– MATSUMARU 2016, p. 14, 16, fig. 5B, pl. 2, fig. 12.
Lepidorbitoides minor (Schlumberger). – HASHIMOTO, MATSUMARU and KURIHARA 1978, p. 68-69, pl. 7, figs. 1-3, 7, 10.



TEXT-FIGURE 10
Catanduanes Island (Area 12). Sample stations are in the Bonagbonag Limestone (inclined brick pattern), Upper Cretaceous, Maastrichtian ms2 to mid Paleocene, Tertiary a0; Sipi Limestone (blank), mid to upper Eocene, Tertiary a3 to b lower, and Payo Formation, upper Eocene, Tertiary b upper. (Hashimoto and Matsumaru 1981, fig. 2)



TEXT-FIGURE 11
Cagraray Island (Area 13). Sample stations are in the Sula Formation (diagonal pattern), upper Paleocene to lower Eocene, Tertiary a1 to a2, and Coal Harbor Formation (horizontal pattern), upper Oligocene to lowermost Miocene Tertiary e4 to e5 lower. The Lower Coal Harbor, unit 5, is the *Spiroclypeus*-bearing facies (Hashimoto et al. 1981).

Description: Test lenticular without pillars. Spherical to subspherical protoconch and slightly larger reniform deuteroconch are followed by two primary auxiliary chambers and two protoconchal and two deuteroconchal nepionic spirals around the embryonic chambers. Equatorial chambers with basal stolons and arcuate to ogival shape are in concentric rings. Lateral chambers are arranged in regular tiers on both sides of the equatorial layer. The wall is calcareous, lamellar and perforate.

Dimensions: Dameter of test = 1.30 to 1.60 mm, thickness = 0.50 to 0.80 mm, diameter/thickness ratio = 2.0 to 3.2. In three specimens, protoconch diameter = 80 × 75, 82 × 84 and 92 × 92 µm, deuteroconch diameter = 116 × 46, 103 × 70 and 100 × 60 µm, ratio of deuteroconch/protoconch diameters = 1.45, 1.26 and 1.74, distance across both protoconch and deuteroconch = 132, 154 and 152 µm, thickness of outer wall of embryonic chambers = 19, 15 and 17 µm; primary auxiliary chamber tangentisal × radial diameter = 58 × 28 and 48 × 24 µm, 52 × 28 and 48 × 28 µm and 54 × 22 and 48 × 24 µm. Lateral chambers = 9 to 11.

Remarks: Lepidorbitoides bisambergensis (Jaeger) is restricted here to Assemblage 1, but according to Neumann (1999, fig. 16) it ranges from the upper Campanian (*Globotruncanita calcarata* zone, KS 27) to early Maastrichtian (lower *Gansserina gansseri* Zone, KS 30) in the Mesogean (west Tethys) region.

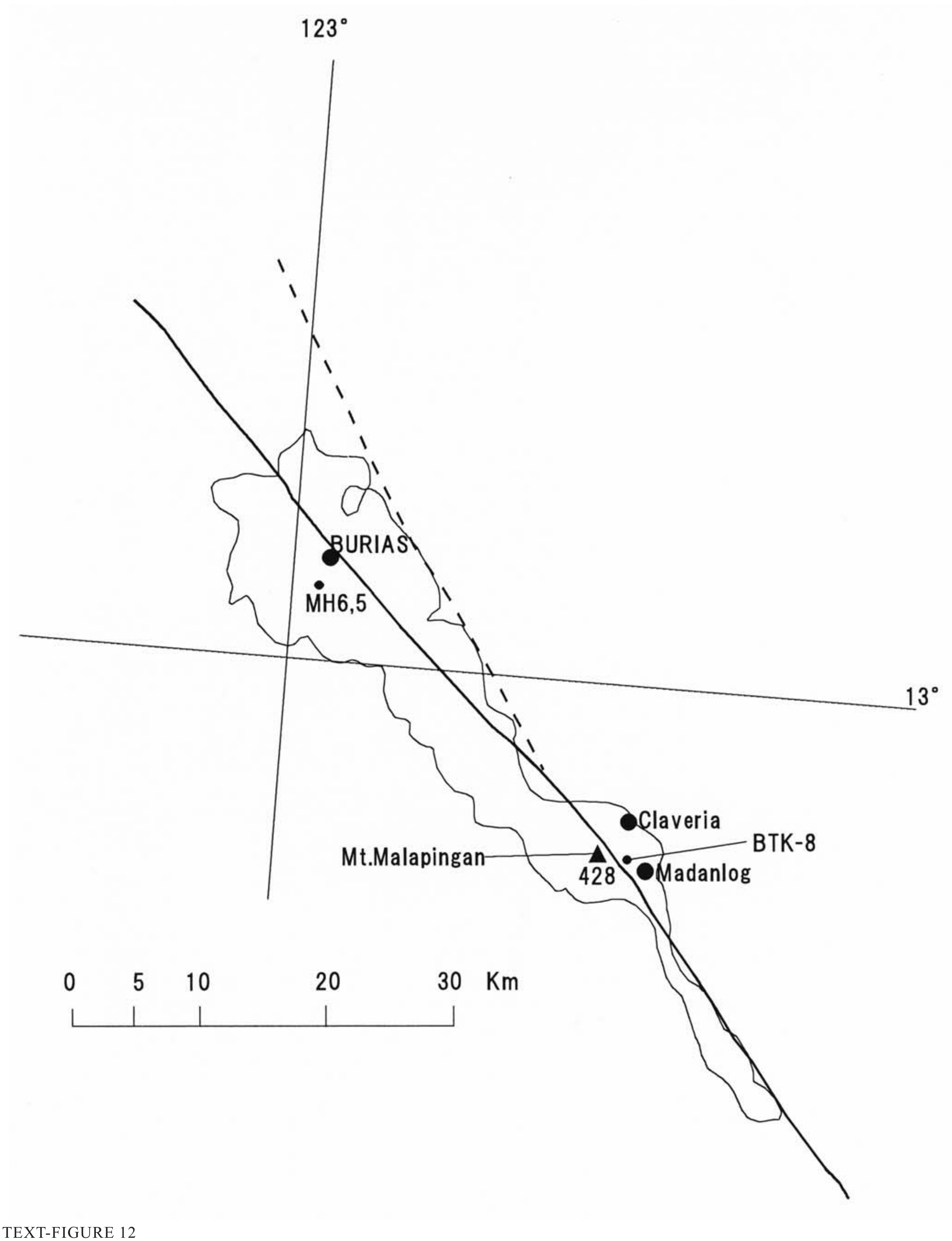
Upper Cretaceous, Maastrictian ms1.

Lepidorbitoides minor (Schlumberger 1901)
Plate 2, figures 5-6

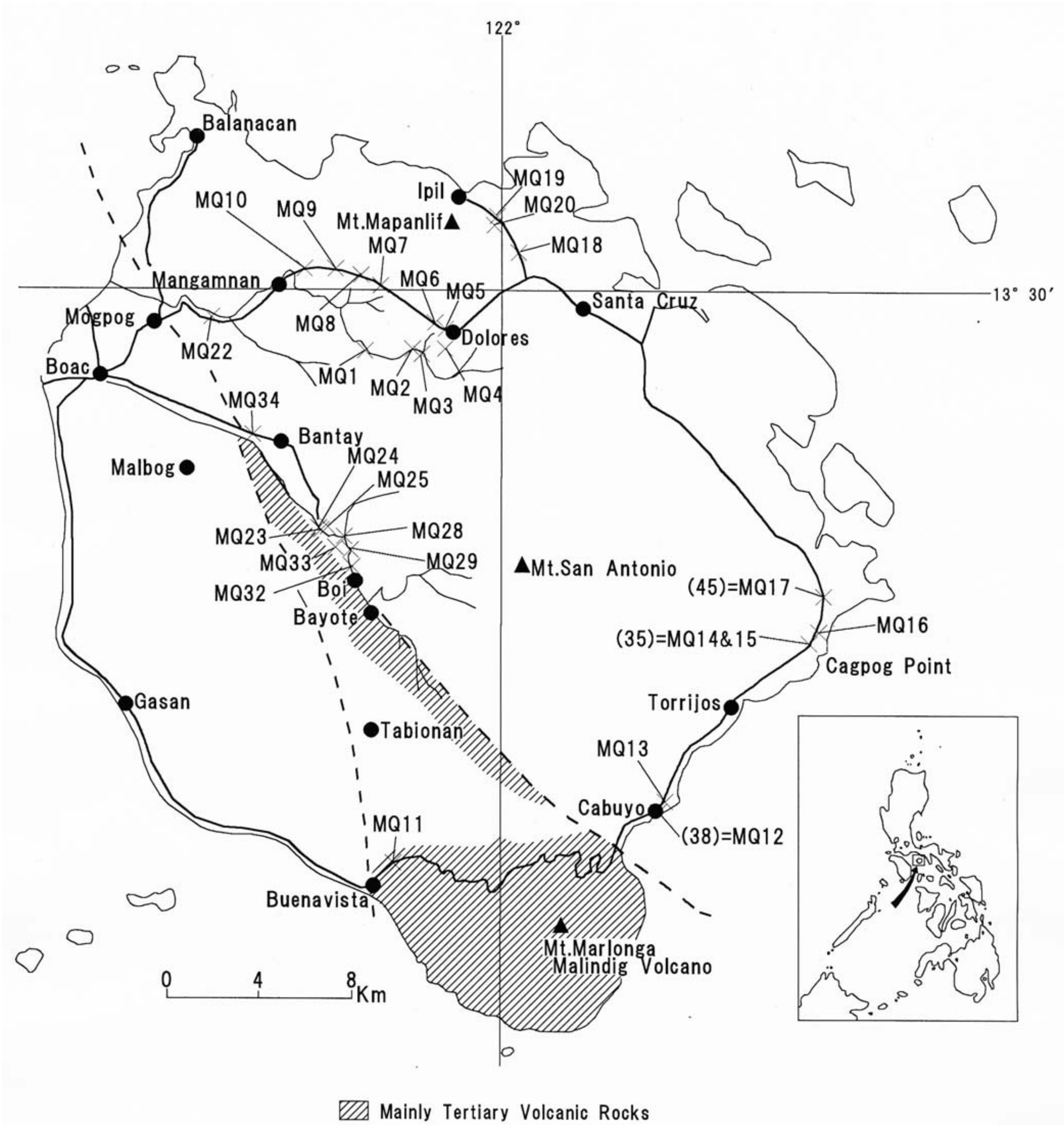
Orbitoides minor SCHLUMBERGER 1901, p. 466, pl. 8, figs. 2-3, 5; pl. 9, figs. 2-3.
Lepidorbitoides minor (Schlumberger). TAN SIN HOK 1939, p. 73-74, pl. 1, figs. 4-5. – PAPP 1954, p. 166-167, figs. 1-10. – NEUMANN 1958, p. 70-72, pl. 8, figs. 1-7, fig. 18. – HANZAWA 1962, p. 134, pl. 1, fig. 3. – VOIGT 1963, p. 498-500, pl. 37, figs. 1-2. – GORSEL 1975, p. 82, pl. 10, figs. a-b; pl. 11, figs. a-c; pl. 12, figs. a-c.– MATSUMARU 2016, p. 2, fig. 5A. pl. 3, fig. 1.

Description: Test lenticular without pillars. Subspheric protoconch and reniform deuteroconch are enclosed by 8 quadriserial nepionic spirals projected from two primary auxiliary chambers, and two adauxiliary chambers are developed on the deuterochoncal wall. The equatorial chambers vary from arcuate with basal and diagonal stolons to ogival and spatulate. The lateral chambers are arranged in regular tiers on both sides of the equatorial layer. The wall is calcareous, lamellar and perforated.

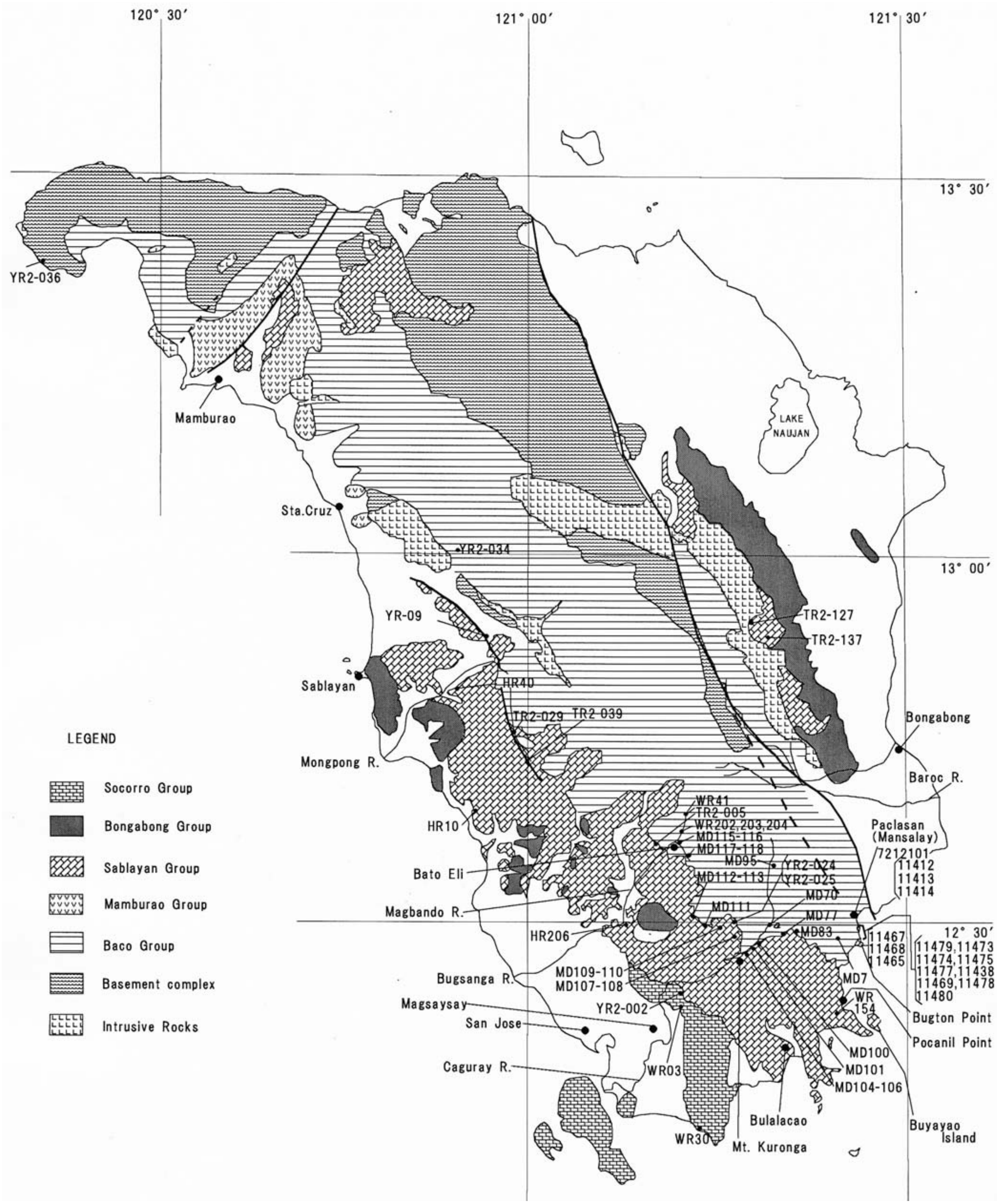
Dimensions: Diameter of test = 1.96 to 2.12 mm, thickness = 0.94 to 1.10 mm, diameter/thickness ratio = 1.88 to 2.13. Protoconch diameter = 112 × 104 µm, deuteroconch diameter = 136 × 76 µm, ratio of deuteroconch/protoconch diameters = 1.21. In three specimens, distance across both protoconch and



TEXT-FIGURE 12
Burias Island (Area 14) Sample stations MH5 and MH6 are in the San Pascual Formation, middle Miocene, Tertiary upper f1 (Hashimoto 1981).



TEXT-FIGURE 13
Marinduque Island (Area 15). Samples are from the Boac Limestone, Upper Cretaceous, Maastrichtisan ms2; Talantunan-Tumicob Formation, upper Paleocene to middle Eocene, Tertiary a1 to a3, and Torrijos Formation, upper Oligocene to lower Miocene, Tertiary e4 to f1 lower (Hashimoto and Sato 1989, fig. 28).



TEXT-FIGURE 14
Mindoro Island (Area 16). Samples are from Abra de Ilog Formation, upper Paleocene, Tertiary a1; Sabrayan Group Caguray Formation, middle Eocene to lower Miocene, Tertiary a3 to e5 lower; Buguton limestone, lower to middle Oligocene, Tertiary c to e1-2; Bandao limestone, lower Oligocene, Tertiary c-d; Tangon limestone, lower Miocene, Tertiary e5 lower; Paclasan limestone, upper Oligocene, Tertiary e4; and Socorro Group, middle Miocene, Tertiary f2 (Hashimoto et al. 1977, fig. 1; PR-Japan Project 1982, geological map).

deuteroconch = 184, 196 and 216 µm. Thickness of embryonic chamber wall = 25 to 26 µm. In two specimens the tangential to radial diameter in auxiliary chamber = 80 × 35 and 87 × 43 µm, in equatorial sections of equatorial chamber = 43 × 40 and 52 × 52 µm; in axial sections of axial chamber 36 × 80 to 45 × 80 µm; in lateral chamber = 112 × 14 and 113 × 22 µm. The thickness of roofs and floors = 18 to 22 µm, and diameter of pillars = 56 µm.

Remarks: The Philippines form is assigned to *Lepidorbitoides minor* (Schlumberger) according to the observation by Gorsel (1975) that there are usually two adauxiliary chambers and 8 nepionic spirals in specimens from the type locality. This species is found in a number of samples of Assemblage 1.

Upper Cretaceous, Maastrichtian ms1.

Genus *Sulcoperculina* Thalmann 1939

Sulcoperculina dickersoni (Palmer 1934)
Plate 4, figures 1-3

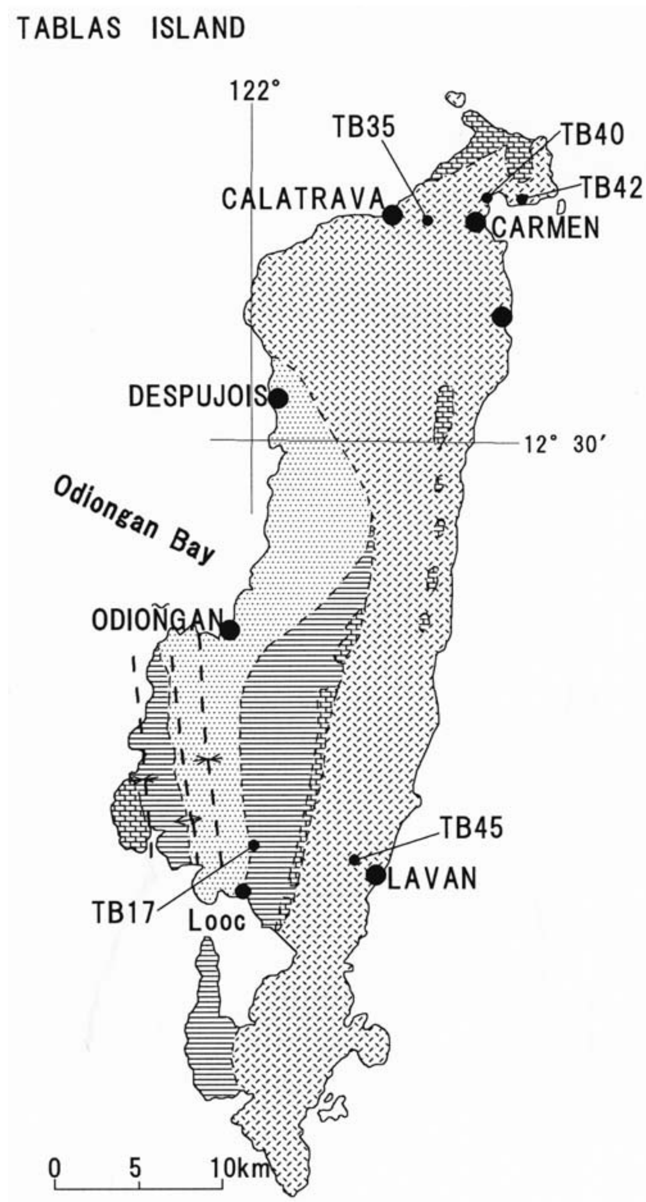
Camerina (?) *dickersoni* PALMER 1934, p. 243-245, pl. 14, figs. 1-2, 4, 6, 8; figs. 4-5.
Camerina vermunti THAIDENS 1937, p. 94-95, pl. 16, figs. 1, 11-12; figs. 2C, 3A, 3E.
Sulcoperculina dickersoni vermunti (Thaidens). – FROST 1974, p. 267-272, pl. 1, figs. 1-8; pl. 2, fig. 1; fig. 1A.
Sulcoperculina dickersoni (Palmer). – COLE and APPLIN 1970, p. 54-57, pl. 10, figs. 10-13. – MATSUMARU 2016, p. 3-4, 9-10, 15-16, 20, figs. 5A, 5B, 10A, 10B, pl. 4, figs. 5-7.

Description: Test lenticular, dorsally expanded, vcentral side convex with a central umbilical plug. Three trochoidal coils are present. Spherical to subspherical protoconch and reniform deuteroconch are followed by rhombic chambers divided by radial and curved septa. Intraseptal and spiral canals are present. The peripheral V-shaped margin is deeply grooved with a sulcus formed by short radial plates on the side slopes. The wall is calcareous and thickly lamellar.

Dimensions: Diameter of test = 0.86 to 0.94 mm, thickness = 0.45 to 0.52 mm, diameter/thickness ratio = 1.58 to 2.10. Protoconch diameter = 52 × 52 and 72 × 56 µm in two specimens. Deuteroconch diameter = 58 × 30 µm, protoconch wall thickness = 8 to 10 µm. First half whorl has 5 chambers, 85 to 178 µm wide; first whorl has 12 to 14 chambers, 290 to 456 µm wide; first 1 1/2 whorls, 21 chambers 437 to 628 µm wide; second whorl has 32 chambers 582 to 760 µm wide. Diameter of umbilical plug, 158 to 220 µm; length and thickness of radial plates = 52 to 130 and 8 to 10 µm, respectively.

Remarks: These specimens differ slightly from those of the Caribbean region in the swollen dorsal side and greater number of spiral chambers in first two whorls. Citing environmental effects, Cole and Applin (1970) considered that *Sulcoperculina dickersoni* should be recognized as the senior synonym of *?Camerina cubensis* Palmer 1934, *Camerina vermunti* Thiadens 1937, *Sulcoperculina cosdemi* Applin and Jordan 1945, *S. globosa* de Cizancourt 1949, *S. obesa* de Cizancourt 1949, *S. angulata* Brown and Brönnimann 1957, *S. diazi* Seigle and Ayala-Castañares 1963, and *S. minima* Seigle and Ayala–Castañares 1963.

Upper Cretaceous, Mastrichtian ms 1.

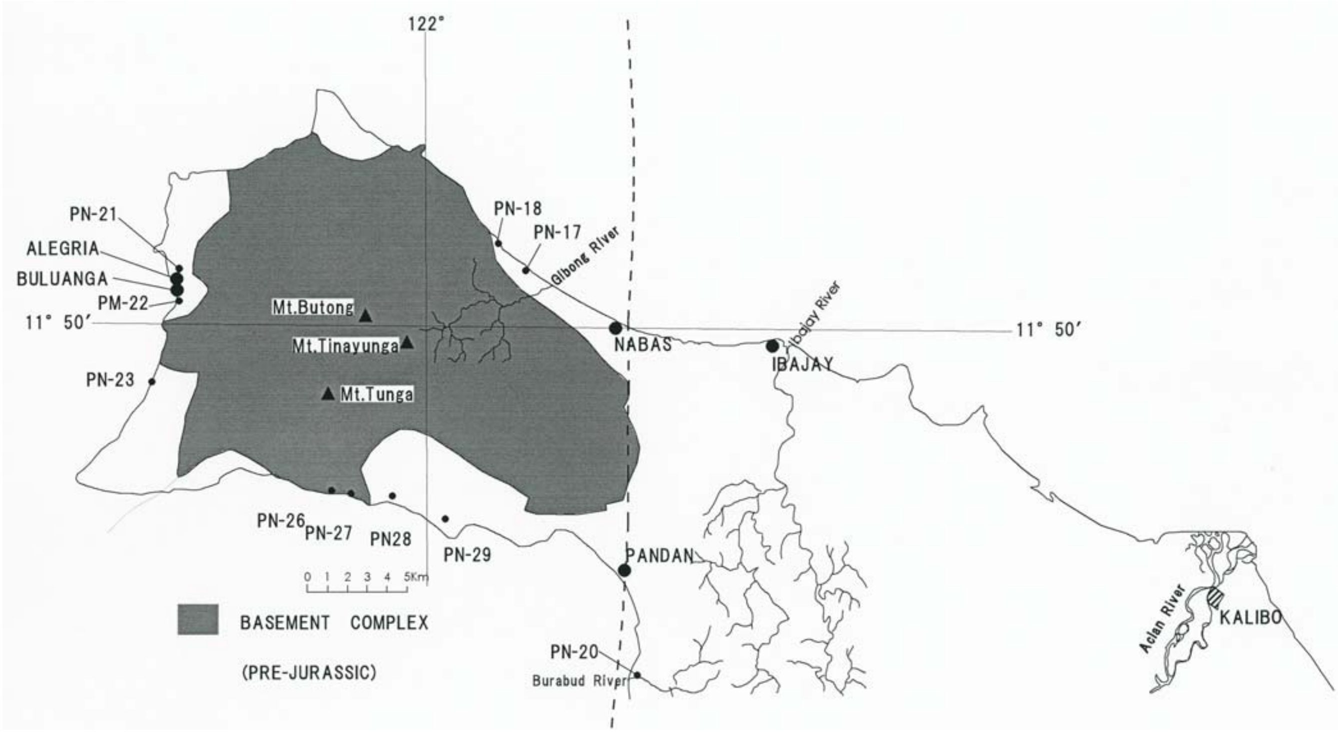


TEXT-FIGURE 15
Tablas Island (Area 17). Samples are mainly in Bagoliano Limestone, early to middle Miocene, Tertiary f1 to f2, and also in Colasi Limestone, Pleistocene, Tertiary h. (Corby et al. 1951, pl. 17).

Superfamily ROTALIIDEA Ehrenberg 1839
Family PSEUDORBITOIDIDAE Rutten 1935
Subfamily PSEUDORBITOIDINAE Rutten 1935
Genus *Pseudorbitoides* Douvillé 1922

Pseudorbitoides philippinensis Matsumaru, **n. sp**.
Plate 1, figure 10 upper; Pl. 2, figures 4 lower, 7-11, 12 center

Etymology: refers to Philippine origin.



TEXT-FIGURE 16
Panay Island (Area 18). Samples on the Buruanga Peninsula are from pyroclastic Fragante Formation at Burabud River mouth, lower Miocene, Tertiary e5, and terrace limestones of Sta. Cruz Formation, Pleistocene, Tertiary h (Hashimoto 1973, figure 1).

Type locality: Station CR63, Caramoan Peninsula, Luzon (text-fig. 9).

Holotype (fig. 7), Saitama Univ. Coll. no. 8881; paratypes (figs. 4 lower, 10) nos. 8882. 8883, resp.

Description: Test lenticular, some with umbonate central boss, with a surface covered by raised pillars. Spherical protoconch and reniform deuteroconch are followed by asymmetric quadriserial nepionic spirals. Accessory auxiliary chambers may not be developed. Equatorial chambers are arcuate to short spatulate, cyclically arranged and connected to other chambers by stolons. Equatorial chambers in the neanic stage are subdivided vertically by short radial plates. Lateral chambers on both sides of the equatorial layer are well developed and rest directly on the radial plates. The wall is calcareous, lamellar and perforate.

Dimensions: Diameter of test = 1.30 to 3.07 mm, thickness = 0.68 to 0.90 mm, diameter/thickness ratio = 1.40 to 4.50. Surface diameter of pillars = 90 to 180 µm; protoconch diameter = 136 × 136 µm, deuteroconch diameter = 180 × 102 µm, ratio of deuteroconch/protoconch diameters = 1.32; distance across both protoconch and deuteroconch = 157 to 227 µm; primary auxiliary chamber tangential × radial diameters = 80 × 56 to 90 × 68 µm; equatorial chamber tangential × radial diameters = 43 × 48 to 40 × 56 µm; lateral chamber tangential × radial diameters = 70 × 12 to 160 × 26 µm. Thickness of roofs and floors = 9 to 27 µm; number of lateral chambers = 8 to 10.

Remarks: The specimens from Pinugay Hill (table 2) were initially identified as *Pseudorbitoides* sp. (Hashimoto et al. 1978, p. 70). The new species differs from the similar *Pseudorbitoides rutteni* Brönnimann in its large test and numeroius equatorial chambers. It is also similar to *Pseudorbitoides trechmanni* Douvillé, but differs in having a thick test, stout pillars and lower height of lateral layers.

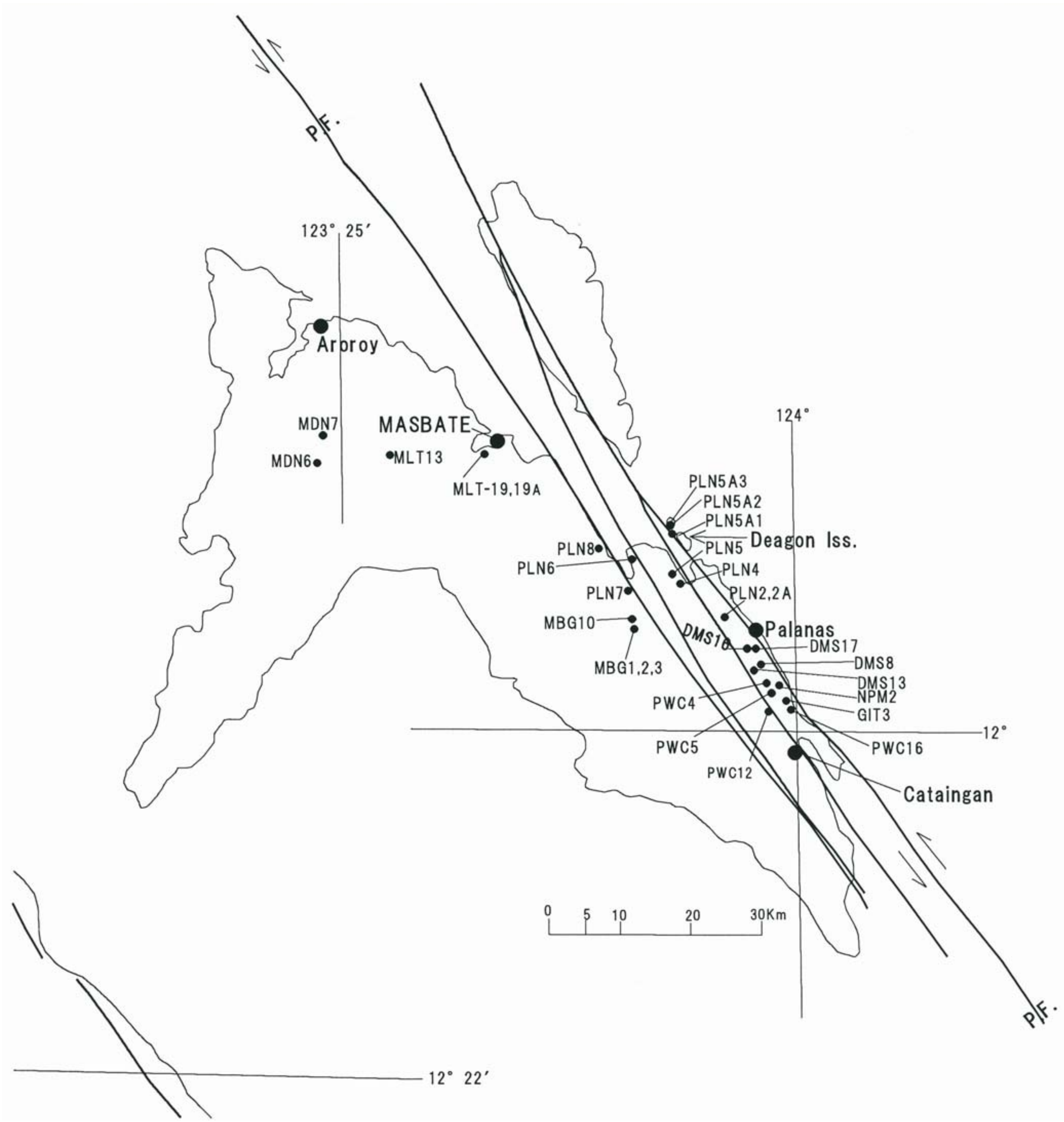
Upper Cretaceous (middle Maastrichtian). Letter Stage ms1.

Genus *Sulcorbitoides* Brönnimann 1954

Sulcorbitoides pardoi Brönnimann 1954
Plate 3, figures 7-8

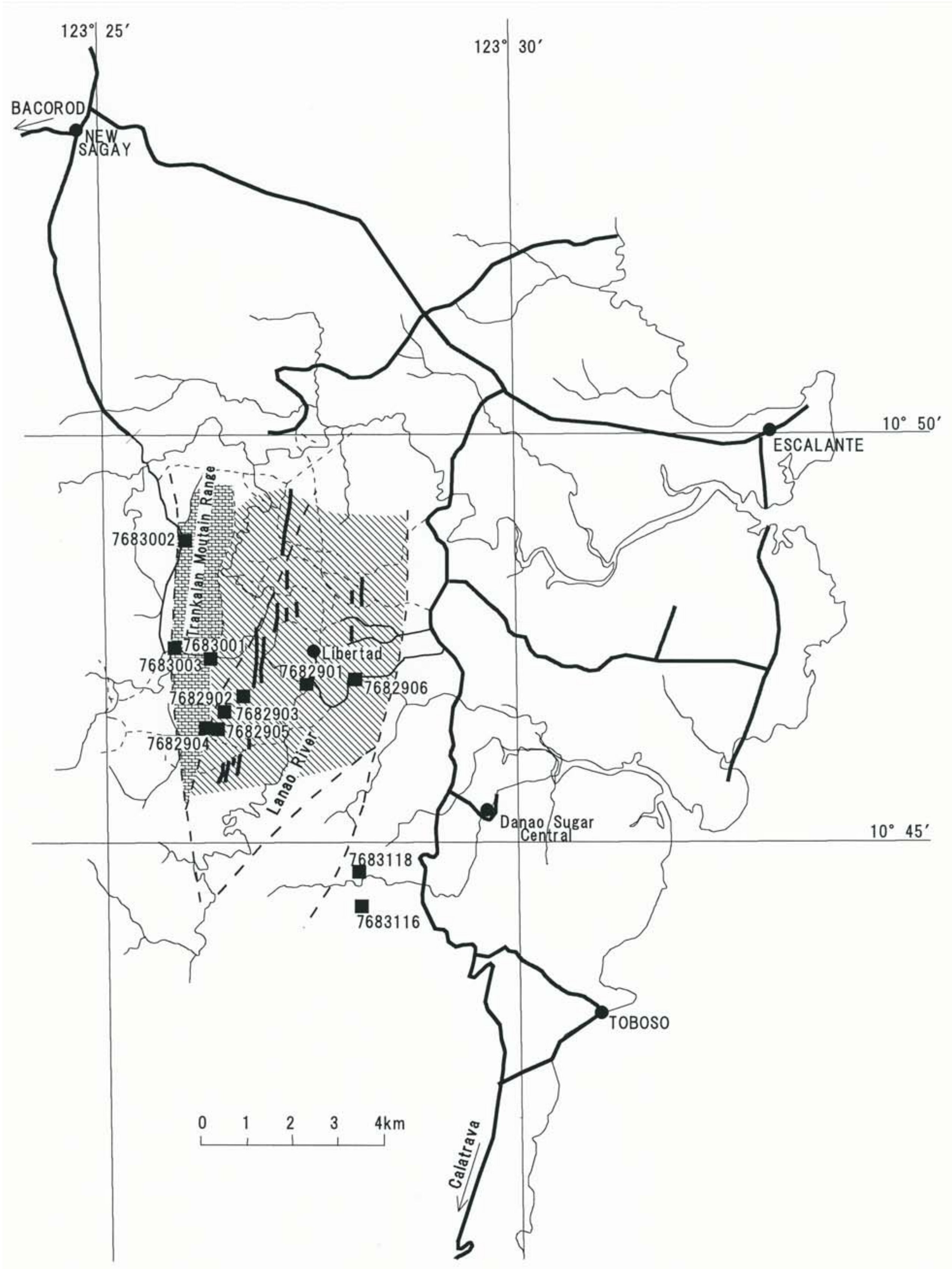
Sulcorbitoides pardoi BRÖNNIMANN 1954, p. 56-62, pl. 9, figs. 1-4; pl. 10, figs. 1-9; pl. 11, figs. 1-10; figs. 1-5. – COLE and APLIN 1970, p. 57-58, pl. 10, fig. 9; pl. 12, figs. 1-12; pl. 13, fig. 9; pl. 17, fig. 4. – FROST 1974, p, 272-276, pl. 2, fig. 2; pl. 3, figs. 1-8; pl. 4, figs. 1-5; pl. 5, figs. 1-4; fig. 2B.- MATSUMARU 2016, p. 10, 20, figs. 5A, 10A, 10B, pl. 4, figs. 8-11.

Description: Test lenticular, umbonate and biconvex, with raised pillars on the surface of test. Subspherical protoconch and reniform deuteroconch are followed by a single nepionic spiral in two and a half to three whorls. The spiral chambers are divided by radial and curved bilamellar septa, and increase in size except in the peripheral part of test. Peripheral chambers are characterized by a sulcus and are bounded by rows of alternating wedge-shaped vertical radial plates. The lateral chambers are arranged in regular tiers resting directly on the radial plates and interconnected by basal stolons and fine pores. The wall is calcareous, lamellar and perforate.

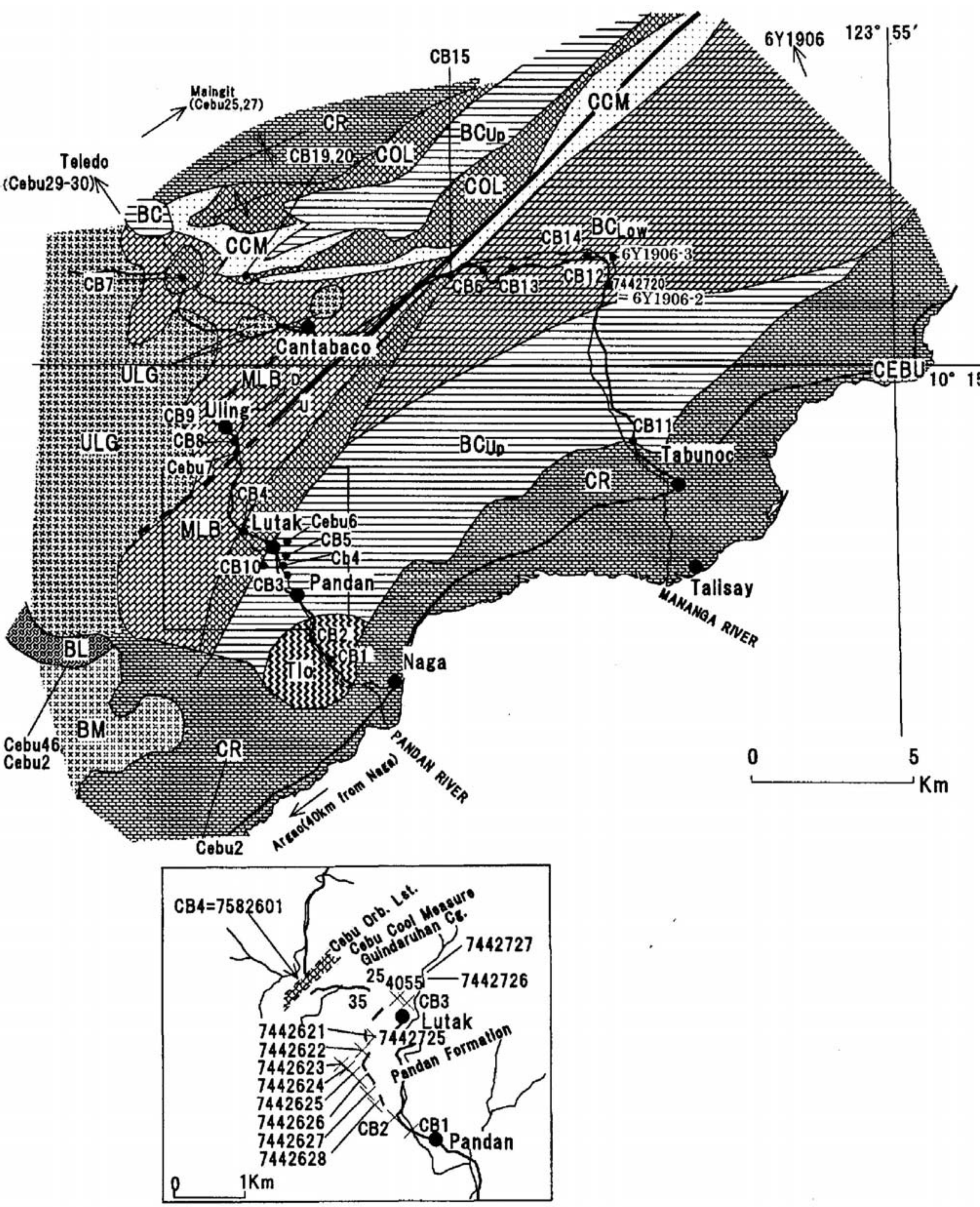


TEXT-FIGURE 17
Masbate Island (Area 19). Samples are from the Masbate Formation, lower Miocene, Tertiary e5; Mountain Maid Limestone, middle to upper Miocene, Tertiary f1 upper to f3; and Masbate Limestone, Pliocene, Tertiary g. (Corby et al. 1951).

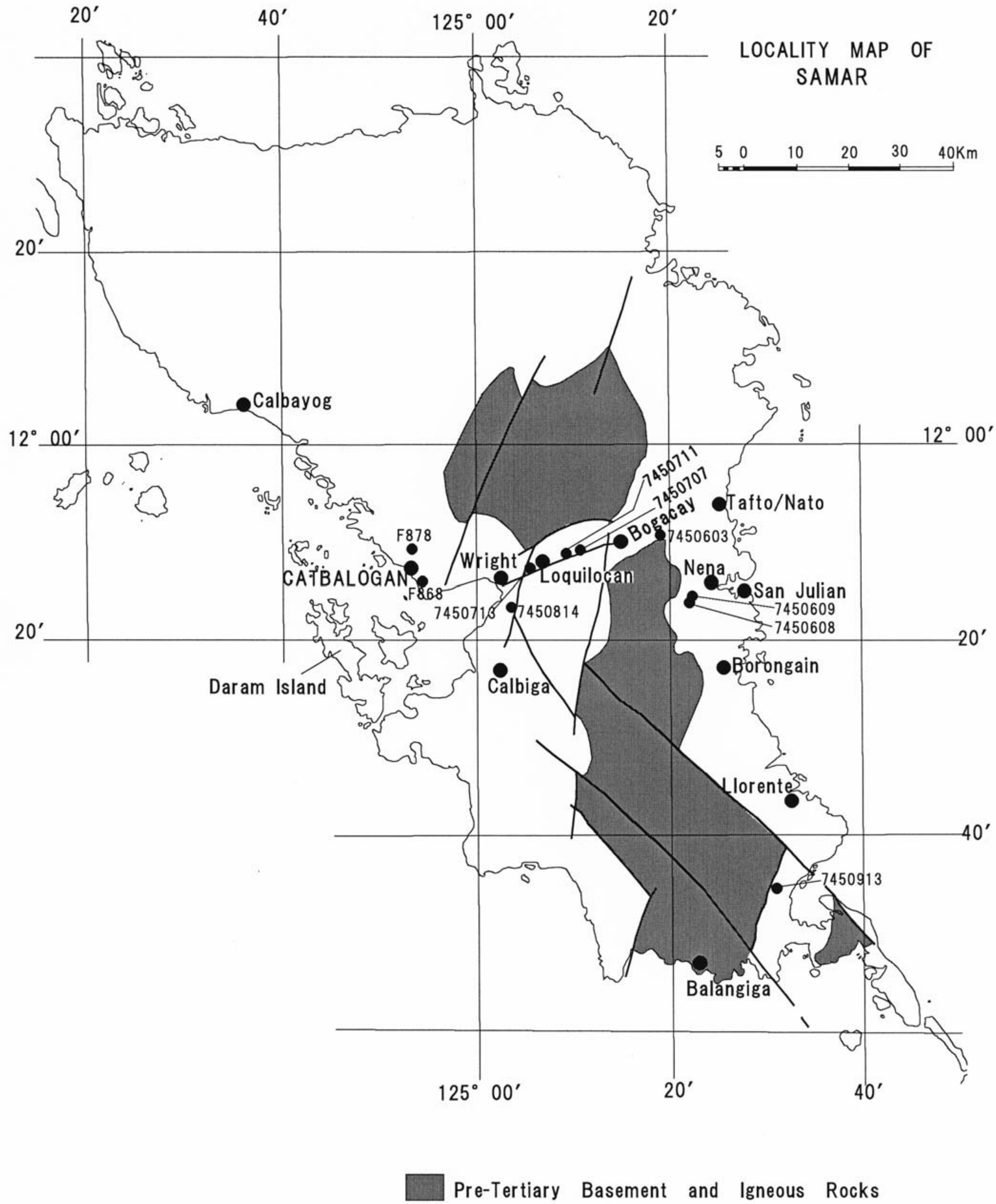
Dimensions: Diameter of test = 0.77 to 1.16 mm, thickness = 0.52 to 0.60 mm, diameter/thickness ratio = 1.48 to 1.93. Surface diameter of pillars = 64 to 96 µm; protoconch diameter = 48 × 28 µm, deuteroconch diameter = 68 × 42 µm, ratio of deuteroconch/protoconch diameters = 1.4. Distance across both protoconch and deuteroconch = 92 ìm; wall thickness of embryonic chambers = 20 ìm; primary auxiliary chamber tangential × radial diameter = 40 × 30 ìm; diameter ofsulcoperculinoid spiral stage = 650 to 750 µm; spiral chamber tangential × radial diameter = 38 × 48 µm; lateral chamber radial diameter × height = 50 × 10 to 90 × 30 µm. Thickness of roofs and floors = 8 to 20 µm; number of lateral chambers = 7 or 8; length and thickness of radial plates = 14 and 9 µm, respectively.



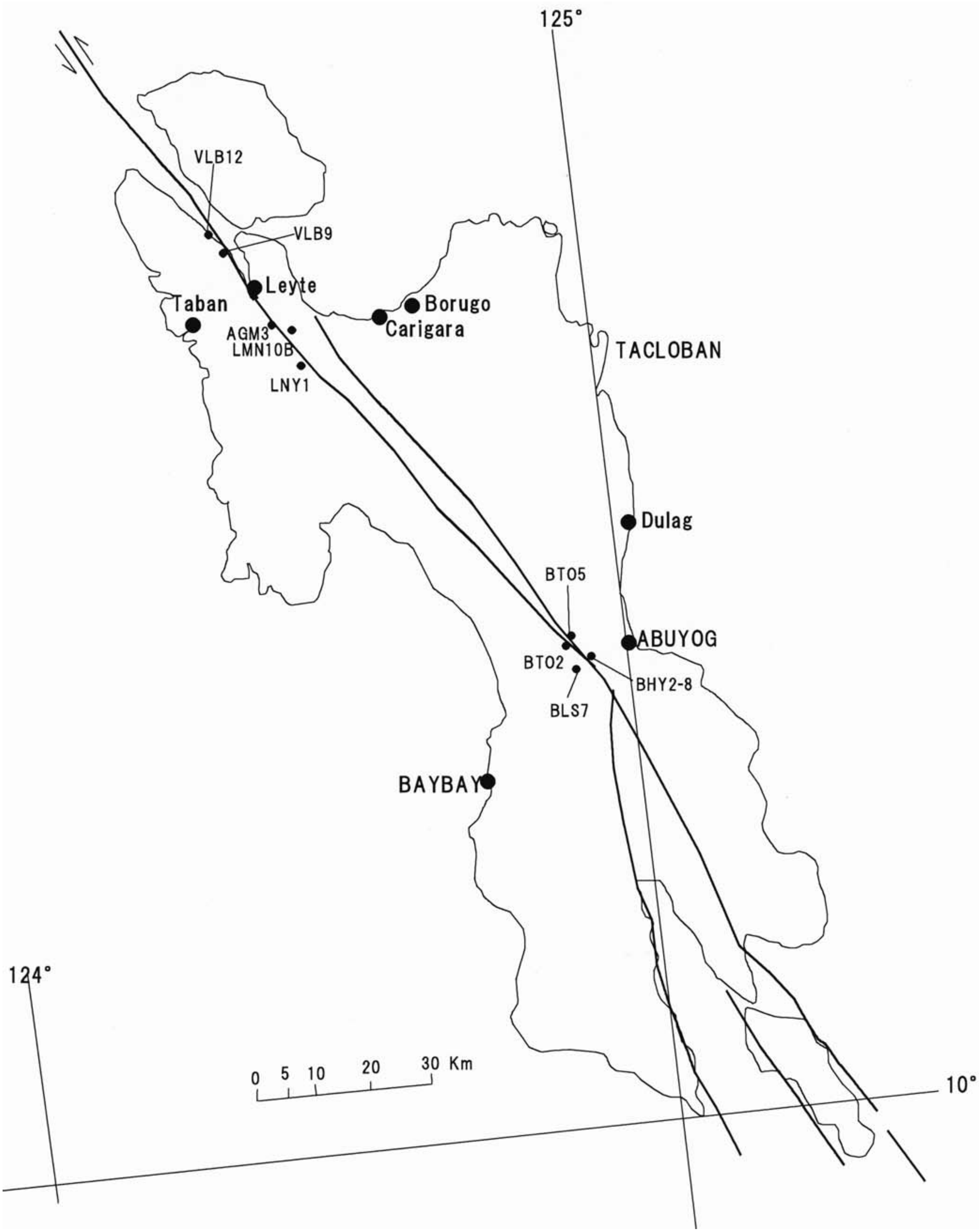
TEXT-FIGURE 18
Negros Island (Area 20). Samples are from the Trankalan Limestone, upper Oligocene to lower Miocene, Tertiary e3 to e5 lower, and Escalante Formation, upper Oligocene, Tertiary e3 to e4 (Hashimoto et al. 1982, figure 1).



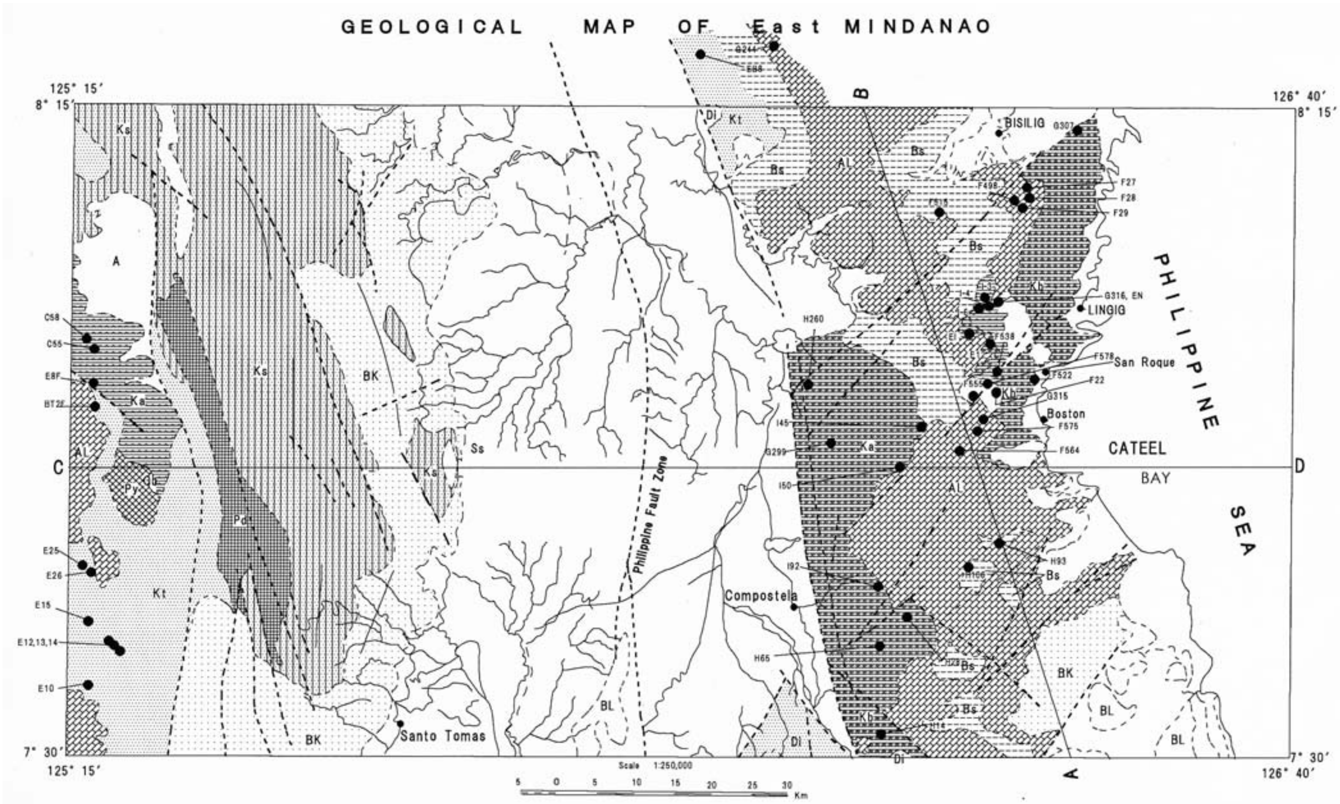
TEXT-FIGURE 19
Cebu Island (Area 21). Sampled exposures are Pandan Formation (BCup), Upper Cretaceous, Maastrichtian ms2; Lutac Hill limestone overlying Pandan Formation, lower Oligocene, Tertiary c and d; Calagasan Formation (station 21760 at Argao, off map), middle Oligocene, Tertiary e1-2; Cebu Orbitoid Limestone (COL), upper Oligocene, Tertiary e3; Malbog Formation (MLB), lower Miocene, Tertiary e5 lower; Mt. Uhlig Limestone (ULG), lower Miocene, Tertiary f1 lower; Toledo Formation (Tlo), upper middle Miocene, Tertiary f2; Maingit Formation, upper Miocene. Tertiary f3; Barili Formation (BL) and Carcar Formation (CR), Pliocene, Tertiary g. (Hashimoto et al. 1978, figs. 1-2).



TEXT-FIGURE 20
Samar Island (Area 22). Of four re-examined samples, Station 7450707 yields a fauna of early-middle Oligocene age, Tertiary d, while 7450608, 7450609, and 7460713 are from the Daram Formation, late Oligocene to early Miocene, Tertiary e4 to e5 lower. (Hashimoto and Matsumaru 1978).



TEXT-FIGURE 21
Leyte Island (Area 23). Samples are from the Leyte Group limestones, Plio-Pleistocene, Tertiary g to h. (PBMG 1981).



TEXT-FIGURE 22
East Mindanao (Area 24). Sampled exposures are limestones (stations G316, I-4, EN, F538, I-3, I-6, E12) of the Barcelona group (Ka), middle and upper Paleocene, Tertiary a0 to a1; limestone (station F578) of Koban group (Kb), middle Eocene, Tertiary a3; limestones (stations H14, H106, F27-29) of Mangangoy Formation, middle Oligocene, Tertiary d and e3; limestones (stations H260, G315, F498, F512) of Bislig Formation (Bs), upper Oligocene, Tertiary e4; limestone (Station H93) of Agtuucanon Formation (AL), lower Miocene, Tertiary f1 lower, and limestones (stations E10, E25-26, C58, BTF2F) of Kalagutay Group (Kt), lower Miocene, Tertiary e5 to f1 lower. (Matsumaru 1974, fig. 2).

Remarks: The type of *Sulcorbitoides pardoi* Brönnimann 1954 is from the Upper Cretaceous of Camaguey, Cuba. It is found here with the fauna of Assemblage 1.

Upper Cretaceous, Maastrichtian ms 1.

Subfamily PSEUDORBITELLINAE Hanzawa 1962
Genus *Asterorbis* Vaughan and Cole 1932

Asterorbis rooki Vaughan and Cole 1932
Plate 3, figures 1-2

Asterorbis rooki VAUGHAN and COLE 1932, p. 611-613, pl. 1, figs. 1-6. – HANZAWA 1963, p. 29-32, pl. 1, figs. 1-8; pl. 2, figs. 1-7, figs 3-6.

Description: Test lenticular and stellate with biloculate protoconch and deuteroconch, slightly obscured in the present specimens by recrystalization. The equatorial chambers in the interray and ray areas are short arcuate to ogival, increasing in height toward the periphery. The lateral chambers on both sides of equatorial layer are arranged in regular tiers. The wall is calcareous, lamellar and perforate.

Dimensions: Diameter of test = 1.10 to 2.00 mm, thickness = 0.80 mm, diameter/thickness ratio = 2.50. Tangential and radial diameter of equatorial chambers in interray = 52 × 52 to 78 × 43 µm; lateral chambers radial diameter × height = 60 × 12 to 87 × 12 µm. Thickness of roofs and floors = 4 to 12 µm.

Remarks: Asterorbis rooki is characterized by its stellate test, with equatorial chambers in the interray and ray portions connected by stolons to the other chambers.

Late Cretaceous, Maastrichtian ms 1.

Subfamily VAUGHANININAE MacGillavry 1963
Genus *Vaughanina* Palmer 1934

Vaughanina cubensis Brönnimann 1954
Plate 3, figures 3, 4 lower, 5 right, 6

Vaughanina cubensis BRÖNNIMANN 1954, p. 91-103, pl. 16, figs. 1-11; pl. 17, figs. 1-6; pl. 18, figs. 4-10, figs. 1-9.

Description: Test thick and lenticular with a central umbo and short marginal flange. Low trochospiral coil in the early stage with an equatorial layer of annular chambers. Vertical radial plates project from roofs and floors of the equatorial layer, which is covered on both sides by lateral chambers. The equatorial chambers are connected to lateral chambers by radial stolons and fine pores. Large pillars are present.

Dimensions: Diameter of test = 1.10 to 2.10 mm, diameter of central umbo = 0.60 to 1.00 mm, thickness = 0.70 to 0.90 mm, diameter/thickness ratio = 1.87 to 2.30. Diameter of sulcoperculinoid spiral stage = 480 to 570 µm; spiral chamber tangential × radial diameter = 45 × 45 to 60 × 40 µm; radial diameter of annular chamber = 43 to 52 µm, lateral chambers radial diameter × height = 50 × 8 to 120 × 17 µm. Thickness of annular chamber wall = 8 to 10 µm; thickness of roofs and floors of lateral chambers = 8 to 15 µm; number of lateral chambers = 10 to 11.

Remarks: Vaughanina cubensis is characterized by a large swollen test, a large spiral stage and vertical plates. Due to lack of specimens, no data on embryonic and periembryonic chambers is known in the Philippine material.

Upper Cretaceous, Maastrichtian ms 1.

Family ROTALIIDAE Ehrenberg 1839
Subfamily CUVILLIERININAE Loeblich and Tappan 1964
Genus *Daviesina* Smout 1954

Daviesina danieli Smout 1954
Plate 8, figures 1-6

Daviesina danieli SMOUT 1954, p. 69-70, pl. 7, figs. 15-17. – CAUS, HOTTINGER and TAMBAREAU 1980, p. 1056, 1058, pl. 2, figs. 5-7, figs. 6 A-C. – MATSUMARU 2016, p.10, 12-13, 20, 28, figs. 5A, 5B, 10A, 10B, pl. 10, figs. 8-10.

Description: Test small, dorsal surface flat to concavo-convex with small pustules, ventral surface convex to subconical with incised pillars, asymmetrical with an acute margin. The spire is low trochospiral. The spherical proloculus is followed by simple and undivided rhombic chambers. Septa are straight, radial and secondarily doubled, with intraseptal vertical canals. There is no marginal cord, but umbilical pillars and fissures are present. The wall is calcareous, lamellar and perforated, except for the imperforate periphery.

Dimensions: Diameter of test = 0.44 to 0.80 mm, thickness = 0.25 to 0.70 mm, diameter/thickness ratio = 2.00 to 2.16. Proloculus diameter = 28 × 28 µm. First whorl has 9 chambers, 0.22 mm in diameter; second whorl has 12 chsambers, 0.46 mm in diameter.

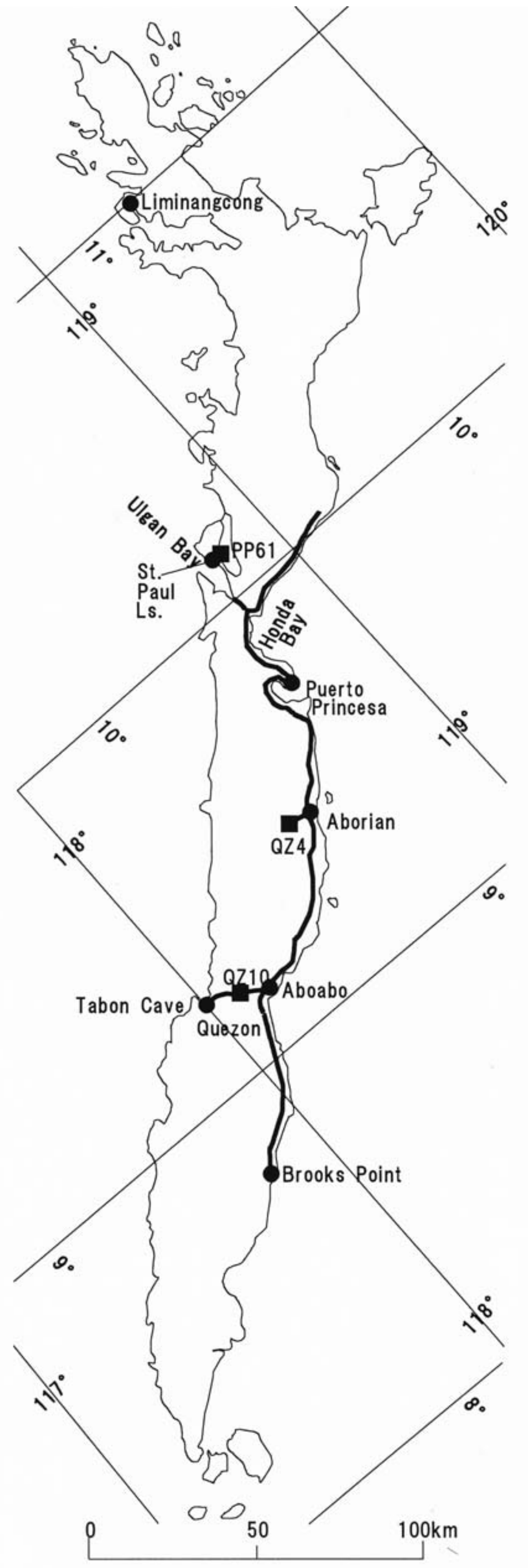
Remarks: Daviesina danieli is typified in the Paleocene (Thanetian) beds of Qatar. The Philippine specimens are found in Assemblage 3 fauna, and also probably reworked in Assemblage 4.

Upper Paleocene (Thanetian), Tertiary a1.

Daviesina khatiyahi Smout 1954
Plate 8, figures 7-10

Daviesina khatiyahi SMOUT 1954, p. 67-68, pl. 12, figs. 1-11; pl. 14, fig. 7. – MATSUMARU and SARMA 2010, p. 544, fig. 3, pl. 3, figs. 3-4.

Description: Test small, lenticular and complanate in outline, concavo-convex. The surface is ornamented with coarse pustules some 70 µm in diameter in the apical portion, with smaller granules 20 to 30 µm in diameter on the spiral suture of the concave side and on the septal sutures of the convex side. The spire is low trochospiral and evolute. The proloculus is subspherical, followed by simple, undivided and rather rhombic chambers.



TEXT-FIGURE 23
Palawan Island (Area 25). Sampled exposures are brown limestone of Aborian, mid Oligocene, Tertiary d; St Paul's Limestone, lower to middle Miocene, Tertiary e5 upper to f1 upper; and Alfonso XIII Formation, Pliocene, Tertiary g (Hashimoto and Matsumaru 1982, fig. 1).

The septa are gently and evenly curved. There is no marginal cord, but umbilical pillars and fissures and ventral canals are present on both sides of test. The wall is calcareous and lamellar.

Dimensions: Diameter of test = 0.40 to 0.51 mm, thickness = 0.30 to 0.38 mm, diameter/thickness ratio = 1.33 to 1.34; Proloculus diameter = 36 × 28 µm; diameter and number of chambers in first half whorl = 0.086 mm and 5, first whorl = 0.214 mm and 10, 1½ whorl = 0.35 mm and 15, and 2nd whorl = 0.44 mm and 22.

Remarks: Daviesina khatiyahi is defined in the middle Paleocene of Qatar, and its single occurrence here in lower Eocene Assemblage 4 is probably reworked. *Daviesina khatiyahi* seems to be the ancestor of *Miscellanea* Pfender 1935, due to its canals and the absence of a marginal cord.

Reworked (?) in lower Eocene (Ypresian), Tertiary Letter Stage a2.

Daviesina langhami Smout 1954
Plate 8, figures 11-13

Daviesina langhami SMOUT 1954, p. /68-69, pl. 11, figs. 1-11.– MATSUMARU 2016, p. 10, 28, figs. 5A, 10B, pl. 10, fig. 11.

Description: Test small, complanate and discoidal with round periphery. It is highly compressed with a slight umbilical depression, completely covered in small granules. The spire consists of low trochoidal to planispiral coiled whorls, with rapid evolution in the second whorl. The spherical proloculus is followed by simple, undividided rhombic chambers, with secondarily doubled septa. There is no marginal cord, but umbilical pillars, fissures and vertical canals are present. The wall is calcareous and lamellar.

Dimensions: Diameter of test = 0.56 to 0.66 mm, thickness = 0.26 to 0.32 mm, diameter/thickness ratio = 2.10 to 2.40. Proloculus diameter = 50 × 40 µm; 9 chambers in first whorl have a diameter = 0.38 mm, 22 chambers in second whorl = 0.85 mm. Chamber length = 0.19 to 0.26 mm, height = 0.14 mm, ratio of length/height = 1.36 to 1.86. Pillar diameter = 22 to 40 µm.

Remarks: The peculiar test and rapidly evolute second coil identify *Daviesina langhami* in several samples with fauna of Assemblage 3.

Upper Paleocene (Thanetian), Tertiary a1.

Subfamily ROTALIINAE Ehrenberg 1839
Genus *Kathina* Smout 1954

Kathina selveri Smout 1954
Plate 6, figures 12-15

Kathina selveri SMOUT 1954, p. 62-63, pl. 6, figs. 11-13.– MATSUMARU and SARMA 2010, p. 541, fig. 3, pl. 6, fig. 5. – MATSUMARU 2016, p. 10, 18, 20, 22, figs. 5A. 5B, 10A, 10B, pl. 10, figs. 5-6.

Description: Test thick, lenticular and unequally biconvex, with smooth dorsal surface and grooves on periphery, with fissures or pores surrounding a solid central plug. Low trochospiral, tightly coiled spire becomes evolute in the last whorl. The chambers are simple and are about twice as long and wide as the height. The septa are double with intraseptal and vertical canals. The wall is calcareous, radially fibrous and lamellar.

Dimensions: Diameter of test = 0.55 to 1.27 mm, thickness = 0.31 to 0.73 mm, diameter/thickness ratio = 1.40 to 1.90. Proloculus diameter = 54 × 43, 90 × 77, 100 × 100, and 110 × 90 µm in four specimens. In megalospheric forms, the first whorl has 10 chambers with diameter of 0.26 to0.45 mm, second whorl has 24 to 25 chambers of 0.45 to 0.88 mm, and third whorl has 44 chambers of 0.72 to 1.27 mm. In microspheric form, diameter of first whorl = 0.08 to 0.10 mm, second whorl = 0.22 to 0.23 mm, and third whorl = 0.39 mm. Diameter of umbilical plugs = 78 to 110 µm with a maximum of 333 µm.

Remarks: Differs from *Kathina major* Smout in its stout umbilical plug. Found mainly with fauna of Assemblage 3, but also occurs in Assemblage 2.

Middle and Late Paleocene (Selandian-Thanetian), Tertiary upper a0 to a1

Genus *Lockhartia* Davies 1932

Lockhartia conditi (Nuttall 1926)
Plate 8, figures 14-16

Dictyoconoides conditi NUTTALL 1926, p. 119, pl. 11, figs. 7-8. – DAVIES 1927, p. 279, pl. 21, figs. 10-12; pl. 22, fig. 5.
Lockhartia conditi (Nuttall) — DAVIES 1932, p. 408, pl. 2, fig. 7; pl. 4, fig. 7. – DAVIES 1937, p. 47-48, pl. 5, fig. 24. – SMOUT 1954, p. 55-56, pl. 5, figs. 16-19. – MATSUMARU and SARMA 2010, p. 541, fig. 3, pl. 3, fig. 7. – MATSUMARU 2016, p. 12, fig. 5B, pl. 13, fig. 4.

Description: Test conical, convex on ventral side. Surface smooth dorsally, ornamented ventrally with indented marginal sutures and horizontal plates between large pustules. The spire is trochospiral coiling and evolute. The chambers are rather rhombic, with double septa and intraseptal canals. The broad umbilicus is filled with many pillars at the umbilical ends of chambers. Umbilical cavities are large and regular with umbilical plates.The wall is calcareous, fibrous, lamellar and coarsely perforate.

Dimensions: Diameter of test = 0.54 to 1.23 mm, thickness = 0.30 to 0.80 mm, diameter/thickness ratio = 1.54 to 1.80. Megalospheric proloculus diamter = 110 × 110 µm; diameter of first whorl = 0.43 mm, second whorl = 0.84 mm, third whorl = 1.20 mm; microspheric first whorl diameter = 0.17 to 0.18 mm, second whorl = 0.32 to 0.35 mm, third whorl = 0.51 to 0.82 mm. Diameter of umbilical pillars = 70 to130 µm.

Remarks: Distinguished by its high conical test, remarkably large umbilical pillars and umbilical plates. Occurs in Assemblage 3 and reworked in Assemblage 4.

Late Paleocene (Thanetian), Tertiary a1.

Lockhartia haimei (Davies 1927)
Plate 8, figures 17 right, 18-19, 20 center

Dictyoconoides haimei DAVIES 1927, p. 280, pl. 21, figs. 13-15; pl. 22, fig. 6.
Lockhartia haimei (Davies) — DAVIES 1932, p. 407, pl. 2, figs. 4-6. – SMOUT 1954, p. 49-50, pl. 2, figs. 1-14.- MATSUMARU and SARMA 2010, p. 540, fig. 3, pl. 3, fig. 6. –MATSUMARU 2016, p. 12, fig. 5B, pl. 13, fig. 5.

Description: Test conical, convex on the umbilical side. Simple chambers in trochospheric spiral increase in height with limbate sutures. The septa are double with intraseptal canals. The umbilical cavities communicate with chamber cavities. Wall calcareous, radially fibrous and coarsely perforate.

Dimensions: Diameter of test = 0.95 to 1.57 mm; thickness = 0.60 to 1.20 mm; diameter/thickness ratio = 1.31 to 1.58. In microspheric form, diameter of first whorl = 0.25 mm 1½ whorl = 0.42 mm, 2nd whorl = 0.59 mm, 2½ whorl = 0.75 mm, 3rd whorl = 1.14 mm, 4th whorl = 1.57 mm. Probably 20 chambers in the last whorl.

Remarks: This species in Assemblage 3 is also known from Qatar (Smout 1954), Oman (coll. Tsukei Sugawara) and Meghalaya (Matsumaru and Jauhri 2003).

Upper Paleocene (Thanetian), Tertiary a1.

Genus *Rotalia* Lamarck 1804

Rotalia trochidiformis (Lamarck 1804)
Plate 6, figures 9-11

Rotalites trochidiformis LAMARCK 1804, p. 183-185.
Rotalia trochidiformis (Lamarck). – DAVIES 1932, p. 416-418, pl. 2, figs. 8, 10-15; pl. 3, figs. 1, 3-13; pl. 4, figs. 3-6, 9-11. – SMOUT 1954, p. 43-45, pl. 1, figs. 1-6. – MILLER-MERZ 1980, p. 18-28, pl. 2, figs. 1-2, 4; pl. 9, figs. 2-4; pl. 15, fig. 3; figs. 16-17. – MATSUMARU and SARMA 2010, p. 541, fig. 3, pl. 3, fig. 5. – MATSUMARU 2016, p. 4-5, 8, 10,19, figs. 5A, 5B, 10A, 10B, pl. 10, fig. 12.

Description: Test hemispherical, flat or slightly convex on the umbilical side and with a fairly sharp peripheral rim in the dorsal side. The spire is trochospiral, with all chambers of final whorl visible on the umbilical side. The imperforate lip and astral lobe are separated from the perforate ventral wall of the main chamber lumen. Secondary deposits form thick pillars. The septal flap is attached to the peripheral margin of septum, and the intercameral foramen is slit at the base of the septum. The umbilical flap extends from the previous septum to the apertural face, and umbilical fissures cut deeply into the shell material. The spiral canals are encircled in a central umbilical mass of pillars or plugs. The wall is calcareous and distinctly perforate except in the peripheral margin, lips, and plugs, and the granules on the center of the umbilical side.

Dimensions: diameter of test = 0.42 to 0.54 mm, thickness = 0.30 to 0.35 mm, diameter/thickness ratio = 1.40 to 1.54. Proloculus diameter = 38 × 38 µm. First whorls has 7 chambers 0.39 mm in diameter, first whorl and a half has 10 chamberst of 0.55 mm. Diameter of central plugs = 60 to 87 µm.

Remarks: Specimens from the Philippines in Assemblage 2 and 3 are smaller than *R. trochidiformis* from the lower Eocene of Qatar (Smout 1954) and British Museum specimens (Davies 1932).

Middle Paleocene (Selandian) to late Paleocene (Thanetian), Tertiary a0 to a1.

Family CALCARINIDAE Schwager 1876

Paleobaculogypsinoides Matsumaru, **n. gen**.
Type species: *Paleobaculogypsinoides catanduanensis* Matsumaru, n. sp.

Etymology: refers to the earliest examples of baculogypsinoid foraminifera from the Late Cretaceous (Maastrichtian).

Diagnosis: Baculogypsinoid genus characterized by tetrahedral test, early trochoidal chambers succeeded by three or four layers of lateral chambers, ornamented by slender radial spines and pillars. Monospecific.

Comparison: This genus resembles the late Neogene *Baculogypsinoides* Yabe and Hanzawa 1930 (Matsumaru 1976, 2011), but is distinguished by the absence of large stout spines and its abundant, irregular radial lateral chambers.

Paleobaculogypsinoides catanduanensis Matsumaru, **n. sp.**
Plate 4, figures 6a-b

Etymology: refers to type area.

Type locality: Station 121002, Catanduanes (text-fig. 10)

Holotype (figs. 6a-b), Saitama Univ. Coll. no. 8867.

Description: Test small and tetrahedral. Early trochospirally coiled chambers are covered by three or four radial layers. Wall is calcareous and lamellar, the inner one thin and finely perforate and the outer thick and coarsely perforate. Thin spines and pillars project from the chamber walls, which are traversed by canals.

Dimensions: Diameter of test = 0.83 × 0.94 mm; protoconch diameter = up to 43 µm; tangential × radial diameter of spiral chambers = 42 × 40 µm; lateral chamber tangential × radial diameter = 40 × 43 µm. Spine diameter = 40 µm; canal bundles in spine = 3 to 4 µm in diameter.

Upper Cretaceous, Maastrichtian ms1.

Genus *Calcarina* d'Orbigny 1826

Calcarina catanduanensis Matsumaru, **n. sp.**
Plate 6, figures 3-8

Etymology: refers to type area.

Type locality: Station 121006, west of Bato, Catanduanes Island (text-fig. 10).

Holotype (fig. 3), Saitama Univ. Coll. no. 8909; paratypes (figs. 6, 7), nos. 8910, 8911.

Description: Test conical, unequally biconvex with greater height on umbilical side; both sides with radial spines. Proloculus subspherical, followed by arcuate or rhombic chambers in trochospiral whorls with gradually increasing diameter more radially than tangentially. The septal flap is attached to the peripheral margin of septum, with aperture and intercameral foramen as rounded openings at the base of the septum. The umbilical flap extends from the previous septum to the apertural face, and umbilical fissures cut deeply into the shell materials. The wall is calcareous, lamellar and coarsely perforate. Radial canals probably connect the chamber foramina, giving rise to anastomosing radial spines, plugs and granules on the umbilical side.

Dimensions: Diameter of test = 0.24 to 0.93 mm, thickness = 0.18 to 0.61 mm, diameter/thickness ratio = 1.33 to 1.52. Proloculus diameter = 38 × 36 and 85 × 70 µm in two specimens. Half whorl has 5 chambers 0.13 to 0.15 mm in diameter, first whorl has 10 chambers 0.40 to 0.99 mm, 1½ whorl has 16 chambers 0.52 to 0.95 mm. Plug diameter 43 to 78 µm.

Remarks: Differs from *Rotalia calcar* (d'Oribgny) of Hofker (1927) and Hottinger and Lutenegger (1980) in a smaller test with fewer whorls and chambers. It is the most primitive *Calcarina* species known, occurring in Assemblage 2 fauna.

Middle Paleocene (Selandian), upper Letter Stage Tertiary a0.

Superfamily NUMMULITOIDEA de Blainville 1827
Family DISCOCYCLINIDAE Galloway 1928
Genus *Orbitoclypeus* Silvestri 1907

Orbitoclypeus ramaraoi (Samanta 1967)
Plate 7, figures 19-20; plate 10, figures 1-9

Discocyclina ramaraoi SAMANTA 1967, p. 234-240, pl. 1, figs. 1-20; figs. 2-5. – MATSUMARU and SARMA 2010, p. 541, fig. 3, pl. 6, fig. 8. – MATSUMARU 2016, p. 20, fig. 10A, pl. 12, fig. 7.

Description: Test lenticular, small to large; small tests thick and centrally inflated, and larger tests more compressed. Surface is papillate; cewntral umbo with subcircular pustules, surrounded by 7 to 10 polygonal lateral chambers with straight walls. The embryonic chambers consist of subspherical protoconch and reniform deuteroconch of nephrolepidine to trybliolepidine types. The nepionic chambers are rectangular and oblique, rather spatulate , and radially or tangentially elongate. The rectangular, rarely spatulate, equatorial chambers are arranged in concentric annuli. Annular stolons may or may not be present at the proximal end of the radial walls of adjacent chambers in concentric annularity. Radial stolons are present at different levels in the equatorial chambers. Vertical stolons are connect equatorial chambers with lateral chambers. Pillars are well developed, and the wall is calcareous, lamellar and perforate.

Dimensions: Smaller tests diameter = 0.80 to 2.20 mm, thickness = 0.40 to 0.67 mm, and diameter/thickness ratio = 1.75 to 3.16/. Larger tests diameter = 2.84 to 5.20 mm, thickness = 0.94 to 1.12 mm, and diameter/thickness ratio = 3.04 to 3.2. Small test protoconch diameter = 52 × 48 and 59 × 46 µm, deuteroconch = 55 × 24 and 60 × 24 µm; large test protoconch diameter = 68 × 50 and 113 × 113 µm, deuteroconch diameter = 120 × 20 and 120 × 35 µm; distance across both protoconch and deuteroconch = 72 to 74 µm in small tests and 52 × 34 µm in large tests. Nepionic chamber tangential × radial diameter = 20 × 16 µm in small tests and 52 × 34 µm in large tests. Tangential × radial diameter of large equatorial chamber = 20 × 30 to 30 × 38 µm; height of equatorial layer near periphery up to 45 µm. There are 7 to 13 lateral chambers in a tier over embryonic chambers, with length × height = 40 × 12 to 50 × 15 µm. Pillar diameter =45 to 100 µm.

Remarks: The small test of the Philippine species is similar to *Discocyclina ramaraoi* Samanta 1967, while the large test is more like *Discocyclina furoni* Samanta 1968, both from southern India. According to Less (1987), *Discocyclina ramaraoi* has concentric annuli of spatulate equatorial chambers, as in genus *Orbitoclypeus*, while *D. furoni* has concentric annuli of rectangular equatorial chambers as in genus *Discocyclina.* Both the small and large sized tests from the Philippines have spatulate chambers, justifying assignment to *Orbitoclypeus.* On the other hand, microspheric specimens of this taxon are unknown, so this re-assignment is not completely certain. The specimens from lower Eocene are reworked from Assemblage 3.

Upper Paleocene (Thanetian), Tertiary a1.

Family ASTEROCYCLINIDAE Brönnimann 1951
Genus *Asterocyclina* Gümbel 1870

Asterocyclina incisuricamerata Cole 1957
Plate 12, figures 3-5

Asterocyclina incisuricamerata COLE 1957, p. 349-350, pl. 117, figs. 1-5. – COLE 1957, p. 776-777, pl. 245, figs. 3, 6-8, 13-15, 17 (non pl. 245, figs. 4-5, 9-10). – MATSUMARU 1996, p. 126-130, pl. 41, fig. 5; pl. 42, figs. 2, 4; pl. 43, figs. 1-5, 7-9; pl. 44, figs. 3a-b; pl. 50, fig. 8; fig. 29-1 (non pl. 40, fig. 6).

PLATE 1

Figs. 1-4 from Station h2518, West Bontoc; figs. 5-8, 10, Station 7451105c, Pinugay Hill, Luzon; fig. 9, Station 121002, Catanduanes.

1 *Praerhapydionina boninensis* Matsumaru, n. sp. Left, longitudinal section; right, oblique section. Miliolids can be seen in upper right, ×20.

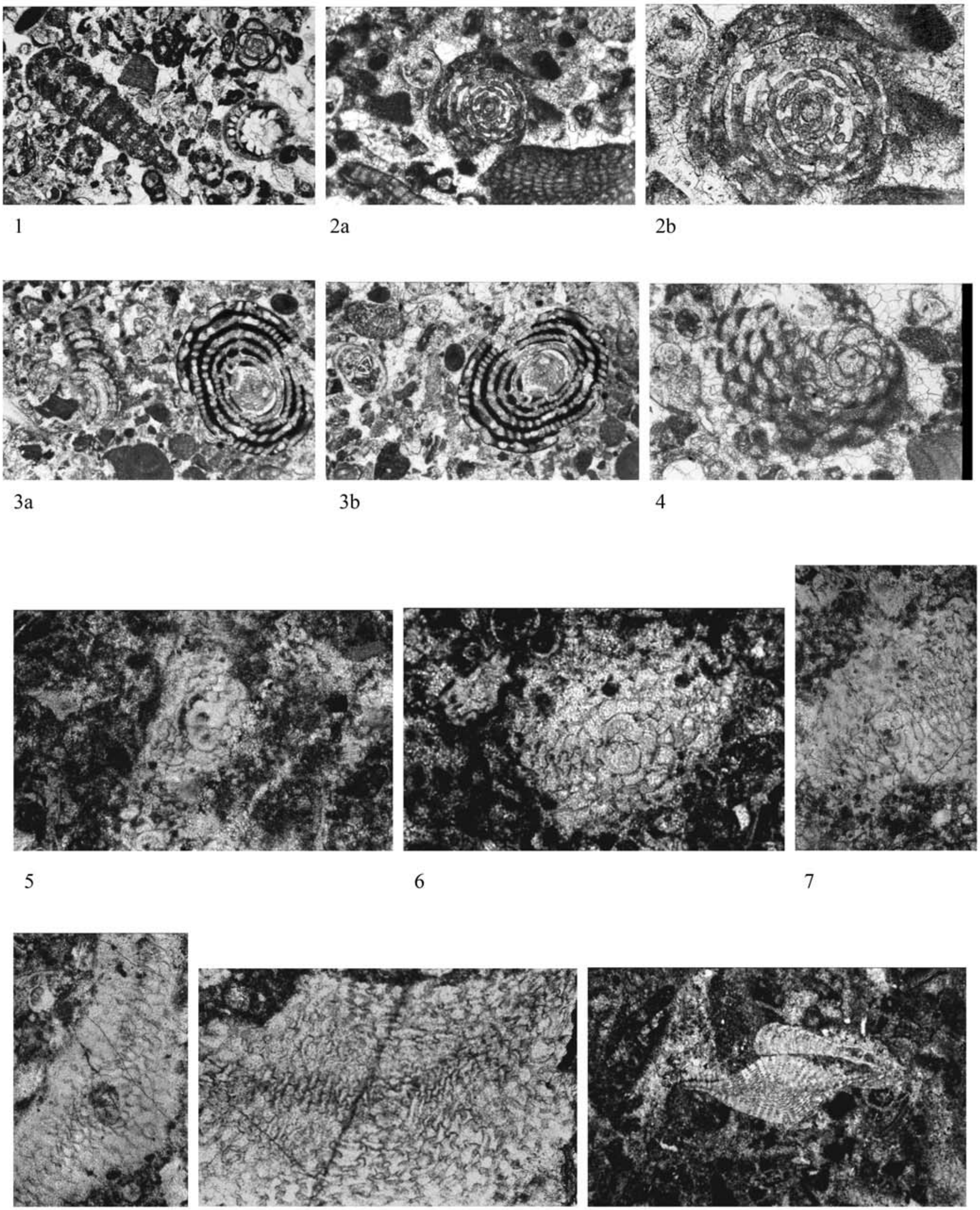
2-3 *Borelis* sp. 2a, b, equaorial section of megalospheric specimen, ×50 and ×100; 3, transverse section, ×20. (3a left. *Peneroplis* sp., oblique section).

4 *Sorites orbiculus* (Forskål). Equatorial section of megalospheric specimen, ×35.

5 *Lepidorbitoides pembergeri* Papp. Equatorial section of megalospheric specimen, ×50.

6-10 *Lepidorbitoides campaniensis* Gorsel. 6-9. Equatorial sections of megalospheric specimens, ×50; 10 lower, axial section of megalospheric specimen, ×20.

10 *Pseudorbitoides philippinensis* Matsumaru, n. sp. 10 upper, axial section of periphery, ×20.


1
2a
2b
3a
3b
4
5
6
7
8
9
10

Asterocyclina matanzensis COLE 1957, p. 350, pl. 117, figs. 6-10; pl. 118, figs. 9-18. – COLE 1957, p. 777-778, pl. 249, figs. 1-17.
?*Asterocyclina centripilaris* COLE 1957, p. 775-776, pl. 248, figs. 1-7, 9-11.
Actinocyclina praecipua COLE 1957, p. 780, pl. 245, figs. 11-12, 16-20. – COLE 1963, p. E24, pl. 9, figs. 12-13, 18.

Description: Test lenticular with umbo surrounded by wide flange and four elevated radial rays. Embryonic chambers consist of subspheric protoconch and reniform deuteroconch of isolepidine to semi-isolepidine type, enclosed by two primary auxiliary chambers and periembryonic chambers. The inter-ray equatorial chambers are small and arcuate to short hexagonal near the center of the test, becoming larger and wider squares the periphery. Those within the ray areas are narrow, elongate rectangles in the center, becoming larger spatulate or rectangular towards the periphery. Lateral chambers are arranged in regular tiers over both sides of the equatorial layer. The chamber cavities are low and slit-like between thick roofs and floors. Pillars are present.

Dimensions: Diameter of test = 1.64 to 2.20 mm, thickness = 0.35 to 0.79 mm, diameter/thickness ratio = 2.78 to 5.51. In 5 specimens, protoconch diameter = 44 × 36 to 80 × 60 µm, deuteroconch = 50 × 28 to 100 × 30 µm, ratio of deuteroconch to protoconch diameter = 1.12 to 1.33; distance across both protoconch and deuteroconch = 64 to 93 µm. Tangential × radial diameter of primary chambers = 22 × 13 to 30 × 15 µm, auxiliary chamber = 22 × 11 to 32 × 16 µm, equatorial chamber in interray area = 26 × 26 to 39 × 18 µm, that of equatorial chamber within rays = 14 × 27 to 22 × 38 µm. Height of equatorial layer near periphery as much as to 29 µm. There are 12 to 13 highly compressed lateral chambers in tiers over embryonic chambers, with width × height = 34 × 10 to 59 × 4 µm; diameter of pillars = 56 to 68 µm.

Remarks: Also known from the middle Eocene of Saipan (Cole 1957) and middle to upper Eocene of Haha-Jima, Ogasawara Islands (Matsumaru 1996).

Upper Paleocene (Thanetian) to middle Eocene (Lutetian), Tertiary a1 to a2.

Asterocyclina pinugayensis Matsumaru, **n. sp**.
Plate 12, figures 11-15

Etymology: refers to Pinugay Hill area, Luzon.

Type locality: Station 7451212, Pinugay Hill (text-fig. 5).

Holotype (fig. 12), Saitama Univ. Coll. no. 8897; paratype (fig. 11), no. 8898; paratype (fig. 15), no. 8899; unfigured specimens from stations 7451213 and 7451209, Pinugay Hill area

Description: Megalospheric test is small and lenticular with wide flange and five elevated rays. Subspherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two primary auxiliary chambers and other nepionic chambers, which are wide tangentially and short radially. Equatorial chambers in the interray areas are small and arcuate to short hexagonal near the center of test, becoming larger square shapes in the periphery, while those within the rays are large and square in the center of the test, becoming large and spatulate toward the periphery. Lateral chambers are arranged in regular tiers over the equatorial layer, with slit-like chamber cavities between thick roofs and floors, and pillars are present. The relatively rare microspheric test is large, compressed lenticular, similar to megalospheric test except in the early stage of the proloculus and spiral nepionic chambers/

Dimensions: In megalospheric specimens, diameter of test = 1.32 to 1.60 mm, thickness = 0.61 to 0.67 mm, diameter/thickness ratio = 1.97 to 2.62. In three specimens protoconch diameter = 75 × 64, 84 × 80, and 131 × 96 µm, deuteroconch = 102 × 48, 96 × 36, and 175 × 82 µm, ratio of deuteroconch/protoconch diameter = 1.34, 1.14, and 1.34; distance across both protoconch and deuteroconch = 113, 116, and 184 µm; tangental × radial diameter of primary auxiliary chamber = 35 × 11 to 43 × 26 µm, auxiliary chamber = 35 × 17 to 65 × 26 µm, equatorial chamber in interray area = 31 × 20 to 48 × 26 µm, equatorial

---

PLATE 2

Figs. 1-4, 6 from Station CT22, Catanduanes; figs. 5, 10, 12, Station 6Y1906-2, Cebu; fig. 7, Station CR63; figs. 8, 9, Station CR56, Caramoan Peninsula; fig. 11, Station 7451105d, Pinugay Hill.

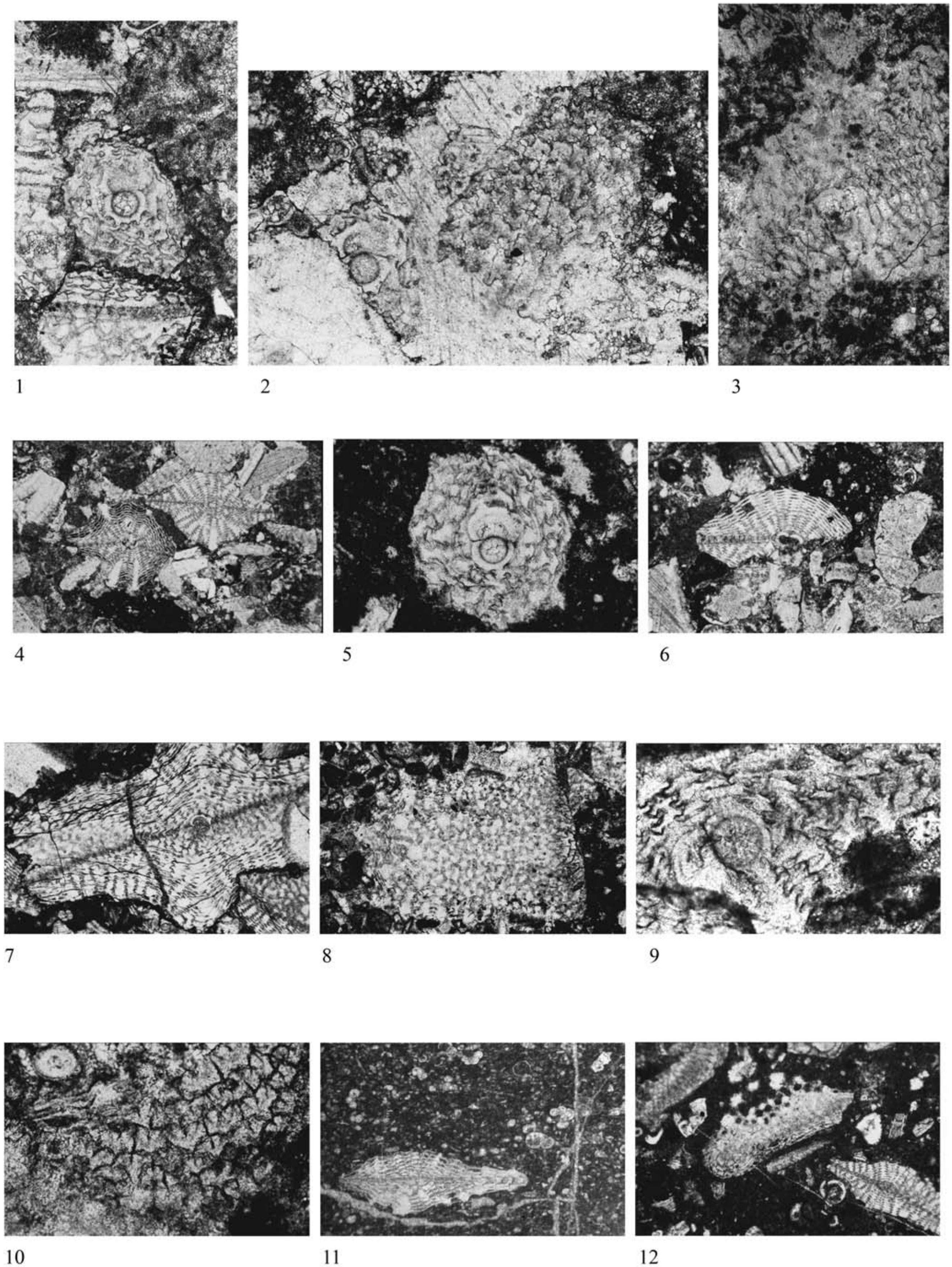
1-4 *Lepidorbitoides bisambergensis* (Jaeger), megalospheric specimens. 1-3. Equatorial sections; 4 upper, axial section. 1, × 60; 2, × 70; 3, ×50; 4, ×20.

4, 7-12 *Pseudorbitoides philippinensis* Matsumaru, n. sp. 4 lower (paratype), axial section of megalospheric specimen. 7 (holotype), and 9, oblique sections of megalospheric specimen. 8, and 10 (paratype). tangential sections of probably megalospheric specimens. 11, transverse section. 12 center, oblique section. 4, 7, 8, 11, 12, ×20; 9, × 90; 10, ×100.

5,6 *Lepidorbitoides minor* (Schlumberger), megalospheric specimens. 5, equatorial section, ×50. 6, axial section, ×20.

12 *Globotruncanita* ex gr. *G. stuartiformis* (Dalbiez), 12 left, ×20

12 *Lepidorbitoides* sp., 12 right, ×20.


1
2
3
4
5
6
7
8
9
10
11
12

chamber within ray area = 11 × 26 to 26 × 40 µm. The height of equatorial layer near periphery is as much as 22 µm. There are 8 lateral chambers in tiers over embryonic chambers, with length × height = 34 × 3 to 36 × 4 µm: Diameter of pillar = 68 to 90 µm. In microspheric specimens, test diameter = 3.52 mm, thickness = 0.72, diameter/thickness ratio = 4.89. Height of equatorial layer near periphery = 25 µm. There are 9 lateral chambers in tiers, 30 × 5 to 34 × 6 µm; Diameter of pillar = 56 to 60 µm.

Remarks: Differs from *Asterocyclina incisuricamerata* Cole 1957, from the upper Eocene of Saipan in its smaller test with five rays and larger embryonic chambers of nephrolepidine type. It also resembles *Asterocyclina elongaticamera* Cole 1959 from the upper Eocene of the Tuamotu Archipelago, but is again different in its nephrolepidine large embryonic chambers.

Lower Eocene (Ypresian) to lower middle Eocene (lower Lutetian), Tertiary a2.

Asterocyclina stella (Gümbel 1861)
Plate 12, figures 6-7; plate 16, figure 9 upper

Hymenocyclus stella GÜMBEL 1861, p. 653.
Orbitoides stella (Gümbel). – GÜMBEL 1870, p. 138-139, pl. 2, figs. 117a-c; pl. 4, figs. 8-10, 19.
Orthophragmina stella (Gümbel). – SCHLUMBERGER 1904, p. 132-133, pl. 6, figs. 47-54, 53-56.
Asterodiscus stella (Gümbel). – DOUVILLÉ 1922, p. 76-77, 93; fig. 13. – NEUMANN 1958, p. 112-114, pl. 28, figs. 1-6; figs. 36a-b.
Discocyclina (D.) stella (Gümbel). – WEIJDEN 1940, p. 50-53, pl. 8, figs. 1-3.
Asterocyclina stella (Gümbel). – BRÖNNIMANN 1940, p. 28-29, pl. 1, figs. 3, 7; pl. 2, fig. 2. – SCHWEIGHAUSER 1953, p. 90-91, pl. 13, figs. 6, 8. – BIEDA 1963, p. 215, pl. 26, figs. 4-6. – SIROTTI 1978, p. 62-64, pl. 4, figs. 1-5. – MATSUMARU AND KIMURA 1989, p. 259-260, figs. 3-3, 8, 11, 4-1-5. – MATSUMARU 1996, p. 134, 136, pl. 44, figs. 1a-b; pl. 45, figs. 2-3, 5; pl. 50, fig. 7; fig. 29-4.
Asterocyclina incisuricamerata COLE 1957, p. 776-777, pl. 245, figs. 4-5, 9-10 (non pl. 245, figs. 3, 6-8, 13-15, 17).
Asterocyclina stella stella (Gümbel). – LESS 1987, p. 231-232, pl. 42, figs. 7-10; fig. 32c.

Description: Test inflated, lenticular and asteroidal with five fundamental rays, rarely six to eight. The embryonic chambers are subspheric protoconch and reniform deuteroconch of nephrolepidine to semi-isolepidine type, followed by two primary auxiliary chambers and subordinate nepionic chambers. Inter-ray equatorial chambers are small and arcuate, while those within the ray area are large and square or hexagonal in the center, becoming rectangulat to spatulate towards the periphery. There are only minor differences in the size of equatorial chambers in the interray and ray areas. The lateral chambers are arranged in regular tiers over the equatorial layer, with well opened, irregular chamber cavities, with stout pillars.

Dimensions: Diameter of test = 0.96 to 3.84 mm, thickness = 0.39 to 1.20 mm, diameter/thickness ratio = 1.91 to 2.46. In 6 specimens, protoconch diameter = 100 × 74 to 190 × 166 µm, deuteroconch = 108 × 69 to 204 × 76 µm, ratio of deuteroconch /protoconch diameter = 1.07 to 1.45, and distance across both protoconch and deuteroconch = 143 to 242 µm. Tangential × radial diameter of lateral chambers = 43 × 17 to 61 × 22 µm, auxiliary chamber = 21 × 43 to 26 × 26 µm, equatorial chamber in interray area = 26 × 26 to 31 × 21 µm and in ray area = 23 × 39 to 31 × 61 µm. Height of equatorial layer near periphery = 18 to 31 µm. There are 17 to 22 lateral chambers in tiers over embryonic chambers, with length × height = 59 × 6 to 68 × 13 µm; pillar diameter = 50 to 113 µm.

Remarks: There is no difference between the Philippine specimens of *Asterocyclina stella* (Gümbel), in Assemblages 3, 4 and 5, and those from the middle and upper Eocene of Haha-Jima, Ogasawara Islands (Matsumaru 1996).

Upper Paleocene (Thanetian) to upper Eocene (Lutetian to Bartonian), Tertiary a1 to a3.

PLATE 3

Figs. 1-5, Station CT22, Catanduanes; fig.6, Station MQ25, Marinduque; figs.7, 8, Station 7451105c, Pinugay Hill Section; figs. 9, 10, 12, Station CR63, Caramoan Peninsula; fig. 11, Station 6Y1902-2, Cebu.

1,2 *Asterorbis rooki* Vaughan and Cole. Oblique sections, ×50.

3-6 *Vaughanina cubensis* Brönnimann. 3, 4 lower, 5 right, 6, oblique sections; 3, ×50, 4-6, ×20.

4,5,10 *Lepidorbitoides* sp. 4 upper and right, 5 left, 10 lower right, axial sections, ×20.

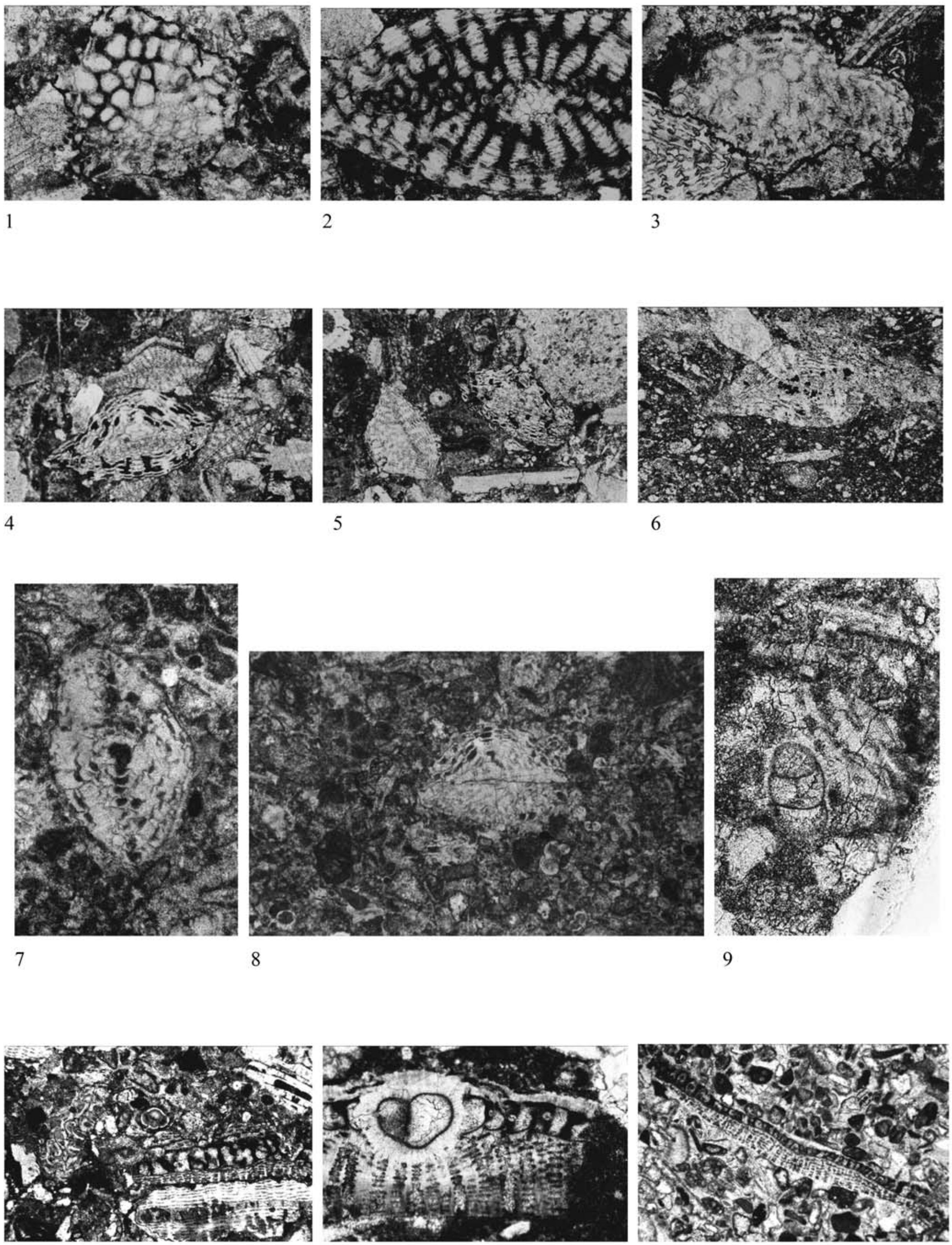
7,8 *Sulcorbitoides pardoi* Brönnimann, megalospheric specimens. Oblique sections, ×60 and ×30, resp.

9,10 *Orbitoides tissoti* Schlumberger, megalospheric specimens. 9, oblique section, ×100. 10 center, equatorial section, ×20.

10 *Omphalocyclus macroporus* (Lamarck). 10 left, oblique section, ×20.

10 *Simplorbites papyracea* Boubée. 10 right, axial section, ×20

11,12 *Orientorbitoides cebuensis* Matsumaru, n. gen., n. sp. 11 (holotype), axial section of megalospheric specimen, ×50. 12, transverse section, ×20.


1
2
3
4
5
6
7
8
9
10
11
12

Asterocyclina stellata (d'Archiac 1846)
Plate 12, figures 8-10

Calcarina stellata D'ARCHIAC 1846, p. 199, pl. 7, figs. 1, 1a.
Orbitoides (asterocyclina) stellata (d'Archiac). – GÜMBEL 1868, p. 713, pl. 2, fig. 115; pl. 4, figs. 4, 7.
Orthophragmina stellata (d'Archiac). – SCHLUMBERGER 1904, p. 126-128, pl. 5, fig. 33; pl. 6, fig. 10.
Asterodiscus stellatus (d'Achiac). – LLUECA 1929, p. 300-301, pl. 25, figs. 12-18.
Discocyclina (Discocyclina) stellata (d'Archiac). – WEIJDEN 1940, p. 54-56, pl. 9, figs. 1-6?, 7.
Asterocyclina aff.*A. stellata* (d'Archiac). – BRÖNNIMANN 1940, p. 29, pl. 1, figs. 1-2, 4, 8-9; pl. 2, figs. 3-4, 11, 13. – LESS 1987, p. 235-236, pl. 39, figs. 5-6.
Asterocyclina stellata (d'Archiac). – SCHWEIGHAUSER 1953, p. 86-88, pl. 13, figs. 3, 5, 10; fig. 57.
Asterodiscus stellatus (d'Archiac). – NEUMANN 1958, p. 116-118, pl. 30, figs. 1-7; fig. 38.
Asterocyclina stellata stellata (d'Archiac). – LESS 1987, p. 235-236, pl. 38, figs. 9-11; pl. 39, figs. 1-4, 7-10; fig. 32h.
Asterocyclina stellata (d'Archiac) *stellaris* (Brunner in Rutimeyer). – LESS 1987, p. 236-237, pl. 39, figs. 11-12; pl. 40, figs. 1-11; pl. 41, figs. 1-6; fig. 32i.

Description: Test thick, lenticular and asteroidal with five, rarely four fundamental rays. Subpherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two primary auxiliary chambers and large auxiliary nepionic chambers. The inter-ray equatorial chambers are small, arcuate to square or short hexagonal, while those within the ray area are large, square or hexagonal in the center and become elongate rectangular or spatulate towards the periphery. The lateral chambers are arranged in regular tiers over the equatorial layer, with open rectangular cavities and pillars.

Dimensions: Diameter of test = 1.59 to 2.00 mm, thickness = 0.41 to 0.62 mm, diameter/thickness ratio = 3.27 to 3.88. In eleven specimens, diameter of protoconch = 70 × 60 to 178 × 133 µm, deuteroconch = 96 × 48 to 224 × 92 µm, ratio of deuteroconch/protoconch diameter = 1.17 to 1.39, and distance across both protoconch and deuteroconch = 112 to 250 µm. Tangential × radial diameter of lateral chambers = 44 × 21 to 87 × 35 µm, auxiliary chamber = 35 × 17 to 70 × 26 µm, inter-ray equatorial chambers = 21 × 17 to 93 × 30 µm, equatorial chambers within ray = 26 × 49 to 61 × 6 µm. There are 12 to 13 lateral chambers in tiers over embryonic chambers, height near periphery = 26 to 27 µm, and length × height = 45 × 4 to 63 × 6 µm; pillar diameter = 20 to 22 µm.

Remarks: Asterocyclina stellata is characterized by its asteroid form with five rays, nephrolepidine embryonic chambers, few large auxiliary chambers and large spatulate equatorial chambers in the ray area.

Upper Paleocene (Thanetian) to middle Eocene (Bartonian), Tertiary a1 to a3.

Family PELLATISPIRIDAE Hanzawa 1937
Genus *Miscellanea* Pfender 1935

Miscellanea globularis Rahaghi 1978
Plate 7, figures 1-4

Miscellanea globularis RAHAGHI 1978, p. 61-62, pl. 12, figs. 10-12. – RAHAGHI 1983, p. 61, pl. 42, figs. 1-7. – MATSUMARU 2016, p. 4-5, 8, 10, 18, 22, 30, figs. 5A, 5B, 10A, 10B, pl. 11, figs. 1-2.

Description: Test small, subglobular, with surface pustules. Subspheric protoconch and reniform deuteroconch are followed by two (rarely two and a half) planispiral whorls with chambers connected by intercameral foramina. The septa are radial, gently curved with intraseptal space created by a distal septal flap. Alar prolongations of the chambers extend to the central pole. The spiral canals connect with the marginal sutural canals of the preceding walls, and lateral canals run below the septal sutures, and intraseptal canals are present. There is no meshing of the marginal canal network into a marginal cord. The wall is calcareous, lamellar and perforate.

PLATE 4

Figs. 1-3, Station CT22; fig. 6, Station 121002, Catanduanes; figs. 4, 5 Station CR63, Caramoan Peninsula; fig. 7, Station MQ25, Marinduque; fig. 8, Station EN, and figs. 9-11, Station G316, Mindanao.

1-3 *Sulcoperculina dickersoni* (Palmer). 1, oblique section. 2, equatorial section of microspheric specimen. 3, axial section, all ×50.

4,5 *Omphalocyclus macroporus* (Lamarck). 4 upper, 5, oblique sections, ×50 and ×20, resp.

4 *Lepidorbitoides* sp. Axial section, 4 lower. ×50.

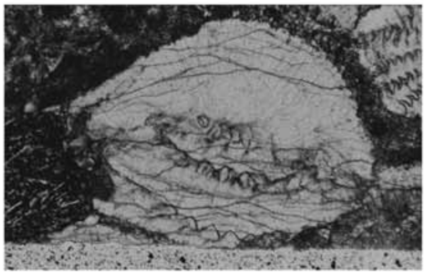
6a,b *Paleobaculogypsinoides catanduanensis* Matsumaru, n. gen., n. sp. Holotype, equatorial section, ×20 and (rotated c. 160°) ×60. In 6a, *Lepidorbitoides bisambergensis* is seen lower left, and *Pseudorbitoides philippinensis* in lower right.

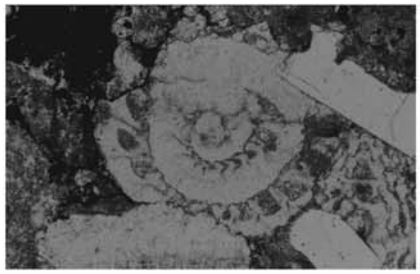
7 *Siderolites calcitrapoides* Lamarck, equatorial section, with *Gansserina gansseri* (Bolli) in lower left, ×20.

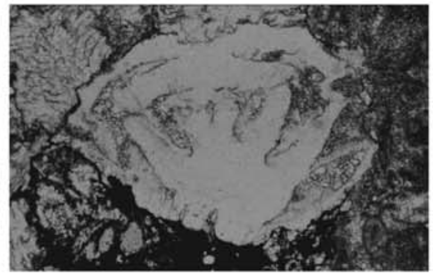
8,9 *Pfendericonus mindanaoensis* Matsumaru, n. sp. 8 (holotype), oblique section, ×40. 9 left, oblique section, ×20.

9 *Pseudolituonella mindanaoensis* Matsumaru, n. sp. Transverse section, 9 right, ×20.

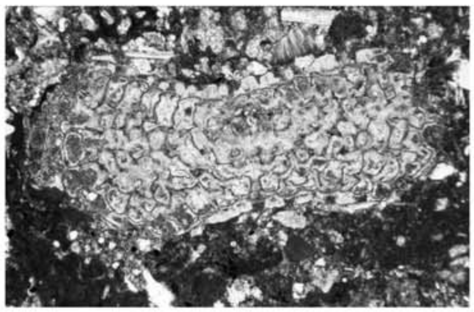
10-11 *Chrysalidina* sp. Longitudinal sections, ×20.

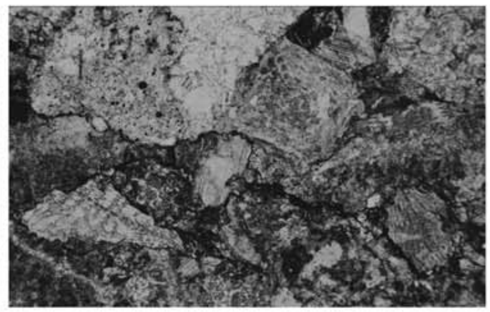

1

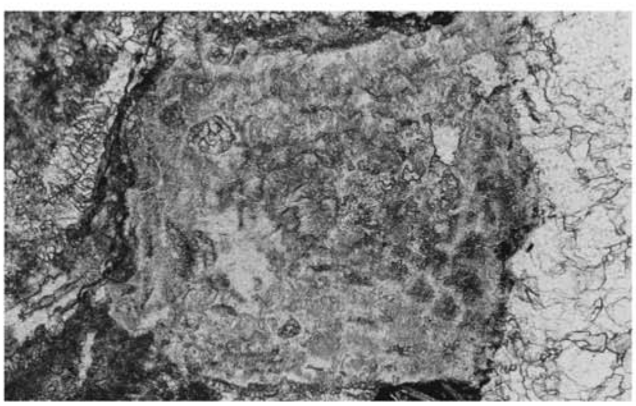

2


3

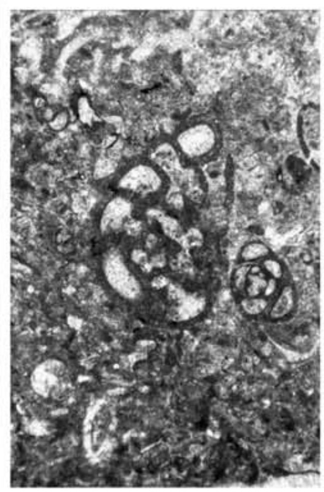

4

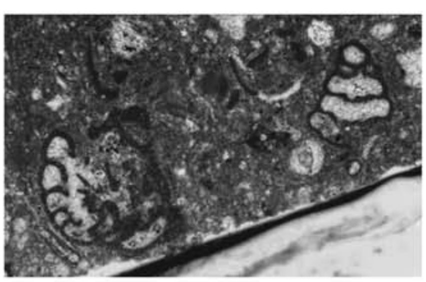

5


6a

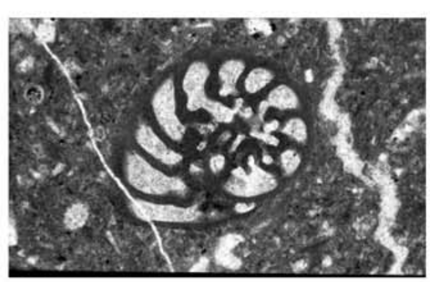

6b


7


8


9


10


11

Dimensions: Diameter of test = 0.68 to 0.88 mm, thickness = 0.48 to 0.64 mm, diameter/thickness ratio = 1.38 to 1.42. Diameter of protoconch = 52 × 35 µm, and deuteroconch = 78 × 38 µm. There are 5 chambers in the first half whorl, diameter = 0.10 to 0.15 mm, 11 chambers in first whorl = 0.26 to 0.32 mm, 19 chambers in first whorl and a half whorl = 0.35 to 0.43 mm, 27 chambers in second whorl = 0.44 to 0.55 mm, and 35 chambers in second whorl and a half = 0.57 to 0.68 mm. Diameter of pustules = 52 to 82 µm.

Remarks: The Philippine specimens compare closely with *Miscellanea globularis* from the type locality in Shiraz area, Iran (Rahaghi 1978), with minor difference of the protoconch size and number of chambers in whorls, but with the same spiral growth.

Upper Paleocene (Thanetian), and Letter Stage Tertiary a1.

Miscellanea miscella (d'Archiac and Haime 1853)
Plate 7, figures 9-14

Nummulites miscella D'ARCHIAC and HAIME 1853, p. 354, pl. 35, fig. 4.
Siderolites miscella (d'Archiac and Haime). DAVIES 1927, p. 277, pl. 22, fig. 9. – NUTTALL 1931, p. 60, pl. 4, fig. 7.
Siderolites stampi DAVIES 1927, p. 278, pl. 21, figs. 1-8.
Miscellanea miscella (d'Archiac and Haime). PFENDER 1935, p. 231-235, pl. 11, figs. 6-7; pl. 13, figs. 2-4, figs. 1-4. – DAVIES 1937, p. 43-45, pl. 6, figs. 1-3, 5, 7-8. – SMOUT 1954, p. 72-73. – LEPPIG 1988, p. 703, pl. 1, fig. 1; pl. 2, fig. 1; pl. 3, fig. 1; pl. 7, figs. 1-6; pl. 8, figs. 1-2. – MATSUMARU, OZER and SARI 2010, p. 444, pl. 6, fig. 4. – MATSUMARU and SARMA 2010, p. 541, fig. 3, pl. 4, fig. 7.
Miscellanea stampi (Davies). – DAVIES 1937, p. 42-43, pl. 4, figs. 4, 6, 9-10, 17-18; fig. 1A.

Description: Test biconical, ornamented by gently curved filaments and scattered pustules. The protoconch and deuteroconch are followed by numerous chambers in two and a half whorls. The spiral wall is thick and pierced by numerous radial canals. There is no marginal cord of intermeshed marginal canals. The wall is calcareous, lamellar and perforate.

Dimensions: Diameter of test = 1.80 to 2.61 mm, thickness = 1.02 to 1.20 mm, diameter/thickness ratio = 1.76 to 2.25. In two specimens, diameter of protoconch = 325 × 300 and 397 × 368 µm, diameter of first half whorl = 0.42 and 0.45 mm, first whorl = 0.95 and 1.16 mm, first whorl and a half = 1.32 and 1.48 mm, and second whorl = 1.70 and 2.10 mm. There are most probably 17 chambers in the first whorl and a half.

Remarks: Distinhuished by protoconch size, diameter of two and a half whorls, and thick spiral walls, as in other examples from Meghalaya, NE India (Matsumaru and Jauhri 2003; Matsumaru and Sarma 2010).

Upper Paleocene (Thanetian), Tertiary a1.

Miscellanea primitiva Rahaghi 1983
Plate 7, figures 5-8; plate 8, figure 17 left.

Miscellanea primitiva RAHAGHI 1983, p. 61-62, pl. 42, figs. 8-16. – MATSUMARU and SARMA 2010, p. 540, fig. 3, pl. 6, figs. 1-2. – MATSUMARU 2016, p. 4-5, 8, 10, 20, 22, figs. 5A, 5B, 10A, 10B, pl. 11, figs. 1-2.
Miscellanea minuta RAHAGHI 1983, p. 62, pl. 43, figs. 1-13.

Description: Test small, lenticular and biconvex, pustules scattered over the surface. Spherical to subspherical protoconch and reniform deuteroconch are followed by planispiral whorls. Septa are radial and curved towards the periphery. As well as spiral canals, the thick outer spiral wall is pierced by numerous radial canals. Umbilical radial canals separate umbilical pillars.

PLATE 5

All ×20 except figs. 4 and 6. Fig. 1 from Station F538; figs. 2-6, Station EN; fig, 8, 10-11, Station G316; fig. 9, Station I-4; Mindanao; fig 7, Station 7451105b, and fig. 12, Station 7451215, Pinugay Hill, Luzon; fig 13, Station WR154, Mindoro.

1-4 *Pseudolituonella mindanaoensis* Matsumaru, n. sp. 1 (paratype), 2, 3 left, longitudinal sections, megalospheric specimens. × 20; 4 (holotype), longitufinal section, microspheric specimen, ×40.

1,5,7 *Idalina sinjarica* Grimsdale. 1 lower, 7, longitudinal sections; 5 lower, transverse section. × 20.

3,5 *Pseudochrysalidina* sp. 3 right, 5 upper, longitudinal sections. × 20.

6 *Coskinon rajkae* Hottinger and Drobne. Longitudinal section, ×50.

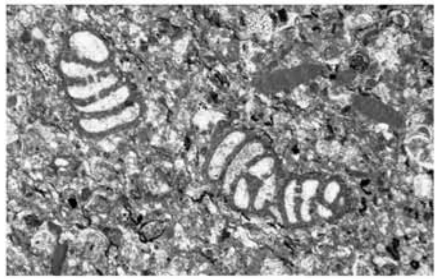
8-11 *Hashimotoina mindanaoensis* Matsumaru, n. gen., n. sp. 8 (holotype), equatorial section of megalospheric specimen. 9, tangential section. 10 (paratype), oblique section of megalospheric specimen. 11, axial section. Valvulinids appear in 9 right, and *Parasubbotina* ex gr. *P. pseudobulloides* (Plummer) in 11 upper. × 20.

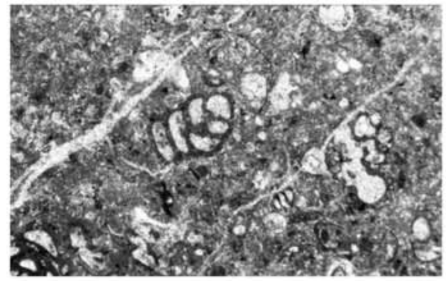
12 *Opertorbitolites douvillei* Nuttall. 12 upper, oblique section. × 20.

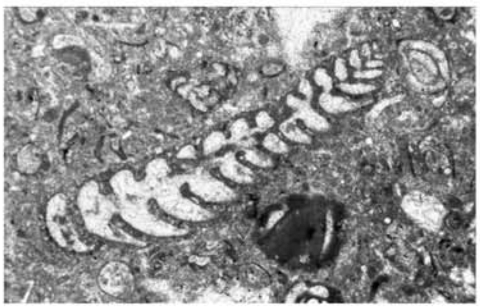
12 *Alveolina luzonensis* Matsumaru, n. sp. 12 lower, axial section. × 20.

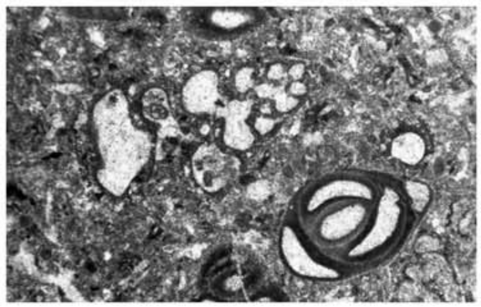
13. *Broeckinella arabica* Henson. Oblique section. × 20.


1

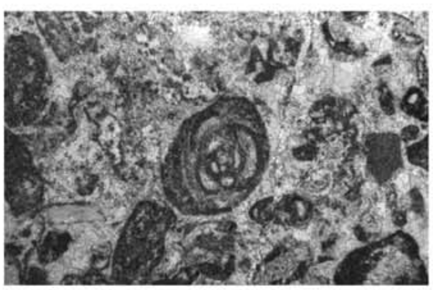

2


3

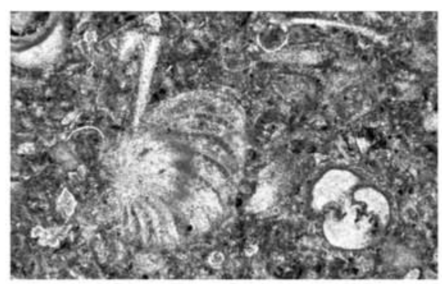

4

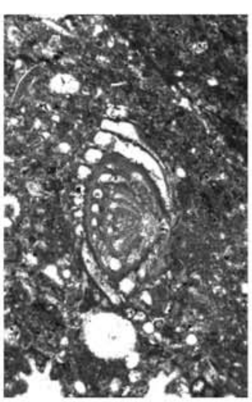

5

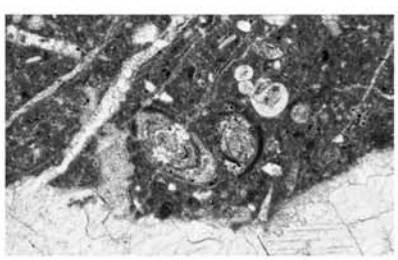

6


7

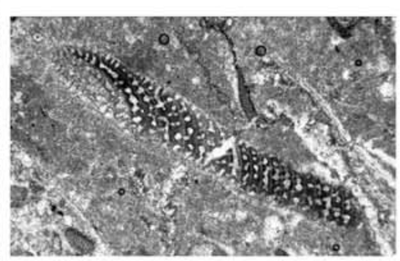

8


9


10


11


12


13

There is no marginal cord at the margin of test. The wall is calcareous, lamellar and perforate.

Dimensions: Diameter of test = 0.70 to 1.30 mm, thickness = 0.48 to 0.88 mm, diameter/thickness ratio = 1.46 to 1.48. Diameter of protoconch in two specimens = 90 × 80 µm and 102 × 102 µm, diameter of deuteroconch = 90 × 35 µm. There are 5 to 6 chambers in first half whorl, with diameters = 0.20 to 0.22 mm, 11 to 12 chambers in first whorl = 0.47 to 0.55 mm; 16 to 17 chambers in first whorl and a half = 0.61 to 0.80 mm, and 23 to 24 chambers in second whorl = 0.89 to 0.98 mm.

Remarks: Miscellanea primitiva and *Miscellanea minuta* are probably the same species, because they have the same protoconch size and number of spiral chambers, and only differ in external test shape.

Middle Paleocene (Selandian) to upper Paleocene (Thanetian), Tertiary a0 to a1.

Family NUMMULITIDAE de Blainville 1827
NOTE: All species of Nummulitidae from the Philippines and Japan are preserved in limestone, hard sandstone or hard shale. Except for rare outweathered free specimens, their identification is based almost entirely on thin sections, which therefore depends primarily on the distance along the apical line, i.e. the distance from the center of the embryonic chambers to the frontal boundary of each whorl, (Matsumaru 2005, fig. 2), and on the number of chambers in each whorl These characters reflect the entire ontogenesis of the test and are more valid for the identification of Nummulitidae species than the traditional spire diagram (i.e., Schaub 1981) that records only half of the ontogenetic growth rate.

Genus *Ranikothalia* Caudri 1944

Ranikothalia nuttalli (Davies 1927)
Plate 9, figures 1-5, 8, 10-11, 13-14

Nummulites planulatus (Lamarck). – NUTTALL 1926, p. 114-116, pl. 10, figs. 1-2; fig. 1.
Nummulites nuttalli DAVIES 1927, p. 266-268, pl. 18, figs. 3-4; pl. 19, figs. 7-9. – VLERK 1929, p. 19-20, figs. 11a-b, 34a-b. – DAVIES 1937, p. 18-20, pl. 3, figs. 1-2, 9; pl. 6, figs. 19-20; fig. 1B.
Nummulites nuttalli var. *kohaticus* DAVIES 1927, p. 269, pl. 19, figs. 4, 6.
Nummulites thalicus DAVIES 1927, p. 269-271, pl. 20, figs. 1-4. – VLERK 1929, p. 21, figs. 13, 36a-b. – DAVIES 1937, p. 20-21.
Nummulites thalicus Davies var. *gwynae* DAVIES 1927, p. 271, pl. 20, fig. 5.
Camerina crasseornata HENRICHI 1934, p. 32-33, pl. 2, figs. 2-5, 12; fig. 15.
Ranikothalia nuttalli (Davies). – CAUDRI 1944, p. 369-370. – JAUHRI 1966, p. 210-212, pl. 1, figs. 4-5, 9-10; text-figs. 3a-b. – MATSUMARU and SARMA 2010, p. 541, fig. 3, pl. 5, fig. 11. – MATSUMARU 2016, p. 13, 20, figs. 5B, 10A, pl. 10, fig. 5.
Operculina bermudezi (Palmer). – SACHS 1957, p. 107-113, pl. 14, figs. 1-20, 22, 24-27.
Ranikothalia sindensis (Palmer). – HOTTINGER 1977, p. 51, fig. 16D; pl. 17, fig. 4; (Nec. p. 51, figs. A-C, E; pl. 17, figs. 2-3, 5-9).
Ranikothalia bermudezi (Palmer). – HASHIMOTO, MATSUMARU and KURIHARA 1978, p. 70-71, pl. 9, figs. 1-4, 6, 8-9, 12-13.

Description: Megalospheric test varies from thick to thin lenticular with thicker marginal rim; surface smooth with strong radial septal filaments, gently curved and flush from the central boss to the blunt margin. Rounded granules, larger towards the center, are distributed on and around septal filaments. Subspherical protoconch and reniform deuteroconch are followed by many chambers in planispiral whorls tight coiled up to 1½ whorls and then more evolute up to 3 whorls, but not inflated. Microspheric test is large, thin and lenticular with pustules on a central boss and blunt, strongly thickened margin. Proloculus is followed by many chambers. Spiral chambers of both megalospheric and microspheric forms have greater radial than tangential diameter, with extended alar prolongations. Septa are thick, regular and only slightly bent peripherally. Conspicuous intraseptal canals are connected with the marginal canal system. Walls are calcareous and lamellar.

PLATE 6

Figs. 1, 2, Station EN, Lingig, Mindanao; figs. 3-11, Station 121006, Catanduanes; figs. 12-13, 17, Station 7451105a, Pinugay Hill, Luzon; figs. 14, 15, stations 86/Lkd/DR6 and 91/Lkd/DR7, Meghalaya, NE India (Matsumaru and Jauhri, 2003); fig. 16, Station 31057, Bondoc, SE Luzon.

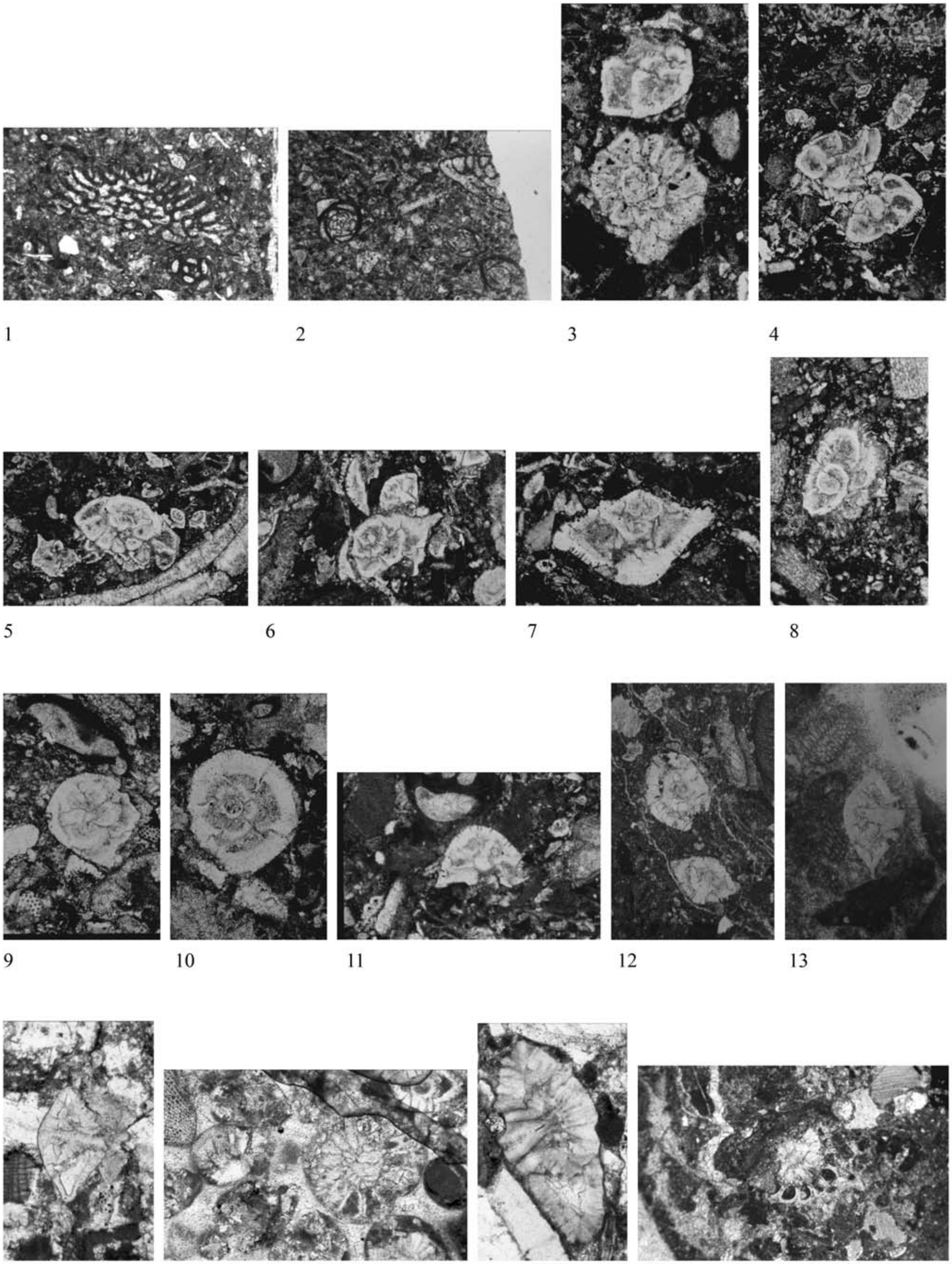
1,2 *Coleiconus* sp. Axial sections, with miliolids in 2 left, ×20.

3-8 *Calcarina catanduanensis* Matsumaru, n. sp. 3 (holotype) and 8, equatorial sections of megalospheric specimens. 4, 5, 6 (paratype), oblique sections of megalospheric and microspheric specimens; 7 (paratype), axial section of megalospheric specimen. Figs.3, 4, 6, 7, ×40; 5, ×20; 8, ×35..

9-11 *Rotalia trochidiformis* (Lamarck). 9, oblique section, ×35. 10, equatorial section of megalospheric specimen, × 70. 11, axial section, ×35.

12-15 *Kathina selveri* Smout. 12, megalospheric specimens; equatorial section above and oblique section below, ×20. 13-14, axial sections of microspheric specimens, ×20 and ×40 respectively; 15, tangential section, ×40.

16-17 *Kathina major* Smout. 16, axial section, ×40. 17, tangential section, ×20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Dimensions: Megalospheric form: Diameter of test = 1.29 to 2.62 mm, thickness = 0.76 to 0.96 mm, diameter/thickness ratio = 1.7 to 2.2. Surface diameter of pustule = 160 to 320 µm. Diameter of protoconch = 124 to 208 µm, deuteroconch = 120 to 229 µm. In three whorls, the number of chambers and distance from center along the apical-frontal line are as follows: first half whorl, including embryonic chambers, 5 to 6 chambers and 236 to 655 µm; first whorl, 9 to 11 and 592 to 1170 µm; first 1½ whorl, 16 to 19 and 824 to 1560 µm; second whorl, 22 to 29 and 1248 to 1880 µm; 2½ whorl, 32 to 40 and 1747 to 2400 µm; third whorl, 44 to 52 chambers and apical distance = 1830 to 2620 µm. Microspheric form: Diameter of test = 1.46 to 3.16 mm, thickness = 0.7 to 2.3 mm, diameter/thickness ratio = 2.1 to 2.6. surface diameter of pustules = 80 to 160 µm. Proloculus diameter = about 24 µm. Number of whorls and apical distances in 4 whorls as follows: first half whorl, 5 chambers and apical 56 µm, first whorl about 10 chambers and 128 µm; 1½ whorl, 14 to 15 and 232 µm; second whorl, 19 and 369 µm; 2½ whorl, 27 and 644 µm; third 3 whorl, 35 and 832 µm; 3½ whorl, 45 and 1123 µm; and 4^{th} whorl, 55 chambers with apical distance of 1456 µm.

Remarks: As well as distinctively different microspheric and megalospheric forms, *Ranikothalia nuttali* has a wide variation in proloculus diameter from small (figs. 1-5) to large (figs. 11, 13) and coiling from tight (figs. 1-4) to loose (figs. 5, 11). While it has been widely reported from Paleocene shallow water faunas of the Tethyan and Caribbean regions (Matsumaru and Sharma 2010) its variability, as well as its close similarity to coeval *Ranikothalia* species, has led to a complicated synonymy. The *Ranikothalia* material from the Pinugay Hill Section was originally assigned to *R. bermudezi* by Hashimoto et al. (1978), but re-examination identifies the megalospheric (fig. 5) and microspheric form (Hashimoto et al. 1974, pl. 9. fig. 1) of *Ranikothalia nuttalli* of station Assemblage 3. This species also occurs in Central Java, in a sample that Natori et al. (1978) initially placed in upper Eocene Tertiary b, but which yields other taxa such as *R. sindensis, Kathina selveri* and *Orbitoclypeus ramaraoi* that indicates Paleocene Tertiary a1.

Upper Paleocene (Thanetian), Tertiary a1.

Ranikothalia sindensis (Davies 1927)
Plate 9. figures 6-7, 9, 12, 15-16

Nummulites planulatus (Lamarck). – NUTTALL 1926, p. 114-116, fig. 1
Operculina canalifera d'Archiac. – NUTTALL 1926, p., 117-118, pl. 11, figs. 1-2.
Nummulites nuttalli var. *kohaticus* DAVIES 1927, p. 269, pl. 19, figs. 1-3, 5.
Operculina sindensis DAVIES 1927, p. 274-276, pl. 19, figs. 10-13.
Nummulites sindensis (Davies). – DAVIES 1937, p. 21-22, pl. 4, fig. 21.
Ranikothalia sahnii DAVIES 1952, p. 156, pl. 1, figs. 1, 4-5, 7-8. – BUTTERLIN 1969, p. 601-602, pl. 3, fig. 8.
Ranikothalia savitriae DAVIES 1952, p. 156-157, pl. 1, figs. 3, 6, 9-10. – BUTTERLIN 1969, p. 601-602, pl. 3, figs. 1, 5.
Operculinoides bermudezi (Palmer). – SACHS 1957, p. 107-113, pl. 14, figs. 21, 23.
Ranikothalia soldadodensis (Vaughan and Cole). – DROOGER 1960, p. 312-318, pl. 5, figs. 1-14.
Operculinoides canalifera sindensis (Davies). – HAYNES 1962, p. 92-95, pl. 17, figs. 1-5; pl. 18, figs. 1-7.
Operculina bermudezi (Palmer). – COLE 1966, p. 248, pl. 23, fig. 5.
Chordoperculinoides bermudezi (Palmer). – ARNI 1966, p. 340-345, pl. 1, figs. 1-6; pl. 2, figs. 1-12.
Ranikothalia bermudezi (Palmer). – BUTTERLIN 1969, p. 595-598, pl. 2, figs. 1-2; pl. 4, figs. 1-2, 5-9. – HASHIMOTO, MATSUMARU, and KURIHARA 1979, p. 70-71, pl. 9, figs. 5, 7, 10-11.
Ranikothalia solimanii BUTTERLIN 1969, p. 598-601, pl. 1, figs. 1-4; pl. 2, figs. 3-6.
Ranikothalia sindensis (Davies). – HOTTINGER 1977, p. 51, figs. A-C, E; pl. 17, figs. 2-3, 5-9. (nec. p. 51, fig. 16D; pl. 17, fig. 4);– BUTT 1991, p. 77-80, pl. 1, figs. 1-h; pl. 2, figs. A-g.
Ranikothalia nuttalli (Davies). – HOTTINGER 1977, p. 53, figs. 17A-G; pl. 17, figs. 1, 4.

PLATE 7

Fig. 1-2. Station F538, Mindanao; fig. 3-4. Station 7682301, Cagraray; fig. 5, Station 7451105a, and figs. 8, 9, 15, 20, Station 7451215, Pinugay area, Luzon; figs. 6, 7. Station CR37, Caramoan; figs. 10-12, Stations 91/Lkd/DR7, 86/Lkd/DR5, and 86/Lkd/DR6, Meghalaya, India (Matsumaru and Jauhri, 2003); fig. 13-14. Station MQ 2, Marinduque; fig. 16, Station 7682301, Cagraray; figs.17. 19, Stations A422 and A138, Caraballo, SE Luzon; fig. 18, Station 93, Myanmar (Matsumaru and Sarma, 2010).

1-4 *Miscellanea globularis* Rahaghi. 1, equatorial section of megalospheric specimen. 2-4, oblique sections, all ×40.

5-8 *Miscellanea primitiva* Rahaghi. 5, 7-8, oblique sections. 6, axial section. Fig. 5, ×40; 6, 8, ×10; 7, ×15.

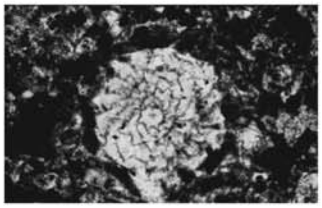
9-14 *Miscellanea miscella* (d'Archiac and Haime). 9-11,equatorial sections of megalospheric specimens. 12-14, axial sections of megalospheric specimens, all ×15

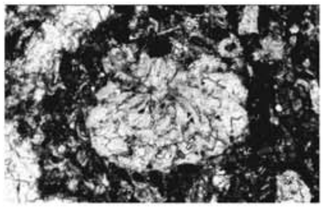
15 *Glomalveolina levis* Hottinger. Equatorial section of microspheric specimen, showing depressed form, ×45.

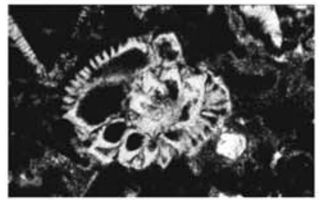
16 *Glomalveolina reicheri* Matsumaru, n. sp. Holotype, axial section of megalospheric specimen, ×70.

17, 18 *Orbitosiphon tibetica* (Douvillé). Megalospheric specimens: 17, axial section; 18, equatorial section, both ×40.

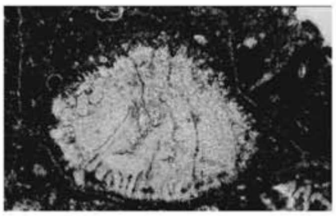
19, 20 *Orbitoclypeus ramaraoi* (Samanta). 19, oblique section. 20, axial section, both ×15


1

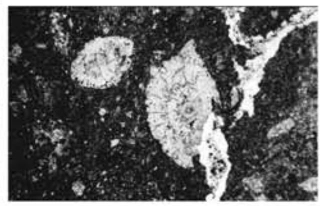

2

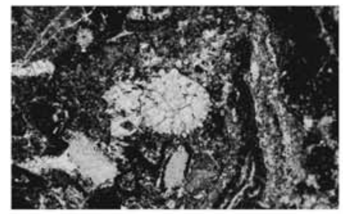

3

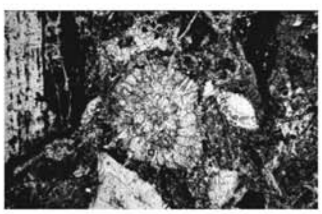

4

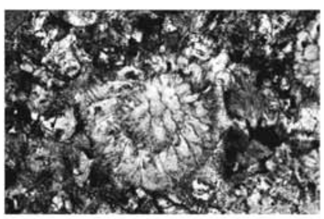

5

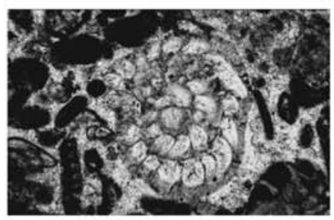

6

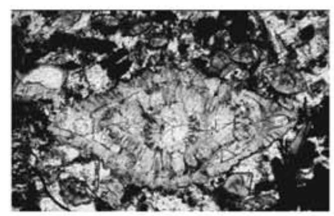

7

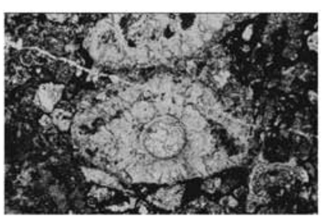

8


9

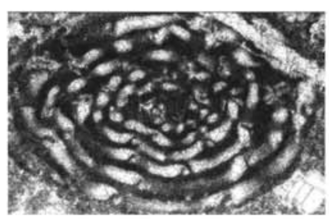

10

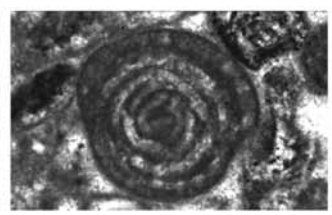

11

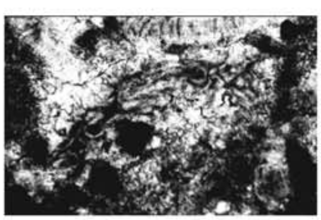

12

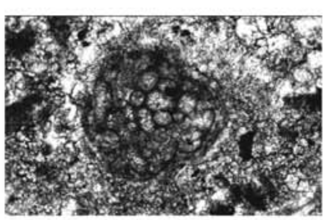

13

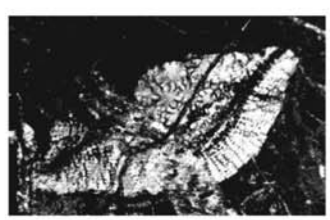

14

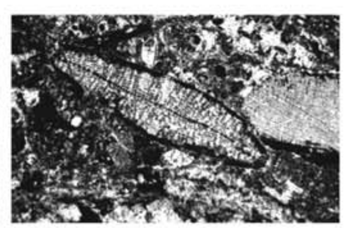

15


16


17


18


19


20

Description: Megalospheric and microspheric specimens have complanate compressed test with central small umbo covered by a few granules. Surface is smooth, with a strong marginal cord due to the extreame compression terminal chamber walls. Septal filaments with anastomozing central sections are created by the prolongation of septal walls to the surface of test. Megalospheric specimen have subspherical protoconch and reniform deuteroconch. Spires are tight coiled up to 1½ whorls, after which they become more loosely coiled. In the microspheric specimens the proloculus is spherical, and after first 1½ whorls the coiling is abruptly expanded. Chambers are higher than wide, and spiral walls are have regularly thickened, finely perforate radial lamella. Septa are regular and straight, slightly curved at the marginal rim. A massive, prismatic marginal cord forms a closely canalicular layer.

Dimensions: Megalospheric specimens have a diameter of 1.77 to 3.28 mm, thickness of 0.50 to 0.96 mm, and diameter /thickness ratio of 2.60 to 2.84; Surface diameter of pustule = 240 µm. Diameter of protoconch = 164 to 216 µm; deuteroconch = 168 to 170 µm. In three whorls, the number of chambers and distance from center along the "apical-frontal line" in the first half whorl (including embryonic chambers) has 5 to 6 chambers, and a distance of 296 to 520 µm; first whorl, 11 to 12 and 800 to 1061 µm; 1½ whorl, 19 to 20 and 1280 to 1560 µm; second whorl, 28 to 29 and 1740 to 2300 µm; 2½ whorl, 39 to 40 and 2280 to 2600 µm; 3rd whorl, 53 chambers and distance 2720 to 3280 µm. Microspheric specimen test diameter is 2.60 to 6.24 mm, thickness 0.81 to 1.00 mm, diameter/thickness ratio 2.60 to 7.61. Surface diameter of pustule = 80 to 360 µm. In 6 whorls, the number of chambers and apical-frontal distance in first half whorl is 5 and 80 to 125 µm; first whorl, 9 and 166 to 240 µm; 1½ whorl, 17 and 260 to 760 µm; second whorl, 17 to 21 and 400 to 1120 µm; 2½ whorl, 28 and 680 to 1640 µm; 3rd whorl, 37 and 1000 to 2520 µm; 3½ whorl, 47 and 1460 to 3520 µm; 4th whorl, 57 chambers and 1980 to 4480 µm; 4½ whorl, distance 2600 to 3760 µm; 5th whorl, 3360 to 4800 µm; 5½ whorl, 5800 µm; 6th whorl, 6240 µm.

Remarks: The Philippine specimens are smaller than *R. sindensis* (i.e., *Operculina canalifera sindensis*) from Libya (Haynes 1962), and the microspheric specimens resemble the specimens from Barbados (Hottinger 1977) in apical distance, while being smaller than *sindensis* from Pakistan (Nuttall 1926, fig. 1; Caudri 1934, pl. 1, fig. 9). It is distinguished from *R. nuttalli* (Davies) by its involute and thick lenticular test.

Upper Paleocene (Thanetian), Tertiary a1.

Genus *Assilina* d'Orbigny 1839

Assilina philippinensis Matsumaru, **n. sp.**
Plate 12, figures 16-18, 19 upper

Etymology: refers to distribution in the Philippines.

Type locality: Station 7451209, Pinugay Hill area, Luzon (text-fig. 5).

Holotype (fig. 17 right). Saitama Univ. Coll. no. 8900; paratype (fig. 16), no. 8901.

Description: Test large and discoidal with fairly sharp periphery. Surface is mainly smooth, with granules or pillars concentrated in the center and on septal filaments. Subspheical protoconch and reniform deuteroconch are followed by crowded rhombic chambers that increase in height rather than width. Septa thin, straight and radial, gently curved peripherally. The initial whorls in the axial section are completely enveloping. A distinct and well-developed marginal cord is seen on chamber peripery wall. Interseptal canals are linked with marginal canals and connect with the lateral lateral canals in superposed lateral walls, which are calcareous and lamellar.

PLATE 8

Fig. 1, Station 7451209 and figs. 12, 13, Station 7451105a, Pinugay Hill area; fig. 2. Station 7682301, Cagraray; figs. 3, 6. Station 93, Myanmar (Matsumaru and Sarma, 2010); fig. 4. Station E12, Mindanao; figs. 5, 11. Station CR35; figs. 7, 8, Station CR42, and fig. 17, Station CR36; Caramoan, Luzon; figs. 9, 10, 20, Station 86/Lkd/ DR5, and fig. 19, Station 91/Lkd/DR7, Meghalaya, India (Matsumaru and Jauhri, 2003); figs. 14-16, Station 31056, Bondoc, SE Luzon; fig. 18, Station MQ2, Marinduque.

1-6 *Daviesina danieli* Smout. 1, 2, axial sections. 3-5, oblique sections; 6, equatorial section. Figs 1, 4, 5, ×40; 2, 3, 6, ×30.

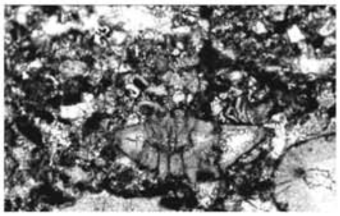
7-10 *Daviesina khatiyahi* Smout. 7, 10, oblique sections; 8, equatorial section; 9, axial section. Figs. 7, 8, ×40; 9, 10. ×15.

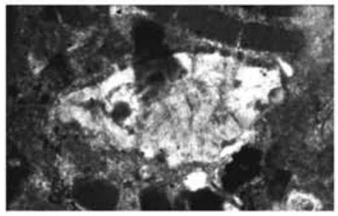
11-13 *Daviesina langhami* Smout. 11, axial section; 12, transverse section; 13, oblique section, all ×40.

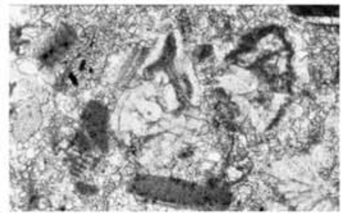
14-16 *Lockhartia conditi* (Nuttall). Oblique sections, ×40.

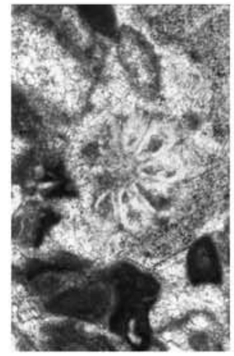
17-20 *Lockhartia haimei* (Davies). 17 right, equatorial section; 18. transverse section; 19, axial section. 20 center, oblique section, all ×15.

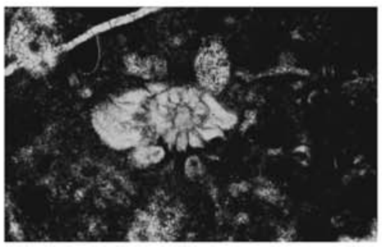
17,20 *Miscellanea primitiva* Rahaghi. 17 left, equatorial section; 20 left, upper and right, oblique and axial sections, ×15.

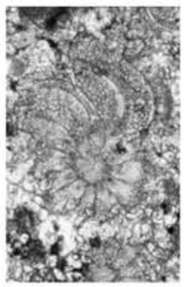

1

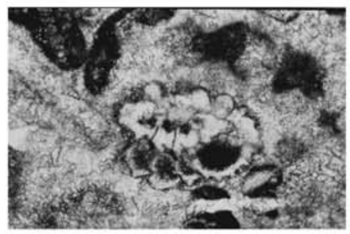

2

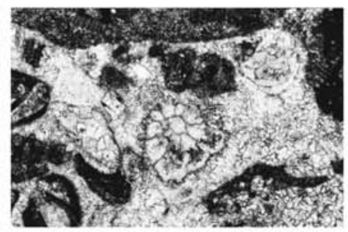

3

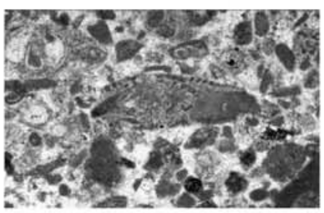

4

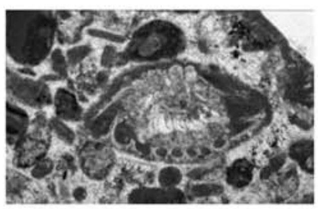

5

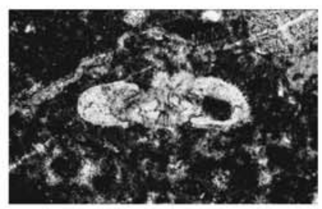

6

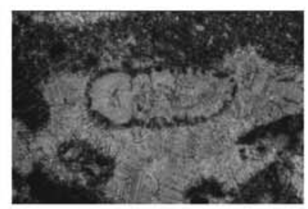

7

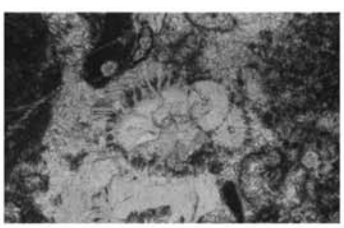

8

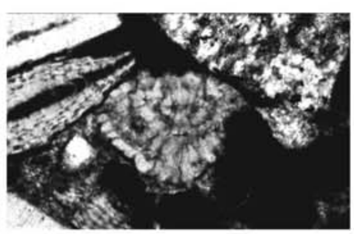

9

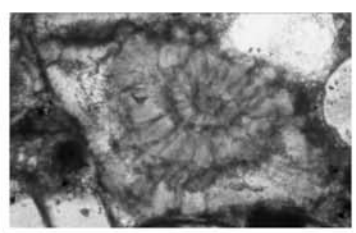

10


11

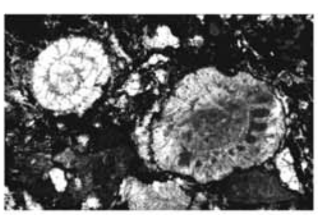

12

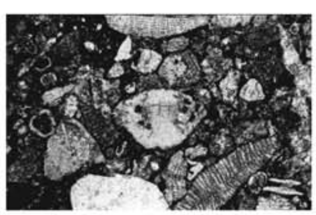

13

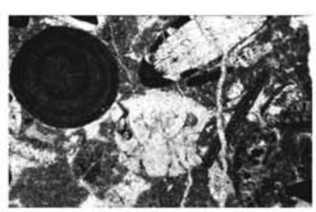

14

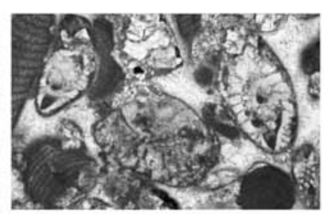

15


16


17


18


19


20

Dimensions: Diameter of test = 5.0 to 8.5 mm, thickness = 1.1 to 1.2 mm, diameter/thickness ratio = 6.9 to 7.6. In two specimens, protoconch diameter = 522 × 423 and 727 × 545, deuteroconch diameter = 500 × 181 and 636 × 254 µm. The number of chambers and the apical distance in the first half whorl is 4 to 5, and 610 to 727 µm; first whorl, 8 to 9 and 1591 to 1818 µm; 1½ whorl, 14 to 15 and 2045 to 2272 µm; second whorl, 21 to 24 and 2545 to 3363 µm; 2½ whorl, 31 to 36 and 3045 to 3863 µm; 3rd whorl, 44 and 3772 to 4363 µm; 3½ whorl, distance is 5272 µm; 4th whorl 5900 µm; 4½ whorl 7090 µm; and in 5th whorl 7636 µm. Diameter of pillars = 75 to 160 µm.

Remarks: Differs from *Assilina granulosa* de la Harpe and *Assilina laxispira* de la Harpe in its larger embryonic chambers and more or less greater apical distance to whorls.

Lower Eocene (Ypresian) to middle Eocene (Lutetian), Tertiary a2.

Assilina exponens (Sowerby 1840)
Plate 12, figures 20-21

Nummulites exponens SOWERBY 1840, p. 719, pl. 41, figs. 14a-e. – D'ARCHIAC and HAIME 1853, p. 148, pl. 10, figs. 1-10.
Nummulites mamillata d'Archiac. – D'ARCHIAC and HAIME 1853, p. 154, pl. 11, figs. 6-7.
Assilina exponens (Sowerby). – SCHAUB 1963, p. 294, fig. 5. – NEMKOV 1967, p. 257-258, pl. 41, figs. 1-12. – IONESI 1971, p. 218-219, pl. 16, figs. 1-5, 7-8. – BLONDEAU 1972, p. 171, pl. 38, figs. 8-10. – SCHAUB 1981, p. 213-215, fig. 116; pl. 92, figs. 1-20; pl. 93, figs. 1-15; pl. 94, figs. 1-34; tableau 18l. – MATSUMARU 2016, p. 13, fig. 5B, pl. 16, figs. 10-12.

Description: Test lenticular with sharp periphery; surface of test is smooth, except for pustules in the central part and on the septal filaments. Subspheric protoconch and reniform deuteroconch are followed by planispirally enrolled chambers that regularly increase in height rather than width, with a thick marginal cord. Septa are radial and straight, with a slight curve at the distal end. Wall is calcareous and lamellar.

Dimensions: Diameter of test = 6.3 to 7.5 mm, thickness = 1.2 mm, diameter/thickness ratio = 5.3 to 6.3; Diameter of protoconch = 340 × 360 µm, deuteroconch = 416 × 316 µm. The number of chambers and apical distance in first half whorl is 6 chambersa and 583 µm; first whorl, 12 and 1680 µm; 1½ whorls, 21 and 2083 µm; second whorl, 31 and 2666 µm; 2½ whorl, 42 and 3250 µm; third whorl, 58 and 3833 µm; 3½ whorl, 4500 µm; 4th whorl, 5666 µm; 4½ whorl 6583 µm; and 5th whorl, 7500 µm. Diameter of pillars = 100 to 160 µm.

Remarks: Assilina exponens in the Philippines is associated with fauna of Assemblage 5.

Middle Eocene (Lutetian to Bartonian), Tertiary a3.

Genus *Nummulites* Lamarck 1801

Nummulites globulus Leymerie 1846
Plate 14, figures 11-14

Nummulites globulus LEYMERIE 1846, p. 27, pl. 13, figs. 140a-d. – DONCIEU × 1926, p. 37, pl. 5, figs. 1-7. – IONESI 1971, p. 209-210, pl. 12, figs. 3-5, 7-9. – BLONDEAU 1972, p. 142, pl. 18, figs. 5-14. – MASSIEU × 1973, p. 92, pl. 14, figs. 10-16. – SCHAUB 1981, p. 137-138, pl. 40, figs. 1-80, tableau 1f. – MATSUMARU and SARMA 2010, p. 544, fig. 3, pl. 4, fig. 1. – MATSUMARU 2016, p. 12, fig. 5B, pl. 13, figs. 8-9.
Camerina variolaria Lamarck. DOORNINK 1932, p. 287-288, pl. 5, figs. 7-11, fig.b.
Camerina semiglobula DOORNINK 1932, p. 292-295, pl. 7, figs. 1-14, figs. D, e.
Camerina gerthi DOORNINK 1932, p. 296-297, pl. 7, figs. 15-21, fig. F.

Description: Test small and globular to inflated lenticular, with involute planispiral coiled whorls, slightly evolute in the last stage. The spherical to subspherical protoconch and reniform deuteroconch are followed by many simple and undivided chambers in each whorl. The septa are straight, with gentle backwards curve at the periphery. There is a distinct marginal cord with numerous superposed marginal canals. Intraseptal canals are connected with lateral canals in superposed lateral walls. The apex of the test has conical pillars. The wall is calcar-

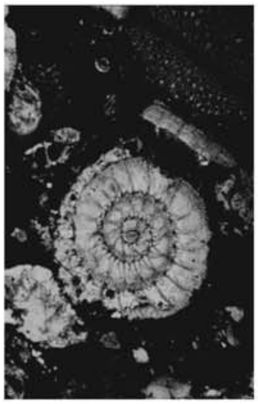
---

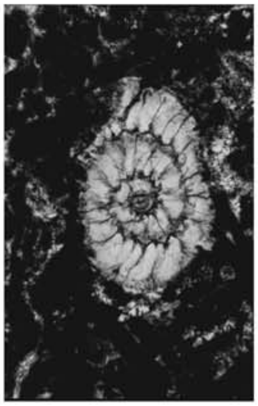
PLATE 9

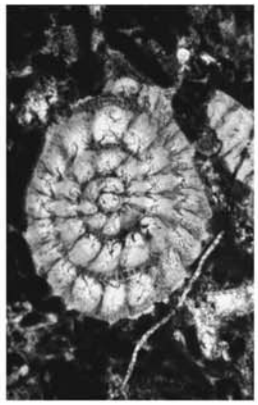
Figs. 1, 3, Station 422, Glagahamba (= Jatibungkus) Hill, Luk Ulo, Java (Natori 1978, p. 96), known as lower Eocene of South Seraju Mts (Van Bemmelen 1949, p. 104, tab. 26); figs. 2, 4, 8, 10, 14. Station A422, Caraballo, Luzon; figs. 5, 6, 16, Station 7451105a, Pinugay area, Luzon; figs. 7, 11, Station 91/Lkd/DR7, fig.13, Station 86/Lkd/DR9, and fig. 15, Station 91/Lkd/DR8+9; Meghalaya, India (Matsumaru and Jauhri, 2003); fig. 12, Station 93, Myanmar (Matsumaru and Sarma, 2010).

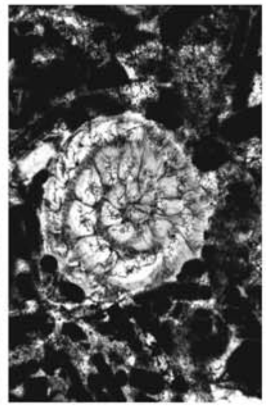
1-5, 8, 10, 11, 13, 14 — *Ranikothalia nuttalli* (Davies). Megalospheric specimens: 1-5, 8, 10-11, equatorial sections; 13, oblique section; 14, axial section. Fig. 1. ×10; 2-5, 8, 10, 13. ×15; 11, 14, ×20.

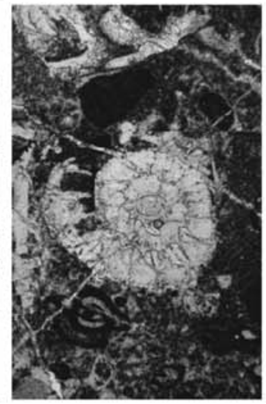
6, 7, 9, 12, 15, 16 — *Ranikothalia sindensis* (Davies). 6, 7, 9, equatorial sections of megalospheric specimens; 12, 15, axial sections of megalospheric specimens; 16, axial section of microspheric specimen. Figss 6, 15. ×20; 7, 16. ×10; 9, 12. ×15.

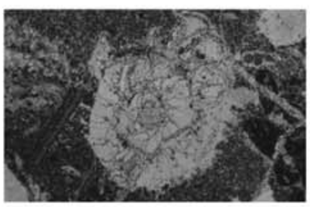

1


2

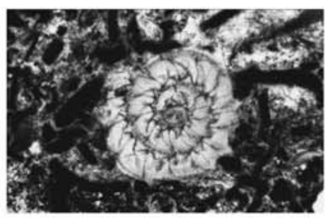

3


4

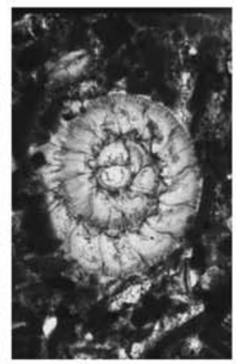

5

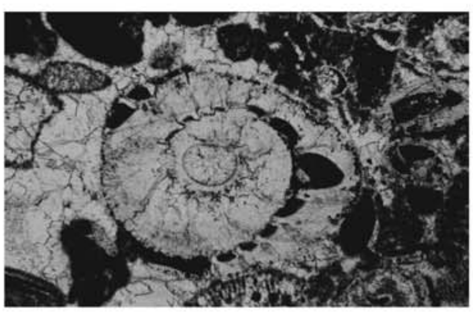

6


7

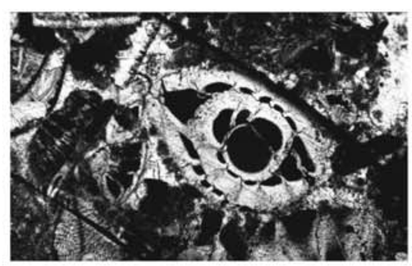

8

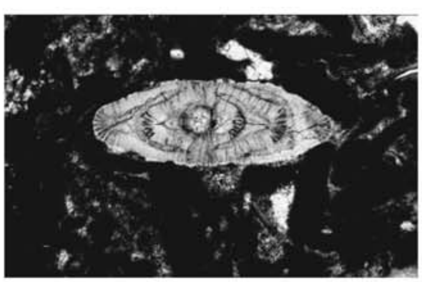

9


10

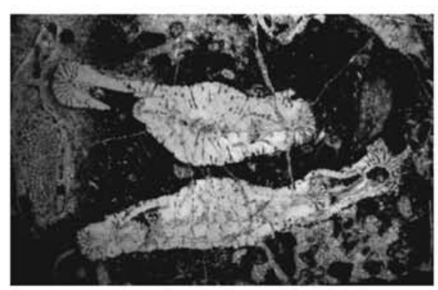

11


12


13


14


15


16

eous and lamellar, and interseptal foramina are formed at the base of the septa.

Dimensions: Diameter of test = 1.23 to 2.36 mm, thickness = 0.67 to 1.56 mm, diameter/thickness ratio = 1.40 to 2.14. In six specimens, diameter of protoconch = 80 × 75 to 220 × 230 µm, diameter of deuteroconch = 84 × 34 to 200 × 140 µm. In the first half whorl there are 5 to 6 chambers (inlcuding embryoinic) with apical distance of 130 × 300 µm; first whorl, 9 to 11 and 310 to 770 µm; 1½ whorl, 16 to 17 and 430 to 1170 µm; second whorl 23 to 25 and 540 to 1420 µm; 2½ whorl, 30 to 32 and 770 to 1640 µm; 3rd whorl, 39 to 44 and 930 to 1720 µm; 3½ whorl, 50 to 55 and 1020 to 1800 µm; 4th whorl. 2000 to 2300 µm. Diameter of pillar = 100 to 227 µm.

Remarks: Nummulites globulus, characterized by a globular test and tightly coiled and regular whorls, ranges from upper Paleocene to middle Eocene in the western Tethys (Nemkov 1967; Ionesi 1971). In the the Philippines it is found in many samples of Assemblage 4.

Lower Eocene (Ypresian) to lower Middle Eocene (Lutetian), Tertiary a2.

Nummulites atacicus Leymerie 1846
Plate 12, figure 19 lower; plate 13, figure 12 left; plate 14, figures 5-10, 11 right upper

Nummulites atacica LEYMERIE 1846, p. 358, pl. 13, figs. 13a-e.
Nummulites atacicus Leymerie. – DONCIEUX 1926, p. 29, figs. 9-14; pl. 3, figs. 20-28; pl. 4, figs. 1-5. – BLONDEAU 1972, p. 148, pl. 17, figs. 4-8. – MASSIEUX 1973, p. 91-92, pl. 14, figs. 1-9. – SCHAUB 1981, p. 119-120, pl. 25, figs. 1-51, tableau 14-i. – MATSUMARU and SARMA 2010, p. 544, fig. 3, pl. 4, fig.10; pl. 5, fig. 1. – MATSUMARU 2016, p. 8, 13, figs. 5A, 5B, pl. 13, figs. 10-11.
Camerina orbignyi Galeotti. – DOORNINK 1932, p. 289, pl. 6, figs. 1-6, fig. C.
Camerina densa DOORNINK 1932, p. 295, pl. 8, figs. 1-5.

Description: Test lenticular with acute margin and a smooth surface ornamented with pustules and peripherally curved radial, birfurcate septal filaments. Biloculine protoconch and deuteroconch are followed by numerous rhombic chambers per whorls; slightly curved septa are strongly re-curved at the periphery. The wall is calcareous and lamellar, and interseptal foramina are present at the base of the septa.

Dimensions: In megalospheric form, diameter of test = 2.08 to 2.80 mm, thickness = 1.22 to 1.57 mm, diameter/thickness ratio = 1.65 to 2.22. In seven specimens, diameter of protoconch = 374 × 322 to 504 × 448 µm, deuteroconch = 291 × 52 to 410 × 196 µm. In first half whorl, number of chambers and apical distance is 4 to 5, and 395 to 714 µm; first whorl, 8 to 10 and 790 to 1500 µm; 1½ whorl, 13 to 17 and 1233 to 1840 µm; second whorl, 20 to 25 and 1570 to 2240 µm; 2½ whorl, 26 to 35 and 1768 to 2628 µm; 3rd whorl, 42 to 47 and 2391 to 2620 µm; 3½ whorl, 56 to 61 and 2956 to 3340 µm; 4th whorl, 68 to 73 and 3130 to 3720 µm. Diameter of pillar = 160 to 220 µm. In microspheric form, diameter of test = 5.84 to 10.50 mm, thickness = 2.00 to 3.32 mm, diameter/thickness ratio = 2.92 to 3.16.

Remarks: Because of the regular thin septa and regular rhombic chambers, *Camerina orbignyi* Galeotti and *C. densa* Doornink from Java (Doornink 1932) belong to the megalospheric and microspheric forms of *Nummulites atacicus*.

Lower Eocene (Ypresian) to middle Eocene (Lutetian), Tertiary a2.

Nummulites burdigalensis de la Harpe 1926
Plate 15, figures 8-13

Nummulites sp. YABE and HANZAWA 1925, p. 79-80, pl. 1, fig. 6; pl. 2, figs. 2-4, 7-8; pl. 3, fig. 6; pl. 4, figs. 2-4; pl. 5, figs. 1, 8-12.
Nummulites burdigalensis DE LA HARPE 1926, p. 71. – SCHAUB 1951, p. 113, figs. 13, 74-81, 83-88, 92-95; pl. 1, figs. 13-17; pl. 2, figs. 1-3, 5-8; pl. 3, figs, 1, 3-5. – BLONDEAU 1972, p. 159, pl. 32, figs. 11-14. – SCHAUB 1981, p. 79-81, fig. 72, pl. 4, figs. 10-12; pl. 5, figs. 1-18, 27-31, 46-51; tab. 2d.

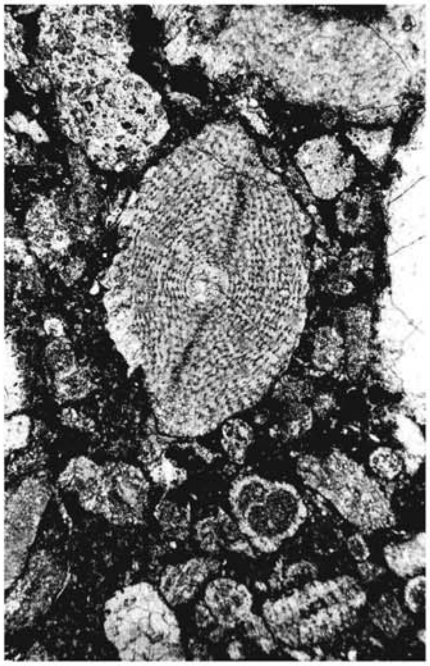
Description: Test thick, lenticular, with acute periphery and a smooth surface showing straight or slightly cutrved radial septal filaments ornamented with spirally arranged pustules. The spherical to subspherical protoconch and reniform deuteroconch are followed by numerous, typically rhombic chambers

PLATE 10

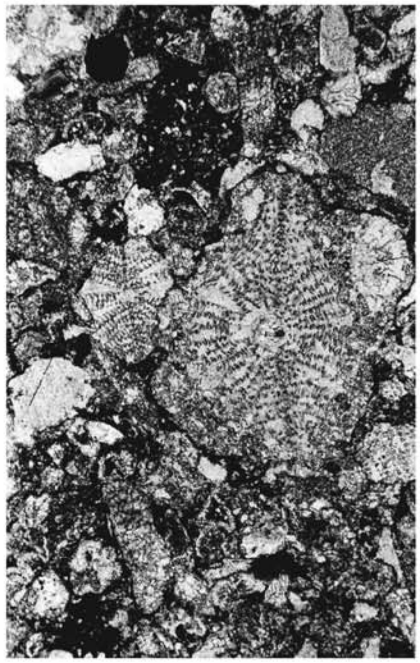
Figs. 1, 2, 7, Station MQ 2, Marinduque; fig. 3, Station 422, Glaghamba (=Jatibungkus) Hill, Luk Ulo, Java (Natori 1978); figs. 4, 8, Station 93, Myanmar (Matsumaru and Sarma, 2010); fig. 5, Station 86/Lkd/DR9; fig. 6, Station 91/Lkd/DR7; and fig. 9, Station 86/Lkd/DR5, Meghalaya, India (Matsumaru and Jauhri, 2003).

1-9 *Orbitoclypeus ramaraoi* (Samanta). 1, 2, 4, 5, oblique sections of megalospheric specimen; 6, equatorial section of megalospheric specimen, showing *Discocyclina variance* (Kaufmann, 1867) type adauxiliary chambers; 7, 8, axial sections of microspheric specimen; 9, axial section of megalospheric specimen. Figs 1, 2, 5, ×30; 4, ×50; 6,. ×100; 7-9, ×20.

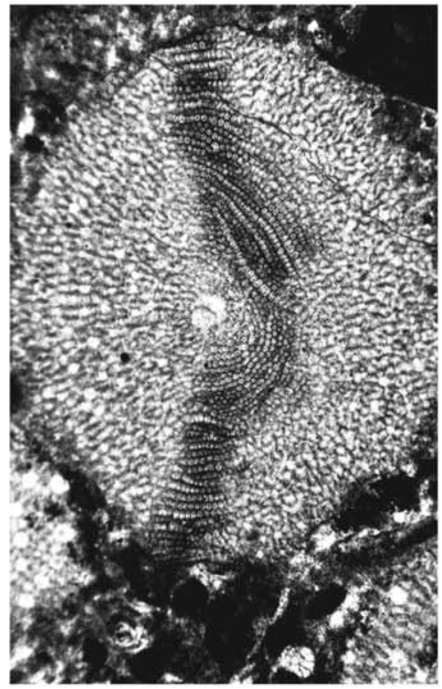
3 Oblique section of megalospheric specimen, showing adauxiliary chambers, ×30. See *Discocyclina daguini* Neumann, 1958 and *D. pygmaeus* Henrici, 1934, compared to *Orbitoclypeus ramaraoi* (Samanta).



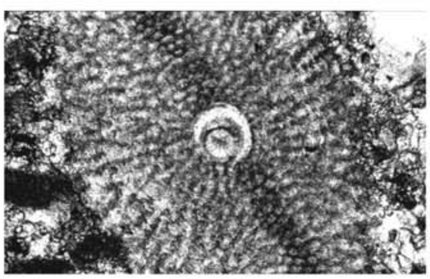
1



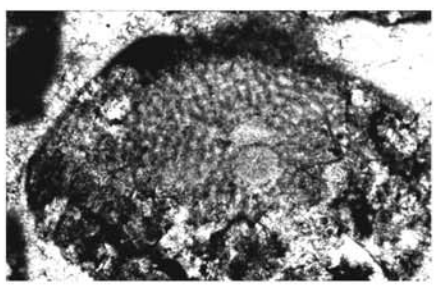
2



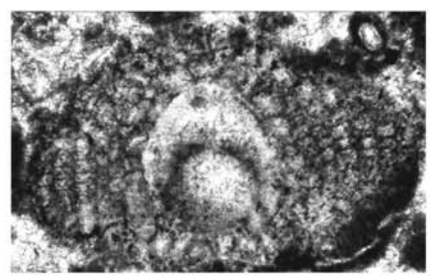
3



4

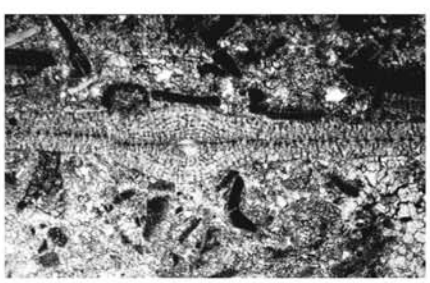


5



6

7



8

9

in tight coils, loosening in the last whorl. The wall is calcareous and lamellar.

Dimensions: In megalospheric form, diameter of test = 1.60 to 3.00 mm, thickness = 0.80 to 1.40 mm, diameter/thickness ratio = 1.91 to 3.25. In six specimens, diameter of protoconch = 160 × 150 to 304 × 230 µm, deuteroconch = 140 × 113 to 290 × 145 µm. In the first half whorl, the number of chambers and apical distance is 5 to 6 and 270 to 310 µm; first whorl, 9 to 11 and 600 to 900 µm; 1½ whorl, 15 to 18 and 930 to 1100 µm; second whorl, 22 to 26 and 1220 to 1430 µm; 2½ whorl, 30 to 35 and 1510 to 1720; 3rd whorl, 42 to 46 and 1810 to 2110 µm; 3½ whorl, 50 to 56 and 2180 to 2510 µm; 4th whorl, 60 to 66 and 2250 to 2810 µm; 4½ whorl, 70 to 75 and 2870 to 3040 µm; 5th whorl, 81 and 3130 µm; 5½ whorl, 94 and 3360 µm. Diameter of pillar = 140 to 190 µm. Microspheric form: diameter of test = 6.16 mm, thickness = 2.5 mm, diameter/thickness ratio = 2.5. Proloculus diameter = 20 × 20 µm. Number of chambers and apical distance in first half whorl, 6 and 56 µm; first whorl, 10 and 136 µm; 1½ whorl, 17 and 204 µm; second whorl, 23 and 272 µm; 2½ whorl, 32 and 409 µm; 3rd whorl, 40 and 522 µm; 3½ whorl 48 and 681 µm; 4th whorl, 56 and 863 µm; 4½ whorl, 66 and 1090 µm; 5th whorl, 76 and 1386 µm; 5½ whorl, 85 and 1800 µm; 6th whorl, 94 and 2113 µm; 6½ whorl, 107 and 2545 µm; 7th whorl, 118 and 3000 µm; 7½ whorl, 132 and 3409 µm; 8th whorl, 3818 µm; 8½ whorl, 4227 µm; 9th whorl, 4727 µm; 9½ whorl, 5010 µm; 10th whorl, 5410 µm; 10½ whorl, 5681 µm. Diameter of pillars = 180 µm.

Remarks: Nummulites burdigalensis from Assemblage 4, identified by regularly coiled whorls, rhombic chambers and thick spiral walls, is also recorded from the lower and middle Eocene of Russia (Nemkov 1967) and the western Tethys (Blondeau 1872; Schaub 1981).

Lower Eocene (Ypresian) to middle Eocene (Lutetian), Tertiary a2.

Nummulites distans Deshayes 1838
Plate 13, figures 10 right, 11, 12 right

Nummulites distans DESHAYES 1838, p. 68, pl. 5, figs. 20-22. – NEMKOV 1967, p. 127-128, pl. 8, figs. 1-10. – BLONDEAU 1972, p. 131, pl. 11, fig. 11; pl. 12, figs. 6-11. – SCHAUB 1981, p. 184-185, pl. 66, figs. 49-51, pl. 67, figs. 1-9, figs. 108-109, tabl. 12g.
Camerina bagelensis Verbeek 1891 – DOORNINK 1932, pl. 2, figs. 3-8 (non 9).

Description: Test thick, lenticular with acute periphery with a smooth surface; septal filament are apically compacted, radiate and bifurcate towards the periphery. The subspherical protoconch and reniform deuteroconch are followed by numerous falciform chambers. The spire increases regularly and septa are radial and gently curved to the periphery. The wall is calcareous and lamellar.

Dimensions: In megalospheric form, diameter of test = 3.00 to 5.10 mm, thickness = 2.75 to 3.03 mm, diameter/thickness ratio = 1.56 to 1.71. In eight specimens, diameter of protoconch = 595 × 547 to 770 × 589 µm, deuteroconch = 381 × 169 to 722 × 220 µm. The number of chambers and apical distance in first half chamber is 5 and 703 to 1360 µm; first whorl, 8 to 9 and 1491 to 2720 µm; 1½ whorl, 14 to 15 and 2076 to 3896 µm; second whorl, 20 to 21 and 2500 to 4280 µm; 2½ whorl, 28 to 30 and 2900 to 4560 µm; third whorl, 37 to 39 and 3274 to 4880 µm; 3½ whorl, 3813 to 4960 µm. In microspheric form, diameter of test is up to 23.0 mm, thickness = 2.5 to 3.0 mm, diameter/thickness ratio = 7.7.

Remarks: Nummulites distans, with its characteristic growth ratio, is part of the distinctive nummulite-rich fauna in Assemblage 4 (table 2).

Lower Eocene (Ypresian) to middle Eocene (Lutetian), Tertiary a2.

Nummulites striatus (Bruguière 1792)
Plate 15, figures 5-7

Camerina striata BRUGUIÈRE 1792, p. 399.
Nummulites striata d'Orbigny. - D'ARCHIAC and HAIME 1853, p. 135, pl. 8, figs. 9-12.

PLATE 11

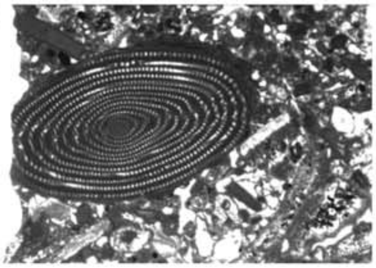
Figs, 1, 6, Station 7682301, Cagraray; fig. 2. Station I-6, Mindanao; figs. 3, 4. Station 7451215; fig. 7, Station 7451209; and figs. 8-14, Station 7451213; Pinugay Hill area, Luzon; fig. 5, Station CR51, Caramoan Peninsula/

1 *Alveolina ellipsoidalis* Schwager. Axial section, ×10.

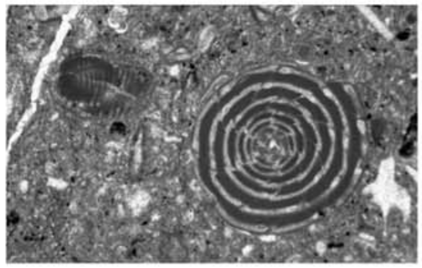
2-4 *Alveolina subpyrenaica* Leymerie. 2, equatorial section of megalospheric specimen, ×20; 3, tangential section; 4, oblique section, both ×10.

5,6 *Alveolina vredenburgi* Davies. 5, 6 right, axial sections of megalospheric specimen. 6 left. oblique section, all ×10.

7-14 *Alveolina luzonensis* Matsumaru, n. sp. Fig. 7 (holotype), 9 (paratype), 10 left, 11, 12, axial sections of megalospheric specimens, in which 7-9 are A1 schizont and 10-12 are A2 gamont; 10 right, transverse section; 13a, b,14 (paratypes), equatorial sections of megalospheric specimens, in which 13 is A2 gamont and 14 is A1 schizont. Figs. 7-12, 13a. ×20; 13b, 14, ×50.

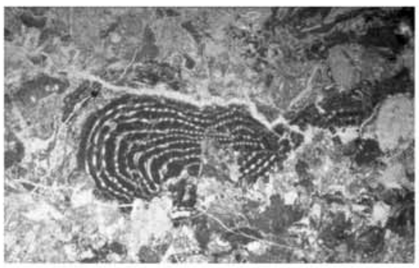


1

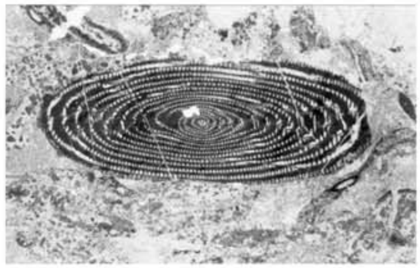


2

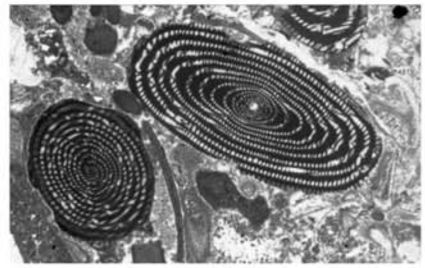
3



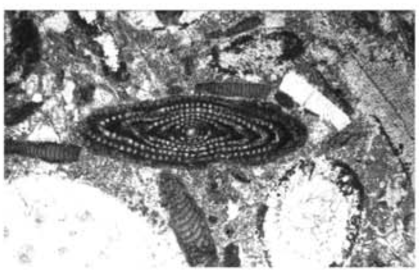
4



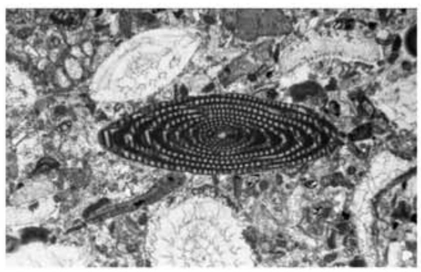
5



6



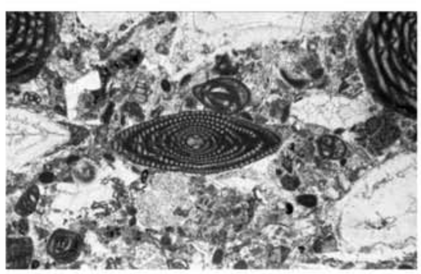
7



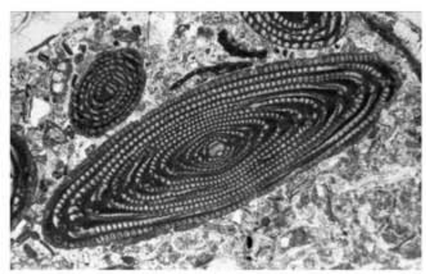
8

9

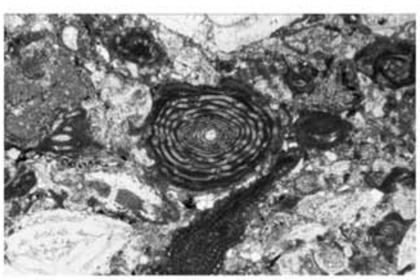
10



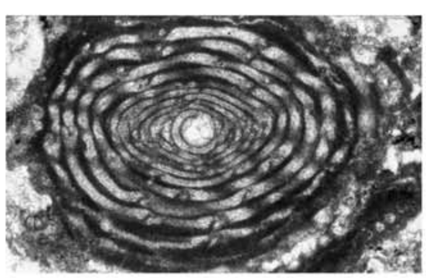
11



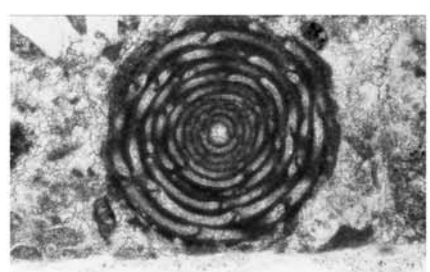
12



13a



13b



14

Nummulites pengaronensis VERBEEK 1871, p. 3-6, pl. 1, figs. 1a-k. – MATSUMARU 1996, p. 84, 88, 90, pl. 21, figs. 3-5; pl. 23, figs. 3-4; pl. 27, figs. 1-2, figs. 26-5, 28.
Nummulites striatus Bruguière sp. – BOUSSAC 1911, p. 40-45, fig. 8.
Nummulites striatus (Bruguière). – NEMKOV 1967, p. 209-213, pl. 28, figs. 1-11. – HANZAWA 1957, p. 41-42, pl. 1, figs. 1-3, 9-11. – BLONDEAU 1972, p. 148, pl. 24, figs. 1-10. – SCHAUB 1981, p. 153-154, pl. 53, figs. 26-31, tableau 14s.
Camerina saipanensis COLE 1953, p. 20-21, pl. 2, figs. 7-19. – COLE 1957, p. 330, pl. 102, fig. 20.
Camerina pengaronensis (Verbeek). – COLE 1957, p. 753-754, pl. 231, figs. 1-17.
Nummulites sp. – CHANG 1972, p. 111, pl. 3, figs. 1-2, 4; pl. 4, figs.1-3.

Description: Test thick, lenticular, evenly biconvex with acute periphery. The surface of test is smooth,with straight radial septal filaments. The spire is closely coiled and regular. Subspheric protoconch and reniform deuteroconch are followed by numerous chambers per whorl. The septa are curved toward the periphery for 3/4 of their length. Wall calcareous, lamellar.

Dimensions: Megalospheric form: diameter of test = 1.3 to 4.1 mm, thickness = 0.92 to 1.35 mm, diameter/thickness ratio = 1.38 to 2.20. In four specimens, diameter of protoconch = 102 × 97, 116 × 104, 116 × 114 and 146 × 133 µm, deuteroconch = 109 × 60, 139 × 78, 122 × 100 and 146 × 75 µm. In the first half whorl the number of chambers and apical distance is 5 and 286 to 426 µm; in first whorl, 9 to 10 and 499 to 582 µm; 1½ whorl, 15 to 17 and 676 to 790 µm; second whorl, 21 to 22 and 874 to 998 µm; 2½ whorl, 30 to 32 and 1123 to 1227 µm; 3rd whorl, 38 to 42 and 1269 to 1435 µm; 3½ whorl, 48 and 1498 to 1122 µm; 4th whorl, 58 and 1810 µm; 4½ whorl, 67 and 1955 µm. Diameter of pillar = 38 to 100 µm.

Remarks: Nummulites striatus was assigned to *Nummulites pengaronensis* in Indonesia (Doornink 1932), Eniwetok Atoll (Cole 1957), Rota Island (Hanzawa 1957) and Haha-Jima, Ogasawara Islands (Matsumaru 1996).

Middle Eocene (Lutetian to Bartonian), Tertiary a3.

Nummulites ptukhiani Kacharava 1969
Plate 16, figures 1-6

Nummulites cf. *N. praefabianui* VARENTSOV and MENNER 1953, p. 15, pl. 1. – SCHWEIGHAUSER 1953, p. 14-15.
Nummulites praefabianii Varentsov and Menner. – PTUKHIAN 1964, pl. 1, figs. 5-8. – BLONDEAU 1972, p. 155, pl. 28, figs. 8-20, pl. 29, fig. 1. – HERB and HEKEL 1973, p. 432-434.
Nummulites ptuchiani KACHARAVA 1969, p. 497. – SCHAUB 1981, p. 125-126, pl. 49, figs. 33-48, tableau 15h. – BASSIONI, ALLAM, BOUKHARY and ZALAT 1988, p. 617-618, pl. 1, figs. 1-21.- MATSUMARU and SARMA 2010, p. 544, fig. 3, pl. 4, fig. 3.

Description: Test thick and lenticular with smooth surface, but with reticulate mesh, central plugs and isolated and combined granules in the spiral whorls. The spire is closely coiled. Subspherical protoconch and reniform deuteroconch are followed by many lozenge shaped chambers that are wider than high. Septa are radial and straight, slightly curved backwards toward the periphery. The wall is calcareous, lamellar and finely perforate.

Dimensions: Diameter of test = 1.50 to 2.88 mm, thickness = 1.0 mm; diameter of protoconch = 136 × 90 µm, diameter of deuteroconch = 131 × 45 µm. The number of chambers and the apical distance in the first half whorl is 5, and 160 to 272 µm; first whorl 9 to 10, 340 to 500 µm; 1½ whorl, 15 and 477 to 656 µm; second whorl, 21 and 636 to 818 µm; 2½ whorl, 28 and 795 to 931 µm; third whorl, 36 and 954 to 1022 µm; 3½ whorl, 44 to 45 and 1045 to 1147 µm; 4th whorl, 54 to 55 and 1227 to 1284 µm; 4½ whorl, 62 to 65 and 1420 to 1454 µm; 5th whorl, 75 and 1568 to 1636 µm; 5½ whorl, 87 and 1704 to 1863 µm; 6th whorl,

---

PLATE 12

Figs. 1, 2, Station 7451215; figs. 6, 10, Station 7451209; figs. 7-9, 12-19, Station 7451212, and fig. 11, Station 7451213; Pinugay Hill area, Luzon; figs. 3, 4, Station 31056; Bondoc Peninsula; fig. 5, Station 120902, Catanduanes

1,2 *Alveolina amarassiensis* (Henrici). Axial sections, ×40.

3-5 *Asterocyclina incisuricamerata* Cole. 3, 4, equatorial sections of megalospheric specimen; 5, axial section of microspheric specimen; 3, 4, ×40; 5, ×20.

6,7 *Asterocyclina stella* (Gümbel). 6, equatorial section of megalospheric specimen; 7, equatorial section of microspheric specimen, both ×20.

8-10 *Asterocyclina stellata* (d'Archiac). 8, 9, equatorial sections of megalospheric specimens; 10, axial section of microspheric specimen. 8, 9, ×40; 10, ×20.

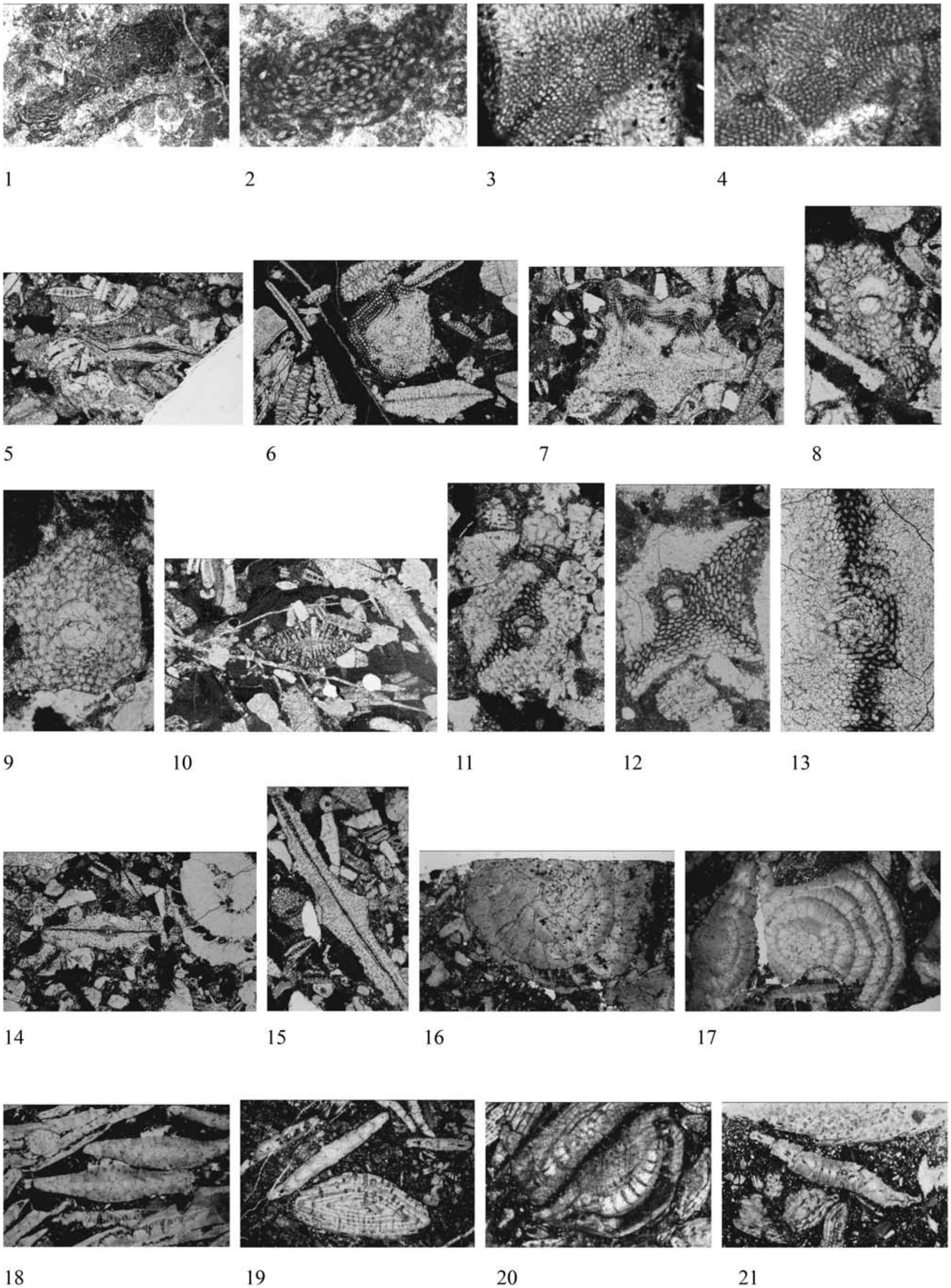
11-15 *Asterocyclina pinugayensis* Matsumaru, n. sp. Fig 11 (paratype), 12 (holotype), 13, equatorial sections of megalospheric specimen; 14 left, axial section of megalospheric specimen; 15, axial section of microspheric specimen. 11-13, ×40; 14-15, ×20.

14 *Operculina custugensis* Massieux. 14 right, tangential section, ×20.

16-19 *Assilina philippinensis* Matsumaru, n. sp. 16 (paratype), 17 right (holotype), equatorial sections of megalospheric specimens; 17 left, oblique section; 18, 19 upper, axial sections, all ×5.

19 *Nummulites atacicus* Leymerie. 19 lower, oblique section, ×5.

20,21 *Assilina exponens* (Sowerby). 20, equatorial section. 21, axial section, both ×5.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

1840 to 2000 µm. Width of chambers = 160 to 280 µm; height of chambers = 140 to 160 µm.

Remarks: Nummulites ptukhiani is considered to be the ancestor of *Nummulites fabianii* (Prever), and is known from the upper middle Eocene of the western Tethys (Schaub 1981; Bassiouni et al. 1988).

Middle Eocene (Lutetian to Bartonian), Tertiary a3.

Suborder MILIOLINA Delage and Herouard 1896
Superfamily SORITACEA Ehrenberg 1839
Family SORITIDAE Ehrenberg 1839
Genus *Sorites* Ehrenberg 1839

Sorites orbiculus (Forskål 1775)
Plate 1, figures 4

Sorites orbiculus (Forskål 1775). – MATSUMARU 1996, p. 222-223, pl. 87, figs. 11-13.

Description: Test small, flabelliform, 1.06 mm in diameter. Subspherical proloculus, 104 × 103 µm in diameter, is followed by a long tubuler and somewhat flattened chamber without sub-epidermal partitions. Later chambers are arcuate, in planispiral whorls that become more evolute in later stages; the chambers aternate in position in equatorial sections. Chamber walls are perforated by basal pores or stolons. The wall is calcitic, microgranular and imperforate.

Remarks: Although incompletely preserved, the Philippine material is similar to *Sorites orbiculus* of the same age from Chichi-Jima, Ogasawara Island (Matsumaru 1996).

Upper Oligocene (Chattian), Tertiary e3.

Subfamily PRAERHAPIDIONININAE Hamaoui and Fourcade 1973
Genus *Praerhapydionina* van Wessem 1943

Praerhapydionina boninensis Matsumaru 1996
Plate 1, figure 1

Praerhapidionina boninensis MATSUMARU 1996, p. 223-224, pl. 87, figs. 3-10.

Description: Test elongate, subconical. Early chambers tiny and obscure. Later chambers are planispirally coiled in uniserial whorls of about 13 chambers each. The arched semicircular chambers are subdivided by a few vertical radial septula that project inward from the periphery. The wall is calcareous, imperforate and porcellaneous. Apertures at the end of each uniserial chamber are probably central pores.

Dimensions: Test length = 1.78 mm, diameter of uniserial chambers = 0.52 to 0.58 mm; ratio of test diameter to length = 0.29 to 0.33.

Remarks: The material from sample h 2518, West Bontoc (text-fig. 25) is ill preserved but similar to *Praerhapydionina boninensis* of the same age from Chichi-Jima, Ogasawara Islands (Matsumaru 1996).

Upper Oligocene (Chattian), Tertiary e3.

Subfamily OPERTORBITOLITINAE Loeblich and Tappan 1986
Genus *Opertorbitolites* Nuttall 1925

Opertorbitolites douvillei Nuttall 1925
Plate 5, figure 12 upper

Opertorbitolites douvillei NUTTALL 1925, p. 447-448, pl. 27, figs. 4-7.

PLATE 13

Figs. 1, 2, 4, 5, 7, 8, Station A408, Caraballo, SE Luzon; figs. 10-12, Station 6611806, Caramoan Peninsula; figs. 3, 6. Station Hongo (Yabe and Hanzawa, 1925) and fig. 9, Station Junbaru; Amakusa-Shimoshima, Japan (Matsumaru, 1971).

1-6 *Nummulites amakusensis* Yabe and Hanzawa. 1-3, equatorial sections of megalospheric specimen (A2 form, gamont). 4, equatorial, oblique and axial sections of megalospheric specimens (A2 form, gamont). 5 upper, axial section of microspheric specimen B form, agamont), and equatorial, oblique and axial sections of megalospheric specimen (5 lower: A2 form, gamont). 6 (topotype), equatorial section of microspheric specimen. Figs. 1-3, ×15; 4-6, ×5.

2,3 *Nummulites hongoensis* Hanzawa. 2 lower., equatorial section of megalospheric specimen. 3 right, tangential section of megalospheric specimen, both ×15.

7-9 *Nummulites junbarensis* Matsumaru 7, 8 lower, oblique sections of megalospheric specimen. 8 upper, oblique section of microspheric specimen. 9 (holotyper). Equatorial section of megalospheric specimen. Figs. 7, 9, ×15; 8, ×5.

10-12 *Nummulites distans* Deshayes. 10 right, 11, equatorial sections of megalospheric specimen. 12 right, oblique section of megalospheric specimen, all ×10.

10 *Operculina custugensis* Massiuex. 10 left, oblique section, ×10.

12 *Nummulites atacicus* Leymerie. 12 left, equatorial section of megalospheric specimen, ×10.

12 *Asterocyclina stella* (Gümbel). 12 left corner, oblique section of megalospheric specimen, ×10.

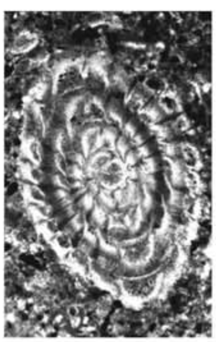
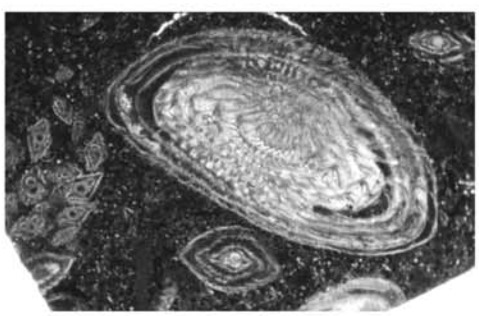
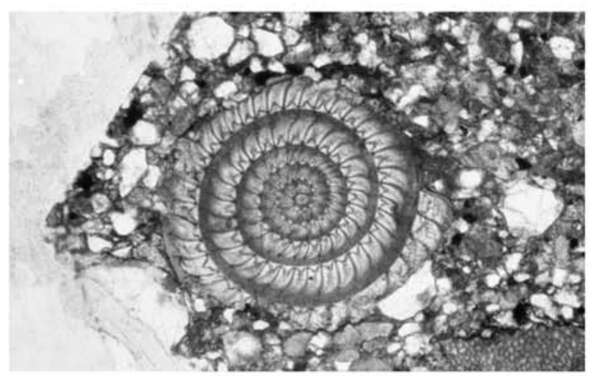
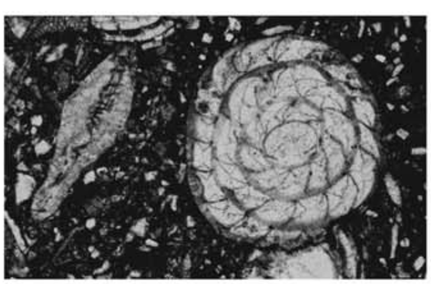
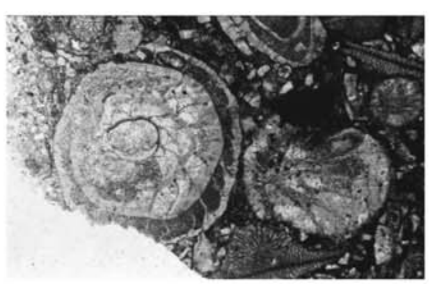
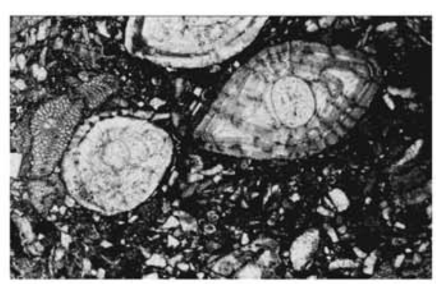

1

2

3

4

5

6

7

8

9

10

11

12

Orbitolites douvilléi (Nuttall). – LEHMANN 1961, p. 630-633, pl. 7, figs. 1-10.

Description: Test thin, lenticular , circular in outline, with subspherical protoconch and reniform deuteroconch. Cyclic chambers in the equatorial layer are subdivided by septula into numerous small chamberlets, alternating in successive cycles. Chamberlets within a cycle are not interconnected, but those of successive cycles are connected by oblique stolons. The thick lamellae are devoid of structure and completely covered on both sides of the equatorial layer. The wall is calcareous, imperforate and porcellaneous.

Dimensions: Diameter of test = 1.82 to 2.50 mm, thickness = 0.30 to 0.45 mm, diameter/thickness ratio = 5.6 to 8.3. In two specimens, diameter of protoconch = 110 × 100 and 110 × 105 µm, deuteroconch =110 × 45 and 150 × 50 µm, ratio of deuteoconch/protoconch diameter = 1.00 to 1.36, lamellar thickness = 0.19 to 0.22 mm. Tangential × radial diameter of chamberlets near periphery in equatorial section = 53 × 53 to 54 × 55 µm.

Remarks: While rare in Assemblage 4 it is recorded from lower to middle Eocene in India (Nuttall 1925; Nagappa 1959; Serra-Kiel et al. 1998; Matsumaru and Jauhri 2003).

Lower Eocene (Ypresian),Tertiary a2.

Family MEANDROPSINIDAE Henson 1948

Genus ***Hashimotoina*** Matsumaru, **n. gen.**
Type species: *Hashimotoina mindanaoensis* Matsumaru, n. sp.

Etymology: in honor of the late Dr. Wataru Hashimoto, a senior co-worker for many years in studies of larger foraminiferal biostratigraphy.

Diagnosis: Peneroplid-like genus characterized by thick lenticular test and planispirally enrolled that are involute in the early stage, uncoiling rapidly and increasing in breadth with strongly arched, upward-flaring height to become operculiniform in the later stage. The marginal zone of chambers in the final whorl occasionally shows interseptal pillars or secondary septula. The aperture is a simple opening at the base of the apertural face, some with a lip. Monospecific, middle Paleocene.

Comparison: This genus resembles *Hottingerina* Drobne 1975, but differs the absence of an umbilical depression or chambers subdivided by thin epidermal septula.

Hashimotoina mindanaoensis Matsumaru, **n. sp**.
Plate 5, figures 8-11

Etymology: refers to type area.

Type locality: Station G316, East Mindanao (text-fig. 22).

Holotype (fig. 11), Saitama Univ. Coll. no. 8868; paratype (fig. 11 left), no. 8869.

Description: Test thick lenticular with flaring, evolute and thin lobes. Spherical proloculus is followed by four involute planispiral coils formed of numerous chambers, that become uncoiled, flaring and evolute in the later stage. Outer wall and septula are thin, calcareous and porcelaneous. The aperture is a simple opening in the apertural face.

Dimensions: Diameter of test = 1.02 to 1.83 mm, thickness = 0.48 to 0.59 mm, diameter/thickness ratio = 2.13 to 2.69; proloculus diameter = 112 × 112 µm; diameter of second chamber = 90 × 44 µm. In the first whorl the number of chambers and the apical distance are 9 and 188 µm; second whorl, 15 and 295 µm; 3rd whorl, 16 and 454 µm; 4th whorl, 23 and 704 µm. Chambers of 4½ whorl are 113 µm wide and and 21 µm high.

PLATE 14

Figs. 1-4 from Station 31055, Bondoc Peninsula; fig. 5, Station 7451213, and figs. 8, 11-14, Station 7451209, Pinugay area; figs. 6-7, 9, Station 6611806, and fig. 10, Station CR 75, Caramoan Peninsula; figs. 15, 16, Station A408, Caraballo, Luzon.

1-4 *Nummulites millecaput* Boubée. 1-3, equatorial sections of megalospheric specimens. 4, axial section of microspheric specimen. Figs. 1-3, ×10; 4, ×5.

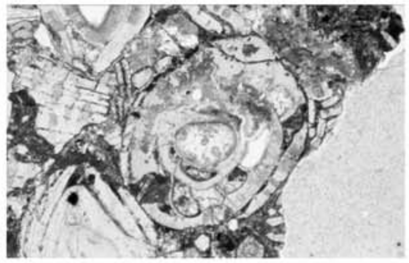
5-11 *Nummulites atacicus* Leymerie. 5-9, equatorial sections of megalospheric specimen. 10, axial section of megalospheric specimen. 11 right upper, oblique section of megalospheric specimen, all ×10.

11-14 *Nummulites globulus* Leymerie. 11 center,12, 13 center, 14 center, equatorial sections of megalospheric specimens. 13 left and right, oblique sections. 14 right upper, axial sections of megalospheric specimens. Figs. 11, 13, 14, ×10; 12, ×20.

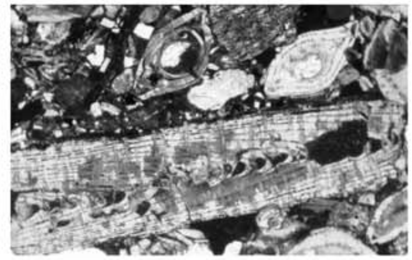
15-16 *Nummulites hongoensis* Hanzawa. 15 left, tangential sections. 15 right, oblique sections of megalospheric specimen. 16, axial section of megalospheric specimen. Fig 15. ×20; 16. ×30.

1

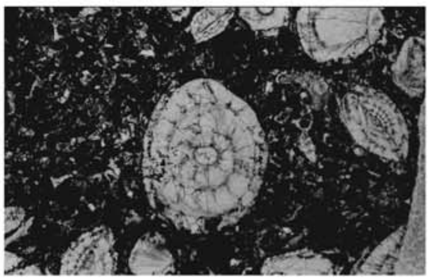
2



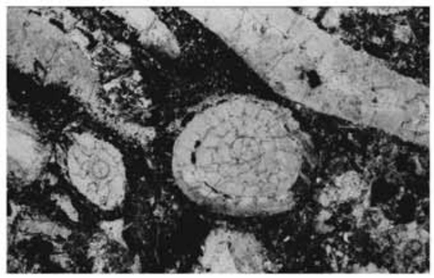
3



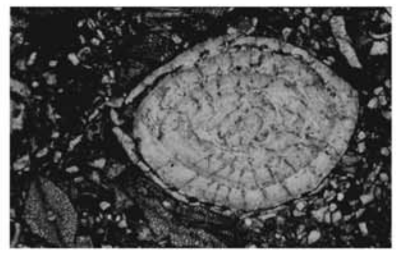
4



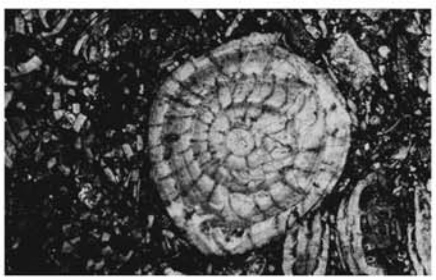
5



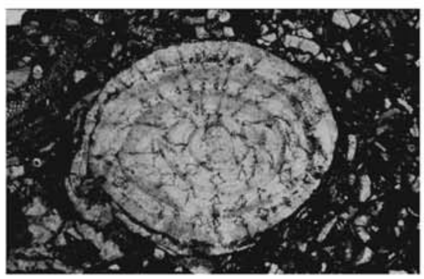
6



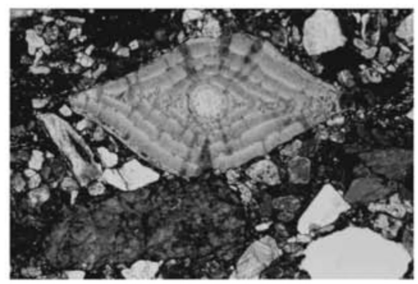
7



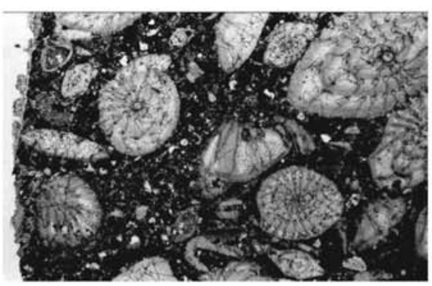
8



9

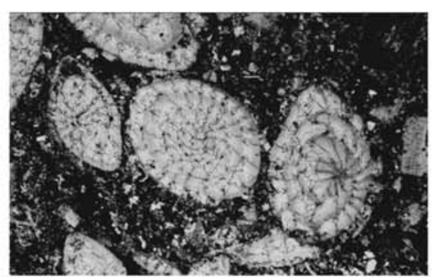


10

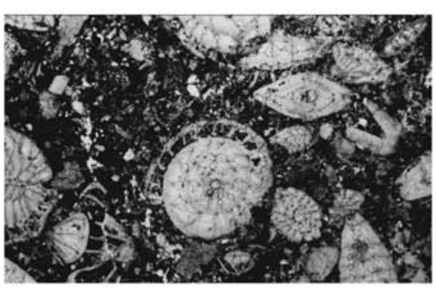


11

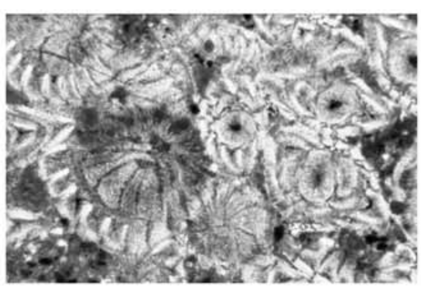
12



13



14



15

16

Middle Paleocene (Selandian), Tertiary a0.

Superfamily ALVEOLINACEA Ehrenberg 1839
Family ALVEOLINIDAE Ehrenberg 1839
Genus *Alveolina* d'Orbigny 1826

Alveolina luzonensis Matsumaru, **n. sp**.
Plate 5, figure 12 lower; plate 11, figures 7-14.

Etymology: refers to type area.

Type locality: Station 7451213, Pinugay Hill area, Luzon (text-fig. 5).

Holotype (fig. 7), Saitama Univ. Coll. no. 8918; paratypes (figs. 9, 13, 14), nos. 8919, 8921, 8920, resp.

Description: Test fusiform with planispiral spire. Proloculus spherical to subspherical, followed by regular coiled chambers that may occasionally be irregular in the early stage. The chambers rapidly increase in width, and are divided by secondary septula perpendicular to main septa. The chamberlets are positioned alternately in successive chambers. Axial thickening is apparent. The wall is porcellaneous and not flosculinized.

Dimensions: Diameter of test = 1.75 to 3.90 mm, thickness = 0.54 to 1.05 mm, diameter/thickness ratio = 3.03 to 3.72; Proloculus diameter in microspheric form = 20 × 20 µm, and in 7 specimens of megalospheric A1 schizont form = 57 × 60 to 89 × 82 µm; in 3 specimens of A2 gamont form = 105 × 95, 120 × 104 and 125 × 83 µm. Axial × equatorial diameter of first whorl = 160 × 125 µm to 244 × 177 µm, second whorl = 295 × 159 to 400 × 205 µm, 3rd whorl = 409 × 198 to 545 × 248 µm, 4th whorl = 705 × 239 to 750 × 300 µm, 5th whorl = 818 × 280 to 977 × 357 µm, 6th whorl = 1000 × 331 to 1214 × 409 µm, 7th whorl = 1182 × 380 to 1455 × 468 µm, 8th whorl = 1455 × 455 to 1602 × 534 µm, 9th whorl = 1682 × 538 to 1852 × 591 µm, 10th whorl = 1955 × 630 to 2159 × 666 µm, 11th whorl = 2318 × 727 to 2500 × 739 µm, 12th whorl = 2591 × 807 to 2705 × 841 µm, and 13th whorl = 2864 × 925 µm. Septa divide the first whorl into 3 to 4 chambers, gradually increasing to 12 chambers in the final whorl.

Remarks: Differs from *Alveolina vredenburgi* Davies 1937 (= *Alveolina cucumiformis* Hottinger 1962) in its small proloculus and relatively small test with a sharp periphery. The A1 schizont form has a small proloculus and large number of whorls (figs, 7-9, 13-14), and the A2 gamont has a larger proloculus and smaller number of whorls (figs. 10-12)..

Upper Paleocene (Thanetian) to middle Eocene (Lutetian), Tertiary a1 to a2.

Alveolina subpyrenaica Leymerie 1846
Plate 11, figures 2-4

Alveolina subpyrenaica LEYMERIE 1846, p. 359, pl. 13, figs. 9 a-c. – HOTTINGER 1960, p. 117-119, pl. 7, figs. 8-13, figs. 23, 63. – DROBNE 1977, p. 33-34, pl. 5, figs. 13-15, fig. 15 c.

Description: Test ovoid, planispiral. The subspherical proloculus is followed by many regularly coiled chambers, divided by secondary septula into chamberlets. The chambers alternate in position and the basal wall is thickened. The wall is porcellaneous and not flosculinized.

Dimensions: Diameter of test = up to 4.00 mm, thickness = 2.18 to 3.02 mm; proloculus diameter = 240 × 160 µm. Equatorial diameter of first whorl = 240 µm, second whorl = 340 µm, 3rd whorl = 436 µm, 4th whorl = 555 µm, 5th whorl = 682 µm, 6th whorl = 818 µm, 7th whorl = 986 µm, 8th whorl = 1182 µm, 9th whorl = 1364 µm, 10th whorl = 1591 µm, 11th whorl = 1800 µm, 12th whorl = 2045 µm, 13th whorl = 2273 µm, 14th whorl = 2814 µm, and 15th whorl = 3023 µm.

Remarks: Found in assemblages 4 and 5, and also in lower middle Ilerdian (lower Eocene) by Hottinger (1960).

Upper Paleocene (Thanetian) to lower Eocene (Ypresian), Tertiary a1 to a2.

PLATE 15

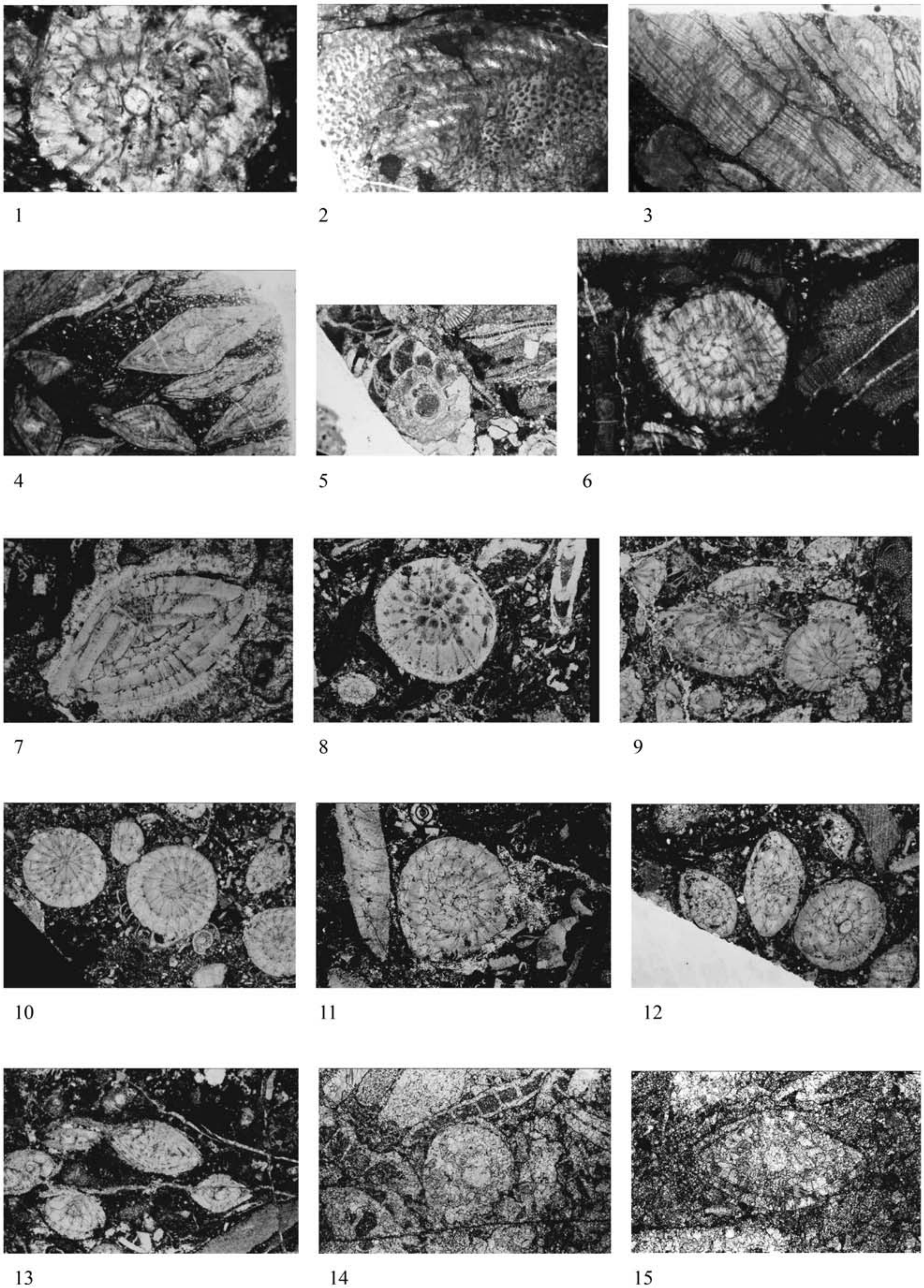
Figs. 1-4 Station H502; fig. 7, Station J310, Caraballo, Luzon; fig. 5, Station 120902, Catanduanes;. fig. 6. Station Mihara, Iriomote Island, Japan; figs. 8-12. Station 7451209, and fig. 13, Station 7451215, Pinugay Hill area; figs. 14, 15, Station MQ28, Marinduque.

1-4 *Nummulites gizehensis* (Forskål). 1, equatorial section of megalospheric specimen. 2. tangential section of microspheric specimen. 3-4, axial sections of megalospheric specimens (4 right upper; 5 upper and lower) and microspheric specimens (4 center and left) Fig. 1. ×20; 2-3, ×5; 4, ×10.

5-7 *Nummulites striatus* (Bruguière). 5-6, equatorial sections of megalospheric specimen (6. comparative specimen). 7, oblique section, all ×20.

8-13 *Nummulites burdigalensis* (de la Harpe). 8, tangential section of megalospheric specimen, showing surface ornamentation. 9-10, 12, 13 left, oblique sections of megalospheric specimen. 11, equatorial section of megalospheric specimen. 13 right, axial sections of megalospheric specimens, all ×10.

14,15 *Nummulites perforatus* (Montfort). 14, equatorial section of megalospheric specimen. 15, axial section of megalospheric specimen, both specimens are metamorphosed by volcanic rocks, all ×10.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Alveolina vredenburgi Davies 1937
Plate 11, figures 5-6

Alveolonga oblonga d'Orbigny. DAVIES 1927, p. 282-283, fig. 5.
Alveolina vredenburgi DAVIES 1937, p. 57-58, pl. 5, fig. 25.- MATSUMARU 2016, p. 8, fig. 5A, pl. 12, figs. 11-12.
Alveolina sp. - NAGAPPA 1959, p. 157-159, fig. 8, tab. 6, pl. 3, fig. 3.
Alveolina cucumiformis HOTTINGER 1960, p. 135-139, figs. 26, 29-1 and 2, 71c, 72 and 73.

Description: Test fusiform to subcylindrical with rounded poles, planispiral. The spherical to subspherical proloculus is followed by many chambers in regular coils, subdivided by secondary septula into chamberlets and arranged alternately. Basal and axial thickning is apparent, and the wall is porcellaneous and not flosculinized.

Dimensions: Diameter of test = 2.41 to 3.86 mm, thickness = 1.30 to 1.78 mm, diameter/thickness ratio = 1.85 to 2.50; proloculus diameter = 135 × 127 to 150 × 150 µm in two specimens. Axial × equatorial diameter of first whorl = 200 × 200 to 272 × 240 µm, second whorl = 290 × 250 to 408 × 331 µm, 3rd whorl = 350 × 310 to 454 × 336 µm, 4th whorl = 590 × 340 to 636 × 563 µm, 5th whorl = 860 × 500 to 818 × 660 µm, 6th whorl = 1270 × 550 to 1136 × 818 µm, 7th whorl = 1680 × 660 to 1572 × 872 µm, 8th whorl = 2090 × 860 to 2000 × 1100 µm, 9th whorl = 2450 × 920 to 2326 × 1136 µm, 10th whorl = 2860 × 1130 µm, 11th whorl = 3210 × 1450 µm, 12th whorl = 3540 × 1570 µm and 13th whorl = 3860 × 1780 µm.

Remarks: Alveolina vredenburgi Davies 1937, identified by its growth data, is found in Assemblage 3, and its presence in Assemblage 4 is probably due to reworking.

Lower Paleocene (Thanetian),Tertiary a1.

Genus *Borelis* de Montfort 1808

Borelis sp.
Plate 1, figures 2-3

Description: Test small, spherical to ovoid. The small spherical proloculus is followed by streptospirally coiled chambers, becoming short and numerous. The septa of adjacent chambers are continuously arranged, short and wide. The preseptal passage is large and circular in the equatorial section. Chamberlets are aligned in a single layer of chamberlets in the transverse section. Walls and partitions are rather thick, calcareous and porcellaneous, with no flosculination. The aperture is a rounded opening at the base of the apertural face.

Dimensions: Diameter of test = 1.52 mm, thickness = 1.28 mm, diameter/thickness ratio = 1.19; Proloculus diameter = 40 × 40 µm; In 7 to 8 whorls, number of chambers and apical distance in first whorl is 4 chambers and 90 µm; second whorl, 6 and 146 µm; 3rd whorl, 9 and 210; 4th whorl, 10 and 270 µm; 5th whorl, 330 µm; the remainder are obscure.

Remarks: Rare in the Assemblage 10 fauna of sample h 2518. Differs from *Ovalveolina ovum* (d'Orbigny) from the Cenomanian of France (Reichel 1936), in the number of chambers in the whorl, form ratio and the few pyriform chamberlets in the transverse section; from *Borelis globosa* Matsumaru 1974 by its shorter whorls; and from *B. parvulus* Hanzawa in its smaller proloculus.

Upper Oligocene (Chattian), Tertiary e3.

Genus *Glomalveolina* Hottinger 1960

Glomalveolina reicheli Matsumaru, **n. sp.**
Plate 7, figure 16

Etymology: In honor of Dr. Manfried Reichel.

Type locality: Station 7682301 (31094), south of Port Sula, Cagraray Island (text-fig. 11).

Holotype (fig. 16), Saitama Univ. Coll. no.8924.

Description: Test very small and globular. The proloculus is small and spherical, followed by streptospiral early chambers and planispiral adult chambers. Chamberlets subdivided by septula alternate in successive chamberlets. The walls of outer whorls may be basally thickened; wall porcellaneous and not flosculinized.

PLATE 16

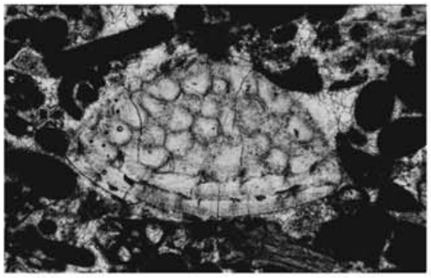
Figs. 1-6, Station F578, Mindanao (text-fig. 15); figs. 7, 9, Station 6611806, Caramoan Peninsula, (text-fig. 8); fig. 8, Station 7451212 and fig. 10, Station 7451209, Pinugay area; fig. 11, Station120902, Catanduanes; fig. 12. Station J310, Caraballo, Luzon.

1-6 *Nummulites ptukhiani* Kacharava. 1-3, 5, oblique sections. 4, tangential section. 6, transverse section. Figs. 1-5, ×20; 6, ×10.

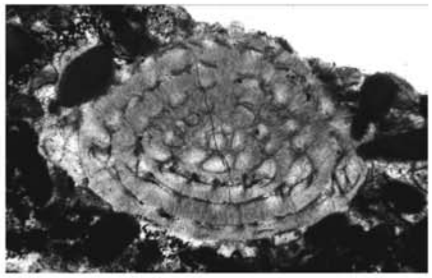
7-10 *Operculina custugensis* Massieux. 7, equatorial section. 8, oblique section. 9 lower, 10, transverse sections, all ×20.

9 *Asterocyclina stella* (Gümbel). 9 upper, axial section of microspheric specimen.

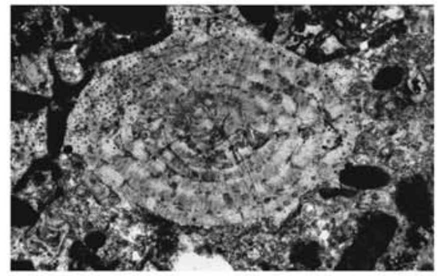
11,12 *Operculina schwageri* Silvestri. 11, centered oblique sections of megalospheric specimen. 12, axial section of microspheric specimen, both ×20.



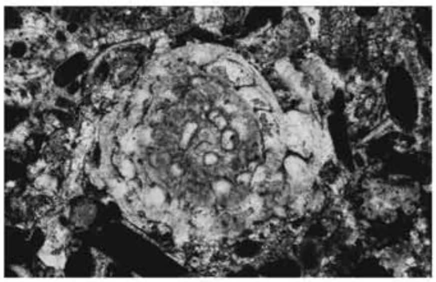
1



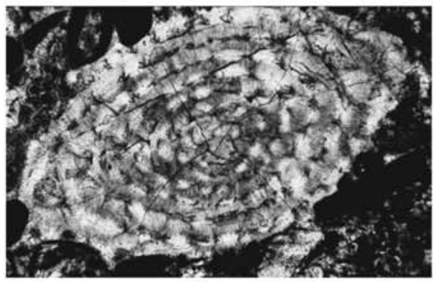
2



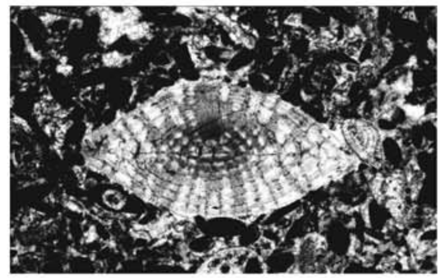
3



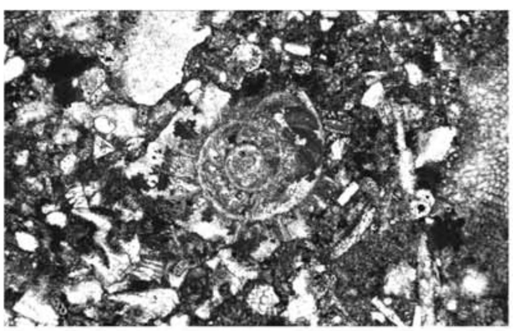
4



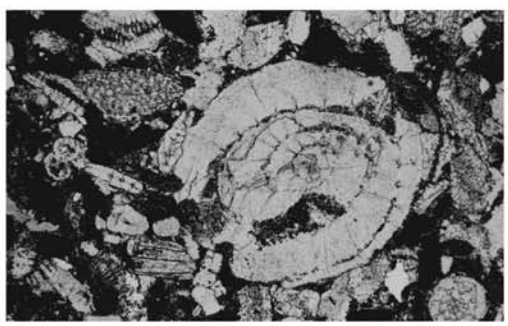
5



6



7

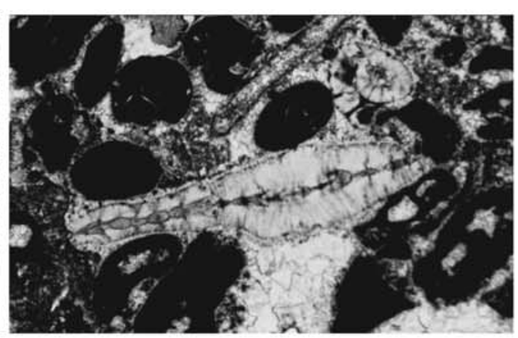


8

9

10

11



12

Dimensions: Diameter of test = 0.33 mm, thickness = 0.31 mm, diameter/thickness ratio = 1.06. Proloculus diameter = 20 × 20 µm; axial × equatorial diameter of first whorl = 59 × 54 µm, second whorl = 102 × 104 µm, 3rd whorl = 154 × 152 µm, 4th whorl = 227 × 186 µm, 5th whorl = 309 × 259 µm, and 6th whorl = 345 × 329 µm.

Remarks: Differs from *Glomalveolina primaeva ludwigi* Reichel 1937, from the mid and upper Eocene (Serra-Kiel et al. 1998) in smaller test and lower number of whorls; it is therefore a more primitive form.

Middle to upper Paleocene (Selandian and Thanetian), Tertiary a0 to a1.

Superfamily MILIOLOLACEA Ehrenberg 1839
Family HAUERINIDAE Schwager 1876
Subfamily MILIOLINELLINAE Vella 1957
Genus *Idalina* Schlumberger and Munier-Chalmas 1884

Idalina sinjarica Grimsdale 1952
Plate 5, figure 1 lower, 5 lower, 7

Idalina sinjarica GRIMSDALE 1952, p. 230, pl. 20, figs. 11-14. – BIGNOT 1972, p. 226, pl. 28, fig. 1. – DROBNE 1974, p. 166-167, pl. 12, figs. 1-2; pl. 13, fig. 2; pl. 14, fig. 1, figs. 8 c-d. – MATSUMARU and SARMA 2010, p. 541, fig. 3, pl. 3, fig. 1. – MATSUMARU, 2016, p. 3-5, 8-9, 10, 18-19, 22, figs. 5A, 5B, 10A, 10B, pl. 8, figs. 2-4.

Description: Test spherical to ovate, with quinqueloculine early stage followed by triloculine and later biloculine stages. Inner wall of chambers is thickened, flosculinized. In the quinqueloculine stage the aperture is a simple opening with a single tooth, becoming crenulate with a single tooth in the triloculine stage and probably crenulate in terminal aperture. The wall is calcareous, imperforate and porcelaneous.

Dimensions: Longitudinal axial diameter of test = 0.95 to 1.10 mm, transverse equatorial diameter = 0.95 to 1.03 mm, ratio of length/breadth = 1.00 to 1.07. In three specimens, proloculus diameter = 50 × 50, 90 × 80, and 90 × 90 µm; normal wall thickness, 25 µm; flosculinized inner wall, 88 µm.

Remarks: Idalina sinjarica from the Philippines has a smaller test and smaller proloculus than specimens from the Paleocene - lower Eocene Sinjar Limestone of Iraq. It is, however, similar in the ratio of length/breadth of the test (Grimsdale,1952). It is common in Assemblages 2 and 3, but apparently reworked in lower Assemblage 4.

Middle to upper Paleocene (Selandian and Thanetian), Tertiary a0 to a1.

Suborder TEXTULARIINA Delage and Herouard 1896
Superfamily ATAXOPHRAGMIACEA Schwager 1877
Family COSKINOLINIDAE Moullade 1965
Genus *Pseudolituonella* Marie 1955

Pseudolituonella mindanaoensis Matsumaru, **n. sp**.
Plate 4, fig. 9 right; plate 5, figure 1-4

Etymology: Refers to type area.

Type locality: Station EN, Lingig, Mindanao (text-fig. 22).

Holotype (fig. 4), Saitama Univ. Coll. no. 8893; paratype (fig. 1), no. 8894.

Description: Test large, elongate, conical with a flat, concave, or slightly convex ventral side. The megalospheric early stage has short trochospiral whorls with a few arcuate chambers, while microspheric early stag is has long trochospiral whorls. The later stage consists of broad, low uniserial chambers in the megalospheric form, and low, gradually widening and more numerous chambers in the microspheric form. The chamber cavity has short tubular pillars projecting upward from the margins, with numerous round apertures in the center of the apertural face. The wall is microgranular and imperforate.

PLATE 17

All axial sections: Figs. 1, 19, Station CB 5, fig. 5, Station 7442725, and figs. 9, 17, Station CB6; Cebu; figs. 2, 3, Station MQ23 and fig. 15, Station MQ22, Marinduque; figs. 4, 6, 11-14, 18, Station 7451105d and fig. 10, Station 7451105c, Pinugay Hill area; fig. 7, Station CT29, Catanduanes; figs. 8, 16, Station CR61, Caramoan Peninsula.

1,2 *Contusotruncana fornicata* (Plummer), × 70.

3,4 *Contusotruncana contusa* (Cushman), ×40.

5,6 *Globotruncana arca* (Cushman), ×60.

7,8 *Globotruncana* ex gr. *G. linneiana* (d'Orbigny), × 70.

9,10 *Globotruncana* ex gr. *G. falsostuarti* Sigal; Fig. 9, ×40; 10, ×60.

11-13 *Globotruncanita* ex gr. *G. stuartiformis* (Dalbiez); 11, 12, ×40; 13. ×70.

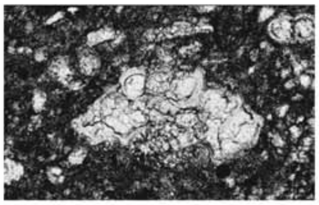
14 *Globotruncanita elevata* (Brotzen), ×40.

15,16 *Globotruncanita stuarti* (de Lapparent), ×40.

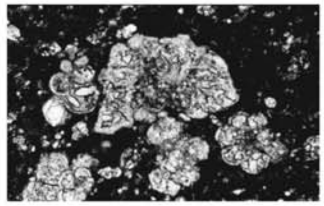
17,18 *Globotruncanita conica* (White), ×40.

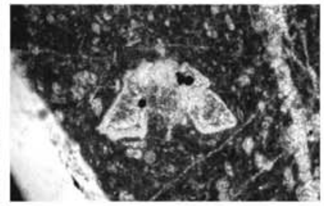
19 *Rugoglobigerina rugosa* (Plummer), ×70.

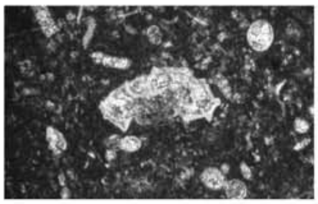
20 *Gansserina gansseri* (Bolli), ×70.

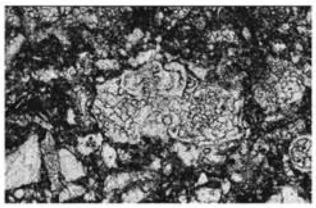

1

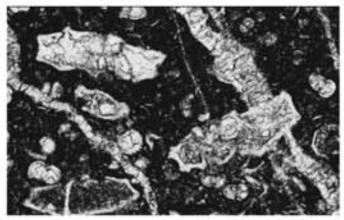

2

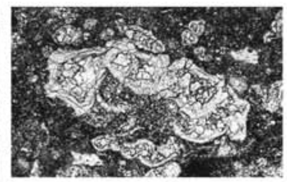

3

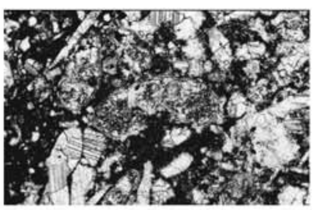

4

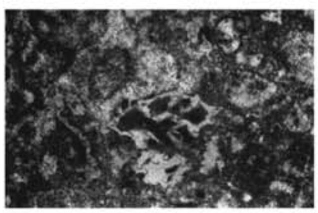

5

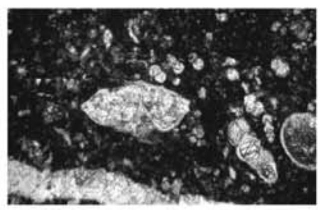

6

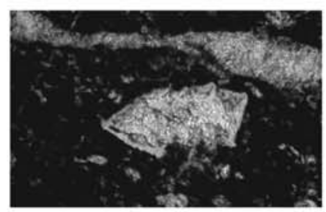

7

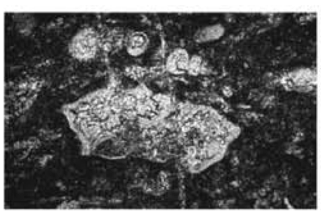

8

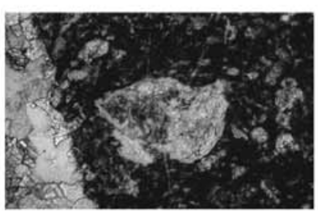

9

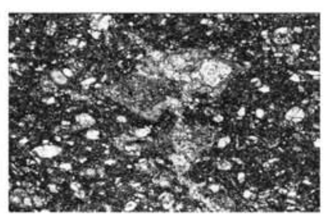

10

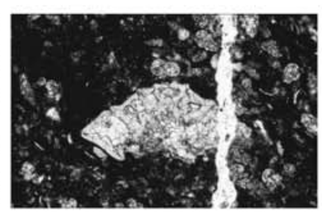

11

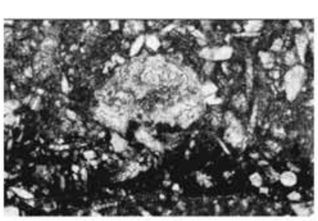

12

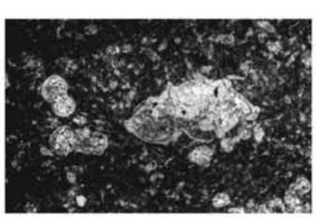

13

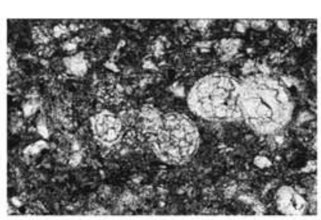

14

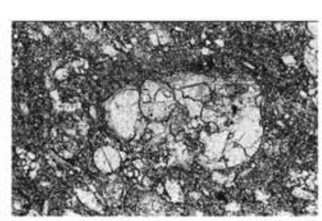

15


16


17


18


19


20

Dimensions: Megalospheric diameter of test at base = 0.57 to 1.02 mm, thickness = 0.82 to 1.10 mm, diameter/thickness ratio = 0.48 to 0.53; diameter × height of chambers = 409 × 90 to 840 × 160 µm. Microspheric diameter of test at base = 0.30 to 0.32 mm, thickness = 1.45 to 2.52 mm, ratio of diamneter/thickness = 0.22 to 0.25, diameter × height of chambers = up to 568 × 136 µm.

Remarks: Differs from *Pseudolituonella reicheli* Marie in its smaller and uniserial chambers.

Middle to upper Paleocene (Selandian and Thanetian),Tertiary a0 to a1.

Genus *Coskinon* Hottinger and Drobne 1980

Coskinon rajkae Hottinger and Drobne 1980
Plate 5, figure 6

Coskinolina (Coskinon) rajkae HOTTINGER and DROBNE 1980, p. 45-46, pl. 2, figs. 2-4; pl. 12, figs. 1-28; fig. 2. – MATSUMARU 2016, p. 10, 28, figs. 5A, 10B, pl. 11, figs. 10-11.

Description: Test small, conical, with low trochospiral and later uniserial spire. There is no exoskeleton in the marginal chamber lumen, but endoskeletal pillars are present. The wall is agglutinated, consisting of granular calcite.

Dimensions: Diameter of test = 0.45 mm, thickness = 0.55 mm, diameter/thickness ratio = 0.82.

Middle Paleocene (Selandian), Tertiary a0.

Genus *Coleiconus* Hottinger and Drobne 1980

Coleiconus sp.
Plate 6, figures 1, 2 right

Description: Test conical, with flat or slightly convex ventral side. Diameter of test is 2.5 mm, height 0.91 mm, ratio of diameter/height = 2.75. Surface smooth except for sutural depressions. Spire is trochospiral in the early stage with no exoskeletal or endoskeletal structures, but later chambers have a simple exoskeleton of widely spaced, thick vertical beams and wide endoskeletal pillars in the central part of the test. The wall is agglutinated with a keriothecal structure of numerous radial pores. The aperture appears to numerous pores on a terminal apertural face.

Remarks: Differs from *Coleiconus elongata* from Jamaica (Hottinger and Drobne 1980) in its greater form ratio.

Middle to upper Paleocene (Selandian and Thanetian), Tertiary a0 to a1.

PLATE 18

All axial sections except fig. 3. Figs. 1-3, 19, from Station 7451105a; figs. 10, 11, 13-15, 20, Station 7451212; fig. 12, Station 7451209; Pinugay area; fig. 4, Station MQ2, Marinduque; figs. 5-8, 16-18, Station CR36 and fig. 9, Station CR35, Caramoan Peninsula.

1,2 *Parasubbotina* ex gr. *P. pseudobulloides* (Plummer); 1, × 85; 2 center, × 70.

2 *Globanomalina compressa* (Plummer); 2 left, × 70.

3 *Parasubbotina trinidadensis* (Bolli). 3 right, axial section. 3 lower right, oblique section, × 70.

4 *Praemurica unicinata* (Bolli), × 70.

5,6 *Morozovella* ex gr. *M. angulata* (White); 5. ×40; 6. × 70.

7 *Morozovella* ex gr. *M. conicotruncata* (Subbotina), ×40.

8 *Morozovella velascoensis* (Cushman), × 70.

9 *Morozovella* ex gr. *M. aequa* (Cushman and Renz), × 70.

10 *Morozovella* ex gr. *M. subbotinae* (Morozova), × 70.

11 *Acarinina mckannai* (White), × 70.

12 *Acarinina nitida* (Martin), × 70.

13 *Acarinina primitiva* (Finlay), × 70.

14 *Acarinina soldadoensis soldadoensis* (Brönnimann), × 70.

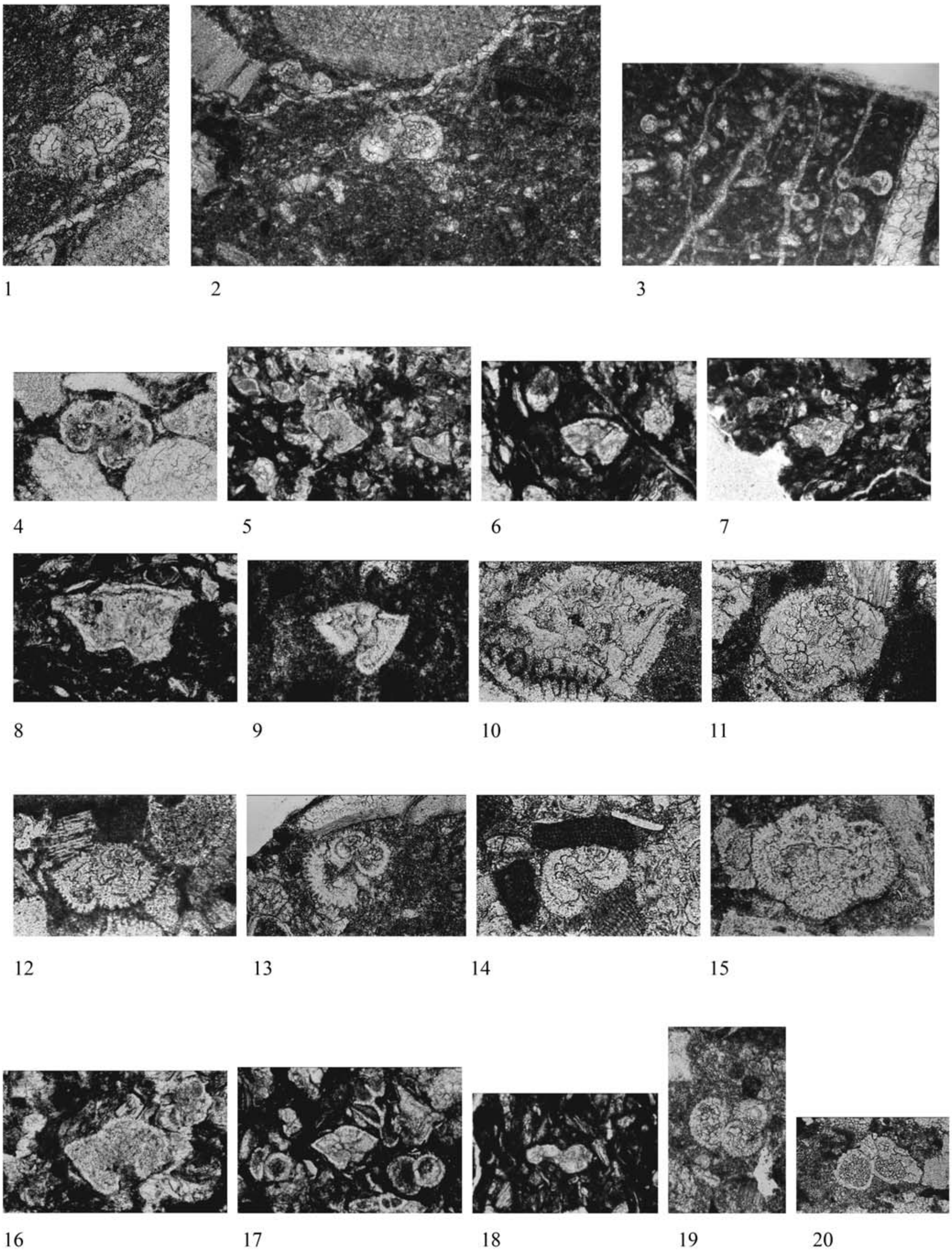
15 *Acarinina broedermanni* (Cushman and Bermudez), × 70.

16,17 *Igorina pusilla* (Bolli), × 70.

18 *Globanomalina* ex gr. *G chapmani* (Parr), ×60.

19 *Subbotina triloculinoides* Plummer, × 70.

20 *Globigerina* ex gr. *G. lozanoi* Colom, × 70.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Superfamily LOFTUSIACEA Brady 1884
Family CYCLAMMINIDAE Marie 1941
Genus *Broeckinella* Henson 1948

Broeckinella arabica Henson 1948
Plate 5, figure 13

Broeckinella arabica HENSON 1948, p. 93, pl. 7, fig. 6, figs. 13a-c. – CHERCHI and SCHROEDER 1978, p. 514-519, figs. 1a-c.

Description: Test flabellate or complanate, finally reniform. Obscured embryonic chambers are followed by a planispiral and evolute spire with increasingly broad chambers that become arcuate, but not completely cyclical with in semiannular arrangement. The exoskeleton has an imperforate outer layer. Subepidermal vertical partitions and two sets of transverse partitions are present in successive chambers. The outermost part of the marginal zone is subdivided by short secondary partitions in the polygonal network. The wall is agglutinated and microgranular.

Dimensions: Diameter of test = 1.40 to 2.95 mm, thickness = 0.18 mm, height of mature chamber = 68 to 90 µm.

Remarks: Although embryonic chambers are not preserved, the coiling pattern and exoskeleton partitions identify this species.

Middle to upper Paleocene (Selandian and Thanetian), Tertiary a0 to a1.

Superfamily TEXTULARIACEA Ehrenberg 1838
Family CHRYSALIDINIDAE Neagu 1968
Genus *Pfendericonus* Hottinger and Drobne 1980

Pfendericonus mindanaoensis Matsumaru, **n. sp**.
Plate 4, figures 8, 9 left

Etymology: refers to type area.

Type locality: Station EN, Linglig, Mindanao (text-fig. 22).

Holotype (fig. 8): Saitama Univ. Coll. no. 9000.

Description: Test low conical, trochospiral in the early stage, with five to six wedgelike chambers per whorl in the later stage. The marginal chamber lumen is undivided by exoskeletal structure, but uniserially arranged final stage has endoskeletal pillars in the central region of the test. The wall is thick, finely agglutinated, and canaliculated.

Dimensions: Diameter of test = 1.07 to 1.36 mm, thickness = 0.82 to 0.95 mm, diameter/thickness ratio = 1.13 to 1.49, thickness of wall = 0.04 to 0.06 mm.

Remarks: Differs from *Chrysalidina* (*Pfendericonus*) *kahleri* Hottinger and Drobne 1980 and *C.* (*P.*) *makarskae* (van Soest) in its smaller and lower spiral test.

Middle Paleocene (Selandian), Tertiary a0.

SUPPLEMENT

Family ORBITOSIPHONIDAE Matsumaru and Jauhri 2003, *sensu* Matsumaru and Sarma 2010
Genus *Orbitosiphon* Rao 1940, emend. Matsumaru and Sarma 2010

Orbitosiphon tibetica (Douvillé)
Plate 7, figures 17-18; plate 19, figures 1-17

Lepidorbitoides tibetica DOUVILLÉ 1916, p. 34, pl. 16, figs. 1-6.
Lepidocyclina (*Polylepidina*) *punjabensis* DAVIES 1937
Orbitospihon punjabenses (Davies). – RAO 1940, p. 414-415, fig. 1.

PLATE 19
(supplement)
Orbitosiphon tibetica (Douvillé)

Figs. 1, 4, 5, Station 02/Lkd/MCCL4, Nongthymmai Quarry Section ; fig. 2, Station 91/Lkd/DR2, and figs. 6, 8, 11, 12, 15, 16, Station 86/Lkd/DR7, Um Sohryngkew River Section (Matsumaru and Jauhri, 2003); fig. 3, Station Myn/Lkd/101, and fig. 17, Station Myn/Lkd/109, Mynkree Section A (Matsumaru and Sarma, 2010); 7, 10. Station LL2 and 13-14, Station LL3 (Matsumaru and Sarma, 2010); Meghalaya, NE India; fig. 9, Station KM10, Çaldağ, west Haymana, Turkey (Matsumaru 2016).
Scale bars 100 µm, except 10 µm in figs. 1, 7, 10b and 14. All ×48 except figs. 1, 2, 7, 10b and 14.

1, 3-7 Equatorial sections of megalospheric specimen. Figs. 1, 7, ×88; figs. 3-6, ×44.

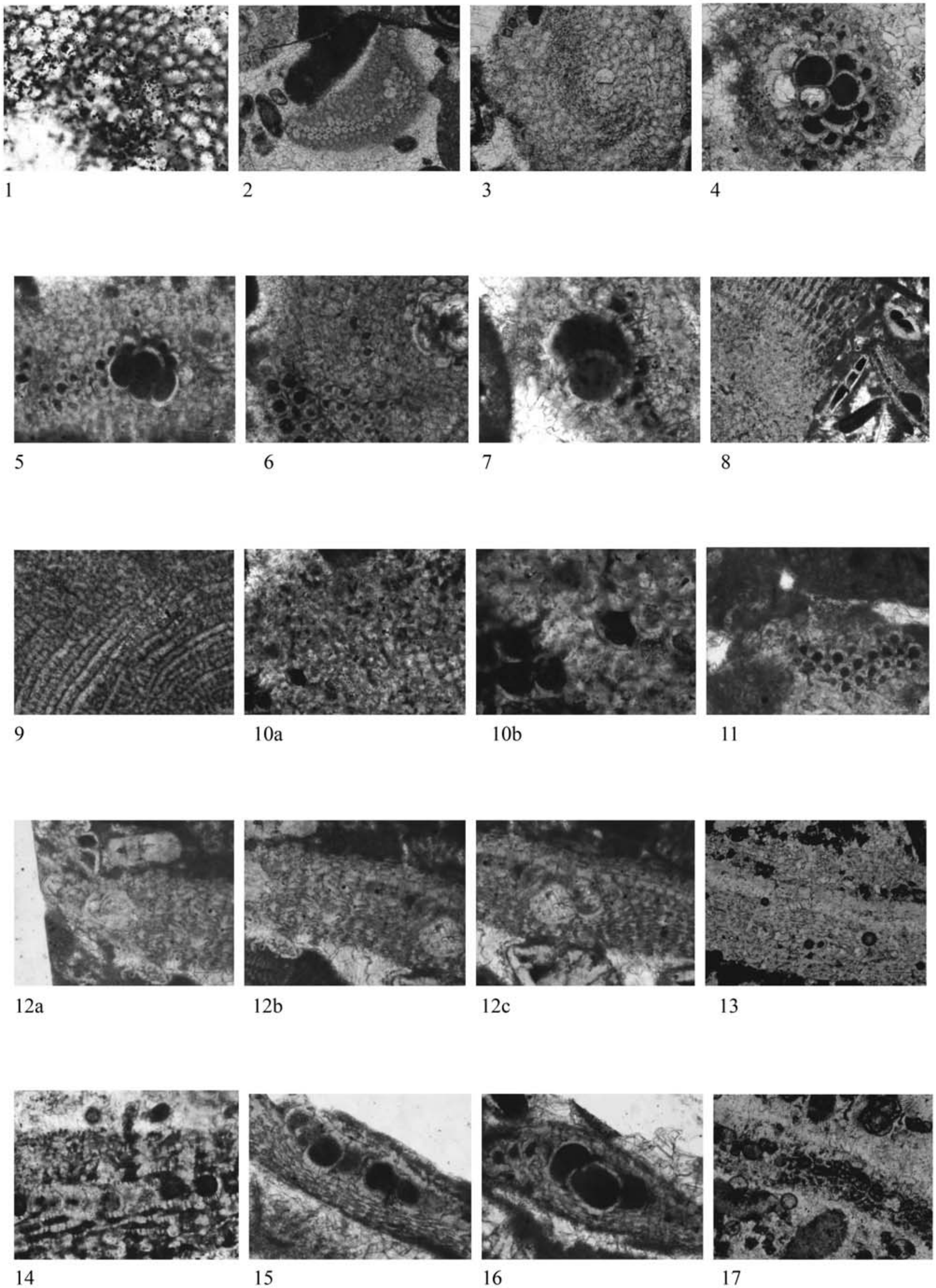
2 Centered oblique section of megalospheric specimen, ×18.

8, 9 Equatorial sections of microspheric specimen, ×18.

8, 12, 15-16 Axial sections of megalospheric specimen, ×48.

10, 11 Oblique sections of megalospheric specimen, ×88.

13, 14, 17 Transverse sections of microspheric specimen. Figs. 13, 17, ×48; fig. 14, ×88


1
2
3
4
5
6
7
8
9
10a
10b
11
12a
12b
12c
13
14
15
16
17

Orbitosiphon tibetica (Douvillé 1916). – RAO 1944, p. 95-99, pl., figs. 2, 3, figs. 1-3 — MATSUMARU and SARMA 2010, p. 551-552, 554, 556; pl. 1, figs. 1-8.

Remarks: Found in only one sample (table 2), the species has a very wide variation in its compound morphology characterized by symmetrical and asymmetrical tests, some with a single primary auxiliary chamber (1 PAC, figs 1-3; A2 form of Rao 1944; "stout specimen" of Davies 1937) or two primary auxiliary chambers (2 PAC, figs. 4-7; A1 form of Rao 1944; "thin specimen" of Davies 1937). The A2 form (1PAC) is characterized by symmetrical tests with both lateral chamber layers lying over the equatorial chamber layer (pl. 19, fig. 13 lower), and with arcuate to ogival equatorial chambers ("lozenge-shaped or rhombic equatorial chambers" of Rao 1944), arranged in intersecting arcs (figs. 1-2, 10-11), that lack canals in the arcuate equatorial chambers of mature stages. The A2 form, however, may have rectangular or spatulate equatorial chambers with canals in the final stages (cf. canal system of Reiss 1963, and tubular canals of Ferràndez-Cañadel 2002). Furthermore, the A2 form sometimes has 10 arcuate peri-embryonic chembers in early stage that later become arcuate, spatulate and hexagonal in concentric rings, or else partially arcuate equatorial chambers arranged in intersecting arcs (fig. 3) as a transitional form between the A1 and A2 styles. The A1 form (2PAC) is characterized by asymmetrical tests with thick lamellar walls over the equatorial chamber layer on one side of test and over the lateral chamber layers on the other side (fig. 13 upper), and with 9 to 10 arcuate per-embryonic chambers in the early stage, becoming, arcuate, spatulate and hexagonal equatorial chambers with canals, arranged in concentric rings in the following stages (figs. 4-7). The A1 form may have a duplicated equatorial chamber layer, causing it to be assigned to *O. tibetica* (Matsumaru and Sarma 2010). In the A1 form the thick lamellar wall tends to change toward the periphery into lateral chambers, not vacuole cavities, in the wall (figs. 12a-c, 15). A1 or transitional A1-A2 forms both have a trace of these thick lamellar walls, with true lateral chambers over the equatorial chamber layer. The lamellar wall has vertical canals (fig. 14).

Both A2 and A1 forms occur together in the Lakadong Limestone of NE India (Matsumaru and Sarma 2010) as seen in fig. 13 lower and upper, in a sample correlated to Meghalaya Assemblage 2 (table 17) and assigned to the Letter Stage Tertiary a1 (Matsumaru 2011). The variation in A1 and A2 forms from India can be seen in figs. 8 right, 12, 14-17.

Ferrández-Cañadel (2002), in describing *Setia tibetica* (Douvillé) noted that the A1 form of *Orbitosiphon tibetica* as described by Rao 1944 (2PAC) has an asymmetrical test and canals, while *Orbitosiphon punjabensis* "stout form" of Davies (1937; cf. figs. 3-4, 6, 8) or A2 form form of Rao 1944 (1 PAC) has a symmetrical test without canals. Both forms occur in the Paleocene Salt Range of Punjab, with the ancestral *Setia primitiva* Ferràndez-Cañadel with A1 characteristics in slightly older levels. Ferrández-Cañadell (2002, p. 397) regarded a canal system to be the main primary character distinguishing the *Setia* from *Oribitosiphon,* but only in *Setia tibetica* are there true tubular canals (loc. cit., fig. 3). Brönnimann (1945, p. 608-610, figs. 22-13) identified the interlocular cavities or spaces in equatorial chambers of *Orbitoclypeus himerensis* Silvestri as 'dunkeln Schicht' , not canals or canal system. Reiss (1957, p. 5; 1963, p. 31) also stated that the interlocular spaces between consecutive chambers do not represent true canals but are only tubular cavities. Glaessner and Wade (1959, p. 198) concluded that the interlocular spaces were not part of any organized system and represented a morphological convergence between the 'Bilamelidea' and the Rotaliidea, where canals may be related to the stream of protoplasm (Drooger 1993, p. 228). As already indicated, the canals in orbitoidal foraminifera are only found in test walls more then 4 µm thick (Matsumaru and Sarma 2010, p. 552). Thus, all three of the *Setia* species from the Punjab Salt Range should be regarded as a junior synonym of *O. tibetica*.

Species that can be identified with *Orbitosiphon tibetica* have also been found in Turkey and Slovenia. *Bolkarina aksarayi* Sirel 1981, established in the Thanetian of central Turkey and also identified in the Selandian of Haymana (Matsumaru 2016) has the embryonic form of *Setia primitiva* (=*O. tibetica*). Ogorelec and Drobne in Drobne et al. (1988) described a *Bolkarina* sp. from the lower Danian of the Dinarides similar to *Lakadongia indica* with a duplicated equatorial chamber layer, while Adams (1987) erected *Orbitosiphon praepunjabensis* based on the "stout specimen" of Davies 1937. All of these should be considered as junior synonyms of *O. tibetica* (Matsumaru and Sarma 2010, p. 551).

PART TWO: LATE EOCENE TO QUATERNARY

The late Eocene (Priabonian) to Quaternary larger foraminifera fauna of the Philippine Archipelago, as discussed in this section, has at least 140 species in 62 genera, collected from 15 islands of the Philippine Archipelago (text-fig. 1). Of these, 117 species are illustrated (pls. 20-46) and 95 of the more age-diagnostic species in 38 genera are given further systematic descriptions, including the type species of five new genera and three additional new species. This record is amplified with 34 species of planktonic foraminifera in 14 genera (pls 47-49).

FAUNAL ASSEMBLAGES

The distribution of larger foraminifera in the sampled stations of this age (table 3), are the base data for 14 faunal assemblage zones (cf. tables 4 to 16), correlative to the letter stages Tertiary b to Tertiary g-h.

TABLE 4
Assemblage 6: Late Eocene (Priabonian), Letter Stage Tertiary b.

Species / Station	N. Luzon, Bontoc						NE Luz		Catanduanes					Mindoro												
	h2144	h2155	BG6A	BG7	BG8	BG12	G102	I 19	CT18	CT19	CT20	CT38	CT39	TR2-005	WR41	MD117	MD115	MD116	YR2-024	MD77	MD104	MD83	MD111	MD70	MD101	MD100
Pellatispira crassicolumnata					X										X								X			
P. orbitoidea					X				X	X					X				X							
P. madaraszi									X	X												X			X	X
P. provalei				X							X				X							X	X		X	
P. inflata					X					X					X											
Eopellatispira mindoroensis, n. gen., n, sp.																							X	X	X	
Biplanispira mirabilis					X		X				X				X	X			X			X	X	X	X	X
B. absurda					X									X		X						X	X			
Mindoroella mindoroensis, n. gen., n. sp.																						X	X	X		
Nummulites fabianii				X	X	X		X						X		X	X	X			X		X			
N. incrassatus										X		X	X							X	X			X		
N. striatus	X	X	X	X	X		X		X											X	X					X
N. vascus									X													X	X	X	X	
Operculina saipanensis				X										X												
O. subformai				X	X	X				X	X	X	X													
O. eniwetokensis						X																				
O. schwageri					X	X		X						X			X			X	X		X	X		
Heterostegina aequatoria														X										X		
H. saipanensis					X	X								X	X	X		X	X			X		X		
Cycloclypeus sp.																X										
Spiroclypeus granulosus					X						X			X	X	X	X	X	X			X		X		X
Discocyclina dispansa					X										X	X	X	X	X			X		X	X	X
D. llarenai																X								X		
Orbitoclypeus pygmaeus																	X							X		
Asterocyclina stella									X		X					X	X	X				X		X		X
A. stellata																X								X		
A. pentagonalis															X							X				
Borelis globosa																X					X		X			
B. parvulus																							X			
B. pygmaeus														X		X							X			
Halkyardia minima																X					X		X			X
Tayamaia marianensis																				X						
Baculogypsinella eocenica, n. gen., n. sp.																							X	X	X	
Orbitogypsina vesicularis																							X			X
O. mindoroensis, n. sp.																							X			
Discogypsina vesicularis		X				X														X						X
Amphistegina radiata				X		X											X			X	X			X		X
Sphaerogypsina globulus				X		X														X						
Acervulina inhaerens					X	X																X				
Carpenteria spp.				X	X	X										X				X						
Fabiania cassis																		X								X

TABLE 5
Assemblage 7: Earliest Oligocene (early Rupelina), Letter Stage Tertiary c.

Species \ Station	N Luzon	Bontoc	NE Luz	Mindoro		Cebu			
	h2505	B	B130	WR202	11479	CB 2	CB 3	7442623	7442624
Nummulites fichteli	X	X	X	X	X	X	X	X	X
N. incrassatus									X
N. vascus	X								
Operculina saipanensis		X		X					
O. complanata				X				X	
***O.* spp.**			X	X					
Cycloclypeus koolhoveni		X							
C. oppenoorthi		X							
Borelis globosa					X				
B. pygmaeus				X		X	X		
B. parvulus						X			
Halkyardia minima			X	X	X		X	X	
H. bikiniensis			X	X		X		X	
Heterostegina saipanensis	X	X		X	X	X			
H. borneensis	X							X	X
H. duplicamera	X		X			X			
***H.* spp.**			X					X	
Peneroplis planatus.				X					
Eorupertia boninensis		X							
Amphistegina radiata		X			X			X	X
Sphaerogypsina globulus								X	
Planorbulinella larvata									X
***Discocyclina* spp.**								X	

Assemblage 6 (table 4) is defined by the presence of *Nummulites fabianii*, *Spiroclypeus granulosus*, and *Biplanispira mirabilis,* as recorded from 26 samples, together with numerous other species (table 16) that indicate correlation to Letter Stage Tertiary b of Borneo (van der Vlerk 1929; Leupold and van der Vlerk 1931). The type locality is Station MD117 in the middle member of the Caguray Formation, Mindoro (text-fig. 14), and is notable for the presence of *Cycloclypeus* sp. together with *Nummulites fabianii*, although more specimens of the embryo of *C.* sp. may be needed. Sample MD 117 and Sample TR2-005 from underlying lower Caguray also yield planktonic foraminifera indicative of planktonic Zones P16-17 (pl. 47, figs. 1-2, 11-12). Sample WR 41 of Caguray yields a fauna more similar to the *Biplanispira absurda – Pellatispira provalei* Assemblage III from Haha-Jima, Ogasawara Islands, also correlated to Letter Stage Tertiary b, and the presence of *Pellatispira madaraszi, P. orbitoidea* and *Nummulites fabianii* correlates with Assemblages 5 and 6 of NE India (table 17).

Upper Eocene (Priabonian), Letter Stage Tertiary b.

Assemblage 7 (table 5) is defined by co-occurrence of *Nummulites fichteli* and *Heterostegina duplicamera* in 9 examples, which establishes the correlation with Letter Stage Tertiary c. The type sample comes from Station B130 of the Mamparang Formation, Caraballo, NE Luzon (text-fig. 4). *Nummulites fichteli* is indicative of Tertiary c in Borneo (van der Vlerk 1929; Leupold and van der Vlerk 1931), as well as the upper member (Tertiary c) of the Alutom Formation on Guam (Cole 1963). Sample B130 also yields planktonic foraminifera indicating Zones P18-19 (pl. 47, figs. 7-10).

Lower Oligocene (Rupelian), Letter Stage Tertiary c.

Assemblage 8 (Table 6) is characterized by association of *Nummulites fichteli* with *Heterostegina borneensis, Eulepidina dilatata, E. ephippioides, Lepidocyclina isolepidinoides, Nephrolepidina marginata, N. borneensis* and *Borelis pygmaeus* (Table 6). Nine of the 22 samples with this assemblage occur in Bugton Limestone, SE Mindoro Island (Hashimoto et al. 1977). The type sample 11474 in the middle Bugton Limestone is assigned to Letter Stage Tertiary d, due to the presence of most of its characteristic species in this interval in Borneo (van der Vlerk 1929; Leupold and van der Vlerk 1931). *Fabiania* sp., *Lepidocyclina pustulosa* Douvillé and *Linderina brugesi* Schlumberger (Table 6) are regarded as reworked, with *Lepidocyclina pustulosa* (as *Lepidocyclina* sp.) known from the late Eocene (Tertiary b) of Meghalaya, NE India (Matsumaru and Sarma 2010). The planktonic foraminifera *Paragloborotalia* ex gr. *opima opima* (Bolli) from Palawan (sample QZ4) indicates Zone P 21. Assemblage 8 correlates with the Assemblage IV of Chichi-Jima and Minami-Jima, Ogasawara Islands (Matsumaru 1996), and also with the fauna of "Hsueshan Group", Southern Cross Mountain Highway, Taiwan (Hashimoto and Matsumaru 1975).

Later early Oligocene (upper Rupelian) to early late Oligocene (lower Chattian), Letter Stage Tertiary d.

Assemblage 9 (table 7), defined by *Heterostegina borneensis, Eulepidina dilatata, E. ephippioides,* and *Lepidocyclina isolepidinoides,* is found in the upper member of the Bugton Limestone, Mindoro Island (text-fig. 14). Station 11467 is the type sample, and the fauna is assigned to Letter Stage Tertiary e1-2 due to occurrence of the type species without *Nummulites fichteli.* The Philippines fauna is also known from Borneo in the Pamaloean Lagen (Leupold and van der Vlerk 1931), the E, F and basal G Formations (Douvillé 1905), and Mesaloi Mergel (van der Vlerk 1929). Assemblage 9 is correlated with the Assemblage V from Chichi-Jima and Minami-Jima, Ogasawara Islands, Japan (Matsumaru 1996).

Late Oligocene (lower Chattian), Letter Stage Tertiary e1-2.

Assemblage 10 (Table 8) is defined by the presence of *Heterostegina borneensis, Spiroclypeus margaritatus, Eulepidina dilatata, E. ephippioides, Nephrolepidina sumatrensis, Miogypsinella boninensis, M. ubaghsi* and *M. complanata,* that occur together in 18 samples. *Eorupertia* spp., *Nummulites* spp. and *Pellatispira* spp. are regarded as reworked. This assemblage is seen on Negros Island in the Trankalan Limestone samples 7682904 and 7683003 and Escalante Formation sample 7682902 (text-fig. 16), which Hashimoto et al. (1982) considered as Letter Stages Te2-3 to Te4 (Oligocene) and Letter Stages Te4-5 (Oligocene–Miocene), respectively. According to Müller and Daniels (1981), however, these formations both range from planktonic foraminiferal zones P22 to lower N4, within nannoplankton Zone NP 25. In this study, the type locality of Assemblage 10 is Station 7682904. Station 7682902 and

TABLE 6
Assemblage 8: Early Oligocene (late Rupelian – early Chattian), Letter Stage Tertiary d.

Species \ Station	N Luzon Bontoc			NE Luzon	Mindoro												Cebu			E Mindan.	Palawan	Samar
	h2506	BG6B	A	B128	TR2-039	TR2-029	WR203	WR204	11473	11474	11475	11477	11483	11469	11478	11480	7442626	7442627	7442628	H14	QZ4	7450707
Nummulites fichteli			X	X	X			X	X	X	X	X	X	X	X	X						
N. striatus		X																		X		
N. vascus			X										X	X						X		
Operculina complanata			X	X			X						X	X								
O. ammonoides			X						X	X		X		X					X		X	X
Heterostegina duplicamera			X	X	X		X			X		X		X							X	
H. borneensis	X	X	X		X	X			X	X	X	X	X	X		X	X		X	X		X
Cycloclypeus koolhoveni				X		X			X	X	X	X	X	X		X					X	
C. oppenoorthi			X	X					X	X	X	X	X	X		X						X
C. eidae																						X
Spiroclypeus margaritatus					X				X	X		X		X	X	X				X		
Pararotalia mecatepecensis					X			X							X	X						
Paleomiogypsina boninensis					X			X							X	X						
Miogypsinella boninensis					X										X	X					X	
M. ubaghsi																X						
Eulepidina dilatata		X	X		X	X			X	X	X	X	X	X	X	X	X	X	X			
E. ephippioides	X	X			X	X	X		X	X	X	X	X	X	X	X		X	X	X		X
Lepidocyclina isolepidinoides					X		X			X		X		X	X		X	X	X			
L. boetonensis									X	X							X					
L. pustulosa										X		X										
Nephrolepidina marginata									X	X				X	X			X		X		
N. borneensis									X	X	X	X	X	X	X	X						
N. sumatrensis																X			X	X		X
Borelis globosa									X	X											X	
B. parvulus									X												X	
B. pygmaeus									X	X	X	X		X		X	X					
***B. fusiformis*, n. sp.**																				X		
B. philippinensis											X										X	
Orbitogypsina vesicularis												X										
Halkyardia bikiniensis								X		X	X			X			X					
H. minima								X														
***Fabiania* spp.**		X																				
Discogypsina vesicularis			X				X								X							
Planorbulinella larvata								X	X			X							X			
Sphaerogypsina globulus			X						X					X	X							X
Orbitogypsina vesicularis												X										
Neoplanorbulinella saipanensis												X										
Linderina brugesi														X								
Amphistegina radiata			X						X	X	X	X	X	X	X	X	X		X			X
Acervulina inhaerens																						X

TABLE 7
Assemblage 9: Middle Oligocene (early Chattian), Letter Stage Tertiary e1-2.

Species \ Station	NE Luzon		SE Luzon		Mindoro		S. Cebu
	A 6	H377	CLG7	GMC18	11467	11468	21760
Operculina ammonoides				X	X	X	X
O. complanata					X	X	X
Heterostegina duplicamera					X	X	
H. borneensis	X				X	X	X
Cycloclypeus eidae	X		X		X	X	
Spiroclypeus margaritatus	X	X	X				
Pararotalia mecatepecensis			X				
Paleomiogypsina boninensis			X	X			
Miogypsinella boninensis	X		X	X			
M. ubaghsi	X		X	X			
Eulepidina dilatata	X	X			X	X	
E. ephippioides	X	X			X	X	X
Lepidocyclina isolepidinoides					X	X	X
L. boetonensis	X						
Nephrolepidina marginata					X	X	
N. borneensis	X				X	X	
N. brouweri			X				X
N. tournoueri	X		X	X			
N. sumatrensis	X	X					
Borelis globosa						X	
B. pygmaeus						X	
***B. fusiformis*, n. sp.**						X	
B. philippinensis						X	
Planorbulinella larvata	X				X	X	
Discogypsina vesicularis					X		
Sphaerogypsina globulus				X	X		
Amphistegina radiata	X		X	X	X	X	
Acervulina inhaerens				X			
Marginopora vertebralis				X			
Sporadotrema cylindricum	X						

7682904 also yield planktonic foraminifera indicating Zone P 22 (pl. 47, figs. 4, 10, 14; pl. 48, fig. 10). Assemblage 10 is correlated with the fauna of Assemblage V of Chichi-Jima and Minami-Jima, Ogasawara Islands (Matsumaru, 1996) due to common occurrences of *Miogypsinella boninensis* and *Spiroclypeus margaritatus,* and is further correlated with the fauna of samples KPW59 and KW17 of the "Hsueshan Group", Southern Cross Mountain Highway, Taiwan (Hashimoto and Matsumaru, 1975) with *Heterostegina* aff. *H. borneensis,* as well as *Lepidocyclina formosensis* and *Eulepidin*a *dilatata*.

Late Oligocene (middle Chattian), Letter Stage Tertiary e3.

Assemblage 11 (table 9) is characterized by the co-occurrence of *Miogypsinoides formosensis, M. bantamensis, M. dehaartii, Miogypsina primitiva, Nephrolepidina ferreroi* and *N. sumatrensis,* found in 22 samples, commonly with a wide range of other species among which *Paleomiogypsina boninensis, Lepidocyclina boetoensis* and *Eorupertia boninensis* are regarded as reworked. Assemblage 11 is typified in Station 7682905, Escalante marls of Negros Island (text-fig. 18), assigned to the Letter Stage Tertiary e4 due to occurrences of *Nephrolepidina ferreroi* and *Miogypsinoides dehaartii* (Leupold and van der Vlerk 1931). The assemblage is correlated with the lower part of the Kita Daito-jima Limestone, Okinawa (Hanzawa 1940), because of the occurrence of *Miogypsinella borodinensis* Hanzawa, a junior synonym of *Miogypsinoides formosensis* due to having the same nepionic chambers (Matsumaru et al. 2010, p. 452), and as well with the similar fauna in limestone blocks from the Komahashi-Daini Seamount (Matsumaru in Mouhiuddin et al. 2000). Assemblage 11 also has several species in common with the fauna of the Botel-tobago Limestone, Taiwan (Yabe and Hanzawa 1930) and is correlative with Assemblage 1 of the Küçükköy Formation, Turkey; see tab. 17).

Late Oligocene (late Chattian), Letter Stage Tertiary e4.

Assemblage 12 (table 10) is defined by the co-occurrence of *Cycloclypeus eidae, Miogypsinoides dehaartii, Miogypsina globulina, Lepidosemicyclina thecidaeformis, Nephrolepidina ferreroi, N. sumatrensis* and *Flosculinella bontangensis,* which is found in 31 samples with numerous other species, among which *Paleomiogypsina boninensi,* and *Eorupertia* spp. are regarded as reworked. The type fauna from Station 7681908 in the upper Coal Harbour Limestone (text-fig. 11), Cagraray Island is assigned to the lower substage of Letter Stage Tertiary e5 due to occurrences of *Miogypsinoides dehaartii, Miogypsina globulina, Lepidosemicyclina thecidaeformis* and *Flosculinella bontangensis,* known from the Beboeloeh Lagen (Leupold and van der Vlerk 1931). Planktonic foraminifera indicate Zone N4 (pl. 48, figs. 1-8). Faunas correlative to Assemblage 12 occur in the Shimizu Formation, Japan (Matsumaru et al. 1993) and Zone 4 of Okinawa (Hanzawa 1940), in which the radiometric dating of 23.1 to 21.1 Ma (Ohde and Elderfield 1992) indicates an Aquitanian age. Assemblage 12 is further correlated with the fauna of the *Miogypsina* limestone at 500 m in well Tungliang TL-1, off Taiwan (Matsumaru 1968) due to occurrences of *Miogypsina globulina* and *M. borneensis,* and with the fauna of the lower Kaizan Beds, Taiwan, with a biometrical value (factor A = 44.13) of lepidocycline enclosure (Matsumaru 1971; Yabe and Hanzawa 1930) and planktonic foraminifera of Aquitanian Zone N5. Assemblage 12 is also correlated with Assemblage 2 of Turkey (Table 17).

Early Miocene (Aquitanian), lower Letter Stage Tertiary e5.

Assemblage 13 (table 11) is defined by the association of *Cycloclypeus eidae, Miogypsina globulina, Lepidosemicyclina thecidaeformis, L. polymorpha, Nephrolepidina ferreroi* and *N. sumatrensis,* which is found in 9 samples that include reworked *Linderina brugesi* and *Eorupertia boninensis.* The type sample from Station C 57, Caraballo (text-fig. 4) in the Palali Formation, is assigned to upper Tertiary e5 due to the occurrences of *Miogypsinoides dehaartii* and *Miogypsina globulina,* but without *Spiroclypeus margaritatus*, as described from the type section in Borneo (Leupold and van der Vlerk 1931). Assemblage 13 is correlated with the fauna of Zone 4 upper of Kita Daito-Jima (Hanzawa 1940), due to occurrences of *Miogypsinoides dehaartii* and *Miogypsina borneensis*, with an Sr isotope age from 21.8 to 18.8 Ma (Ohde and Elderfield 1992). Assem-

TABLE 8
Assemblage 10: Late Oligocene (middle Chattian), Letter Stage Tertiary e3.

Species \ Station	N. Luzon	M. Luzon	NE Luzon	SE Luzon				Cebu				Negros			E. Mindanao			
	BG9	RZ4	A 3	PTG9	At 8	CLG1	31058	CB 7	CB 8	CB 15	CB 20	7682902	7682904	7683003	F27	F28	F29	H106
Operculina ammonoides	X		X													X	X	X
O. balcei																		X
O. complanata			X					X										X
Heterostegina borneensis	X		X					X	X	X			X	X		X	X	
H. duplicamera								X					X					
Cycloclypeus eidae			X	X			X						X	X	X	X	X	
Spiroclypeus margaritatus		X	X	X		X	X		X			X	X		X	X	X	X
Pararotalia mecatepecensis	X			X		X	X					X	X					
Paleomiogypsina boninensis				X			X	X	X	X		X	X					
Miogypsinella boninensis	X			X		X	X					X	X	X				
Miogypsinella ubaghsi	X					X	X					X	X					
M. complanata	X				X	X	X					X	X					
Luzonella trochidiformis, n.g.,n.s.	X																	
Eulepidina dilatata		X	X					X			X	X	X	X				
E. ehippioides		X	X	X			X	X		X	X	X	X	X				
Lepidocyclina isolepidinoides								X			X		X	X				
L. boetonensis			X															
Nephrolepidina marginata							X				X							
N. brouweri		X																
N. japonica			X	X			X					X	X	X				
N. sumatrensis			X	X			X	X	X		X		X	X				
Austrotrillina howchini		X						X										
Borelis globosa	X															X		
B. parvulus			X															
B. pygmaeus	X	X	X	X			X	X				X			X	X		
B. fusiformis, n. sp.							X	X							X	X	X	
B. philippinensis	X		X															
Discogypsina vesicularis								X				X						
Planorbulinella larvata									X									
Peelella boninensis												X						
Eorupertia spp.			X			X	X						X					
Amphistegina radiata	X	X	X	X	X	X								X		X		
Nummulites spp.	X																	
Pellatispira spp.	X																	
Sorites orbiculus		X														X		
Carpenteria proteiformis															X	X		
Sphaerogypsina globulus		X													X	X	X	
Archaias spp.		X																

TABLE 9
Assemblage 11: Latest Oligocene (late Chattian), Letter Stage Tertiary e4.

Species / Station	N Luzon	N Luzon Bontoc		NE Luzon		Mid Luzon	SE Luzon	Cagra-gay		Marin-duque			Min-doro		Negros		Samar	E. Mindanao			
	No.1	c2711	c2712	A107	A2	RZ3	PYG5	7681-903	7681-904	MQ15	MQ16	MQ17	MD7	7212-101	7682-905	7682-906	7450-713	F498	H260	F512	G315
Operculina ammonoides	X				X					X		X									X
Operculina venosa	X																				
O. complanata	X								X												
Cycloclypeus eidae	X				X		X			X		X	X			X	X	X	X		
C. indopacificus					X																
Katacycloclypeus transiens	X														X						
Spiroclypeus margaritatus				X	X	X	X	X	X		X	X				X		X		X	
Heterostegina borneensis	X																X				
Pararotalia mecatepecensis					X								X								
Paleomiogypsina boninensis					X															X	
Miogypsinella complanata					X																
Miogypsinoides formosensis						X	X								X						X
M. bantamensis		X	X			X	X				X			X	X	X	X				
M. dehaartii		X	X								X			X	X	X			X		
Miogypsina primitiva	X	X	X	X							X	X	X	X	X	X			X		X
M. borneensis	X			X						X	X	X	X	X	X	X			X		
Boninella negrosensis, n. sp.																X					
Lepidosemicyclina thecidaeformis				X			X			X								X			X
L. polymorpha										X											X
L. indonesiensis										X											X
Eulepidina dilatata					X										X	X	X	X			
E. ephippioides	X	X	X	X	X	X	X			X		X			X	X	X	X		X	X
Lepidocyclina boetonensis		X																			
L. radiata					X																
Nephrolepidina marginata					X	X		X													
N. brouweri					X	X										X	X				
N. borneensis	X				X																
N. ferreroi	X				X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
N. japonica		X	X		X			X	X	X		X		X		X		X	X	X	X
N. sumatrensis	X	X	X	X	X		X	X	X	X	X	X			X	X	X	X	X	X	X
N. verbeeki							X								X			X			
Austrotrillina howchini		X				X		X				X									X
Flosculinella globulosa				X	X	X						X						X		X	
Borelis pygmaeus						X															
Kanakaia marianensis											X										
Tayamaia marianensis																X			X		
Planorbulinella larvata	X	X			X				X				X				X		X		
Discogypsina vesicularis					X				X										X		
Sphaerogypsina globulus	X				X				X	X		X						X			
Neoplanorbulinella saipanensis			X														X		X		
Halkyardia bikiniensis										X											
Eorupertia boninensis					X		X								X						
Amphistegina radiata	X						X				X	X				X	X	X	X	X	X
Planorbulinella larvata																X			X		
Marginopora vertebralis									X										X		
Carpenteria proteiformis	X												X						X		X
Acervulina inhaerens	X					X					X	X					X		X		X
Sorites orbiculus																					X
Homotrema rubrum	X																				
Borodinia septentrionalis											X										

TABLE 10
Assemblage 12: Earliest Miocene (Aquitanian), Letter Stage Tertiary e5 (lower).

Species \ Station	N Luzon			NE Luzon					Mid Luzon	Cagra-gay		Marin-duque			Mindoro								Cebu	Panay	Masbate	Negros	Samar		E Min-danao		
	No.3	No.4	BG1	C56	K732	B102	B395	A 29	No.19	7681-908	7681-905	MQ12	MQ14	MQ20	YR09	HR206	MD112	MD112	MD113	MD118	TR2-127	TR2-137	Cebu23	PN20	PLN8	768-3001	7450-608	7450-609	C58	E25	E26
Operculina ammonoides							X					X				X			X		X					X		X			
O. bartschi																X															
O. complanata									X		X	X				X	X	X													
O. balcei			X																												
O. venosa	X		X													X	X											X			
Heterostegina spp.											X	X					X	X				X	X	X			X				
Cycloclypeus eidae								X	X	X	X						X	X	X	X		X	X	X		X				X	
C. indopacificus									X								X	X						X							
Katacycloclypeus transiens																	X	X													
Spiroclypeus margaritatus								X																		X					
Paleomiogypsina boninensis													X																		
Miogypsinoides bantamensis										X	X															X			X		X
M. dehaartii		X								X	X		X							X				X		X		X	X	X	X
Miogypsina primitiva		X		X					X	X	X						X	X			X			X	X				X		X
M. borneensis												X		X	X	X				X									X		X
M. globulina			X						X	X	X	X	X	X	X	X		X	X	X					X					X	
Lepidosemicyclina thecidaeformis								X	X	X	X			X	X	X	X	X	X		X	X								X	X
L. polymorpha								X	X								X		X					X					X		X
L. indonesiensis			X														X							X		X					
L. musperi			X																												
Eulepidina dilatata				X			X			X										X			X			X					
E. ephippioides							X			X																X					
Lepidocyclina radiata																					X										
Nephrolepidina ferreroi			X	X			X	X	X	X	X	X	X			X	X	X		X	X	X		X					X	X	X
N. japonica			X				X										X		X			X		X					X	X	X
N. sumatrensis		X	X	X				X	X	X	X	X					X				X		X	X	X	X	X	X	X	X	
N. verbeeki																										X					X
Austrotrillina howchini						X		X		X				X				X		X									X	X	X
A. striata								X																							
Flosculinella bontangensis	X	X	X		X	X	X	X	X	X	XX		X		X	X								X		X	X	X		X	
F. fusiformis		X	X			X		X					X																		
F. globulosa	X	X		X						X		X	X		X			X											X	X	
Borelis philippinensis																			X									X			
Quasibaculogypsinoides primitiva, n.gen.,n.sp.																X															
Kanakaia marianensis				X						X																					X
Tayamaia marianensis																													X		
Discogypsina vesicularis				X					X														X	X							X
Sphaerogypsina globulus	X	X				X	X	X		X			X		X		X		X					X			X	X	X		X
Planorbulinella larvata							X	X		X					X	X	X			X				X					X		X
Neoplanorbulinella saipanensis																								X							
Peneroplis planatus	X	X			X	X			X						X																
Orbitogypsina globulus									X								X														
Amphisorus hemprichii				X	X								X																X		
Amphistegina radiata	X			X		X		X		X	X		X				X	X	X	X				X		X			X	X	X
Miniacina miniacea	X	X	X			X		X			X		X				X	X						X		X		X	X	X	X
Acervulina inhaerens																															
Carpenteria proteiformis			X																X					X					X	X	X
Eorupertia spp.											X																				
Sorites orbiculus				X		X		X					X																X		
Marginopora vertebralis	X	X		X		X		X																					X		
Homotrema rubrum																								X					X		
Sporadotrema cylindricum																			X											X	X
Archaias spp.				X																											

TABLE 11
Assemblage 13: Early Miocene (early Burdigalian), Letter Stage Tertiary e5 (upper).

Species \ Station	N Luzon	Palanan	Bontoc	NE Luzon	Mid Luzon	Marin-duque		Palawan	Masbate
	No.2	No.6	BG 15	C57	AG 3	MQ19-1	MQ28?	PP61	PLN2
Operculina ammonoides	X	X		X			X	X	
O. complanata			X				X		
O. venosa	X						X	X	
Cycloclypeus eidae				X			X		X
C. indopacificus						X		X	
Katacycloclypeus transiens		X					X	X	
Miogypsinoides dehaartii				X				X	
Miogypsina borneensis				X					
M. borneensis				X		X	X	X	
M. globulina				X	X	X			X
Lepidosemicyclina thecidaeformis				X	X	X	X	X	
L. polymorpha	X			X	X			X	
L. indonesiensis							X		
Eulepidina dilatata.		X				X	X	X	
E. ephippioides						X	X	X	
Lepidocyclina radiata							X	X	X
Nephrolepidina ferreroi	X	X		X	X	X	X		X
N. japonica	X		X			X		X	
N. sumatrensis		X		X	X		X	X	X
N. verbeeki							X		
Austrotrillina howchini				X		X			
A. striata				X					
Flosculinella bontangensis			X						
F. globulosa						X			
Kanakaia marianensis				X					
Tayamaia marianensis				X					
Neoplanorbulinella saipanensis				X					
Discogypsina vesiculralis				X			X		
Planorbulinella larvata				X				X	
Amphisorus hemprichii			X						
Linderina brugesi					X	X			
Amphistegina radiata				X		X	X	X	
Sphaerogypsina globulus						X		X	
Acervulina inhaerens				X	X				
Eorupertia boninensis				X					
Sorites orbiculus						X			

blage 13 is correlated to the lower Misaki Formation, Yokomichi (Matsumaru and Kimura 1989) with planktonic foraminifera of Zone N5, as well as with Zone 4 of Okinawa (Hanzawa 1940) and Assemblage 3 of Turkey (table. 17)

Early Miocene (lower Burdigalian), Letter Stage Tertiary e5 upper.

Assemblage 14 (table 12, part) is defined by *Cycloclypeus posteidae, Miogypsina globulina, M. intermedia, Lepidosemicyclina thecidaeformis,Nephrolepidina ferreroi, Austrotrillina howchini* and *Flosculinella globulosa* that occur together in 20 samples with many other species, including reworked *Cycloclypeus eidae, Spiroclypeus margaritatus,* and *Nephrolepidina brouweri*. The type sample is from locality MQ10 of the upper Torrijos Formation of Marinduque, assigned to Tertiary f1 due to occurrences of all the defining species in the type Poeloe Balang Lagen (Leupold and van der Vlerk 1931). Planktonic foraminifera from four samples indicate Zones N8-9, while *Flosculinella bontangensis* and other *Flosculinella* species occur only in the three samples of probable Zones N5-7 age. On this basis, Assemblage 14 is distinguished from newly identified Assemblage 15 (below), in a division of Letter Stage Tertiary f1. Assemblage 14 is correlative to the fauna from Zone 3 of of the Kita-Daito-Jima Limestone, Japan, which has been dated by Sr isotope analysis to between 18.8 and 15.7 Ma (Ohde and Elderfield 1992). It can be partially correlated with a *Nephrolepidina/Miogypsina* assemblage in the Coastal Range and offshore islands of eastern Taiwan (Chang 1966; 1968).

Late early Miocene (upper Burdigalian), Tertiary f1 (lower)

Assemblage 15 (table 12, part) is identified by *Cycloclypeus posteidae*, *Lepidosemicyclina thecidaeformis*, *L. polymorpha*, and *Nephrolepidina martini* The type of Assemblage 15 is the sample F31 of the Natbang Formation, Caraballo Mountains, NE Luzon (text-fig. 4). Among other species (table 12), *Cycloclypeus eidae* is reworked. The planktonic foraminifera *Praeorbulia glomerosa*, *P. sicanus*, *Globigerina* ex gr. *G. praebulloides* and *Globigerinoidesoides* ex gr. *G. obliquus* (pl. 48, figs. 13, 12; pl. 49, figs. 7, 3; resp.) indicate Zones N8-9. A fauna closely similar to Assemblage 15 is found in the Abuta Limestone of the middle Idozawa formation, central Japan, with planktonic foraminifera of Zones N7-8 (Matsumaru 1967, 1971, 1977), in a series bracketed by fission track ages of 16.5 ± 1.9 Ma on the basal Idozawa tuff, and 15.2 ± 0.5 Ma on theconformably overlying Haratajino tuff (Nomura and Ohira 1998). In addition, an Assemblage 15 fauna is found (Matsumaru in Nomura et al. 2003) in the Yabuzuka Formation, Ota City, overlain by pumice tuff with a fission track age of 14.9 ± 0.5 Ma.

Early middle Miocene (Langhian), Tertiary f1 (upper).

Assemblage 16 (table 13), identified by *Cycloclypeus posteidae, Nephrolepidina rutteni, N. martini* and *N. angulosa,* is found in 10 samples, in which *L. thecidaeformis* is reworked. The type material from sample Cebu 30 of the Toledo Formation, Cebu, is assigned to Letter Stage Tertiary f2 due to presence of *Nephrolepidina angulosa, N. sumatrensis,* and *Miogypsina cushmani,* known from the Tertiary f2 type level in Borneo (Leupold and van der Vlerk 1931). Mohler (1949) recorded *Flosculinella borneensis* from the Tertiary f2-3 of Borneo, associated with *Alveolinella quoyii*, *Cycloclypeus inornatus* (= *C. guembelianus* (Brady), *C.* (= *Radiocycloclypeus*) *radiatus* Tan, *Miogypsina* (= *Lepidosemicyclina*) *musperi, M.* (= *L.*) *polymorpha* and *Lepidocyclina* (= *Nephrolepidina*) *rutteni*, but in the Philippines, however, this younger association could not be found (see table 13). Sample Cebu 30 also yields the planktonic foraminifera *Orbulina universa* (pl. 48, fig. 14) and sample Cebu 29 yields *Dentoglobigerina* cf. *D. altispira* (pl. 48, fig. 15), placing Assemblage 16 within the interval of Zones N9-N20. The assemblage is closely correlated with the fauna of upper Zone 3 of the Kita Daitojima Limestone (Hanzawa 1940), with strontium isotope ages from 13.65 to 11.61 Ma (Ohde and Elderfield 1992), which is consistent with placing Assemblage 16 to be equiva-

TABLE 12
Assemblage 14, Middle Miocene (later Burdigalian), Letter Stage Tertiary f1 lower; Assemblage 15 (shaded columns), Middle Miocene (Langhian), Letter Stage Tertiary f1 upper.

Species \ Station	N Luon	NE Luzon	SE Luzon			Marin-duque			Cebu							Tablas			Mindanao				Masbate		Palawan		Bunas	
	120	F31	A 9	MA11	SML10	MQ6	MQ10	MQ19-2	Cebu28	Cebu38	Cebu52	Cebu54	Cebu9	Cebu18	Cebu51	TB35	TB40	TB45	BT2F	H93	E 10	E 28	MBG1	MSG10	QZ10-2	QZ10-1	MH5	MH6
Operculina ammonoides	X		X				X				X							X			X		X				X	
O. complanata	X															X					X							
O. heterosteginoides	X																											
O. balcei	X																	X										
O. venosa			X															X	X		X	X						
Heterostegina spp.		X		X															X									
Cycloclypeus eidae		X		X			X						X								X	X						X
C. posteidae		X		X	X	X	X									X								X	X	X		X
Spiroclypeus margaritatus				X																								
Miogypsina globulina			X	X	X	X	X					X		X		X		X			X		X					
M. intermedia	X				X	X	X				X	X			X	X												
M. cushmani	X										X				X	X								X				
Lepidosemicyclina thecidaeformis		X	X	X	X		X	X	X	X	X	X			X			X	X	X	X	X	X	X				
L. polymorpha		X							X	X				X				X	X	X	X	X						
L. indonesiensis												X						X										
L. musperi	X																											
Lepidocyclina radiata																									X	X	X	
Nephrolepidina brouweri							X						X															
N. ferreroi	X	X		X		X	X	X					X			X	X	X			X			X				
N. japonica			X			X	X									X			X		X	X	X					
N. sumatrensis	X	X	X	X	X	X		X		X	X		X								X		X		X	X		
N. angulosa	X	X											X					X										
N. rutteni			X			X																	X		X	X		
N. martini	X	X											?											X	X			
N. verbeeki	X	X																X				X						
Austrotrillina howchini						X	X														X	X						
Flosculinella bontangensis																X			X	X	X							
F. fusiformis											X					X	X			X								
F. globulosa							X	X			X			X						X								
Alveolinella quoyii	X																											
Neoplanorbulinella saipanensis	X	X																										
Planorbulinella larvata	X	X		X									X		X				X		X				X	X		
Tayamaia marianensis															X													
Pseudorotalia schroeteriana																											X	
Sorites orbiculus								X	X					X					X		X	X						
Amphisorus hemprichii									X					X														
Discogypsina vesicularis															X	X					X							
Orbitogypsina vesicularis															X													
Sphaerogypsina globulus		X					X									X					X	X			X	X		
Acervulina inhaerens	X	X														X					X	X			X	X		
Amphistegina radiata		X	X	X	X	X	X									X			X		X	X			X	X		
Miniacina miniacea				X																					X	X		
Marginopora vertebralis																					X							
Homotrema rubrum																					X							
Carpenteria proteiformis						X		X										X			X							
Borodinia septentrionalis						X									X													
Sporadotrema cylindricum								X																				

TABLE 13
Assemblage 16: Middle Miocene (Serravallian), Letter Stage Tertiary f2.

Species \ Station	N Luzon	NE Luzon				Mindoro	Cebu		Tablas	Masbate
	BG 2	B 53	D 20	K 16	F 28	MD 106	Cebu 29	Cebu 30	TB 42	PWC 5
Operculina ammonoides	X	X	X	X	X			X	X	
O. balcei	X									
O. complanata	X	X		X	X			X	X	
O. venosa	X				X				X	
Heterostegina spp.	X								X	
Cycloclypeus posteidae		X	X	X				X		
C. carpenteri								X		
Miogypsina cushmani		X		X		X			X	X
Lepidosemicyclina thecidaeformis		X		X					X	
Lepidocyclina radiata				X				X		X
Nephrolepidina japonica			X							
N. rutteni				X		X		X	X	X
N. martini		X				X	X	X		
N. angulosa		X	X	X		X		X	X	
N. sumatrensis		X	X					X		
Austrotrillina howchini				X						
Sorites orbiculus						X				
Planorbulinella larvata		X	X		X	X	X			
Discogypsina vesicularis					X	X				
Marginopora vertebralis					X				X	
Rotalia spp.	X				X					
Homotrema rubrum	X									
Amphistegina radiata	X	X	X		X	X		X	X	
Carpenteria proteiformis									X	X
Acervulina inhaerens	X	X	X		X	X			X	
Sphaerogypsina globulus		X		X	X					
Archaias spp.									X	
Sporadotrema cylindricum	X					X				

lent to the Serravallian stage (table 3), with calibration between 13.82 to 11.63 Ma.

Middle Miocene (Serravalian), Letter Stage Tertiary f2.

Assemblage 17 (table 14), definied by *Heterostegina suborbicularis* and *Nephrolepidina rutteni,* is found in 4 samples. This fauna, which has an unusually low diversity fauna, is typified in Station Cebu 25 of the Maingit Formation, Cebu, and is assigned to the Letter Stage Tertiary f3 due to the occurrence of *Nephrolepidina rutteni,* the last occurrence of which defines the Tertiary f3 and Tertiary g boundary (table 16), typified in the Gelingseh Beds or Upper Balikpapan Formation (Leupold and van der Vlerk 1931). Sample MBG2, Masbate Island, yields the planktonic foraminifera *Candeina* cf. *C. nitida* d'Orbigny (pl. 49, fig. 14) of Zones N17-23. In Japan, the occurrence of *Nephrolepidina rutteni* in the Shimoshiroiwa Formation, Izu Peninsula corresponds to Assemblage 17 (Matsumaru 1992), where this species has a degree of enclosure (Factor A = 55.39 to 59.70) indicating late Miocene (Matsumaru 1971; Matsumaru et al. 1981). Assemblage 17 is also correlated with Zone 2 of the Kita Daito-jima Limestone (Hanzawa 1940, with Sr isotope age of 11.61 to 5.33 Ma (Ohde and Elderfield 1992), and to the Nakajima Formation of the Oki Islands (Hanzawa) and planktonic foraminifera of lower upper Miocene Zone N16

TABLE 14
Assemblage 17: Late Miocene (Tortonian – Messinian), Letter Stage Tertiary f3.

Species \ Station	N Luzon	SE Luzon	Cebu		Masbate
	W9	BHK 4	Cebu 25	Cebu 27	MBG 2
Operculina ammonoides		X			X
O. complanata			X		
O. venosa		X	X		X
Heterostegina suborbicularis	X	X	X	X	X
Lepidocyclina radiata			X		
Nephrolepidina rutteni		X	X	X	X
N. martini				X	X
Planorbulinella larvata	X	X	X	X	X
Baculogypsinoides spinosus	X	X			
Calcarina spp.		X			
Amphistegina radiata	X	X	X		
Asterigerina spp.	X		X	X	
Acervulina inhaerens	X	X			
Miniacina miniacea	X	X			
Sphaeroidinella dehiscens	X				

(Matsumaru 1982). Assemblage 17 is partially correlated with the fauna of *Nephrolepidina* sp. and *Amphistegina* from the Maoshan Limestone of Taiwan (Chang 1967; 1969), which is not younger than the *Globorotalia mayeri* Zone, and is overlapped by the Paliwan Formation with a fauna of the *Sphaeroidinella dehiscens* Zone.

Late Miocene (Tortonian to Messinian), Letter Stage Tertiary f3.

Assemblage 18 (Table 15, part) is defined by *Baculogypsinoides spinosus* and *Amphistegina radiata,* but only tentatively resolved due to the poor preservation of diagnostic larger foraminifera in 9 samples (tab. 15) in which *Lepidocyclina radiata, Nephrolepidina rutteni* and *N. martini* are regarded as reworked. The type sample comes from Station Cebu 2 in the lower Barili Formation, Cebu, and is correlated to Letter Stage Tertiary g due to the absence of *Nephrolepidina rutteni* and *N. martini* (cf. Leupold and van der Vlerk 1931). The planktonic foraminifera *Globorotalia* ex gr. *miocenica* (pl. 49, figs 11 right, 12), *G.* ex gr. *menardii* (pl. 49, fig. 13), and *Globigerinoides* sp. (pl. 49, fig. 11 left) indicate Pliocene Zones N19-21. Assemblage 18 partially correlates with Zone 1 in the Kita Daitojima Limestone (Hanzawa 1940), dated between 5.33 to 1.81 Ma (Ohde and Elderfield 1992). It is also correlated with Pliocene, Tertiary g faunas in the *Sphaeroidinella dehiscems* Zone in Taiwan (Chang 1967), Barrigada Limestone, Guam (Cole 1963); interval 860 to 615 feet in the Eniwetok Atoll core (Cole 1973), and interval 1030 to 694 feet in the Bikini Atoll core (Cole 1954).

Pliocene (Zanclean to Piacentian), Letter Stage Tertiary g.

TABLE 15
Assemblage 18, Pliocene, Letter Stages Tertiary g; Assemblage 19 (shaded columns), Pleistocene, Letter Stage Tertiary h.

Species \ Station	SE Luzon, Bondoc Penins.					Cebu			Panay		Tablas	Palawan	Masbate	Leyte						
	BYG 1	BYG3	BYG4	BHK7	PRS7	Cebu 46	Cebu 2	Cebu 44	PN 21	PN23	TB 17	QZ 10-3	PWC16	LMN10	VLB9	BHY2	VLB12	AGM3	BHY5	BHY6
Operculina ammonoides									X	X										
O. bartschi		X	X					X												
O. complanata		X							X		X	X		X	X		X			
O. venosa			X		X		X		X	X		X								
Herterostegina suborbicularis	X	X	X	X																
Cycloclypeus carpenteri					X	X	X			X										
Borelis melo												X								
Alveolinella quoyii			X		X							X	X				X		X	X
Baculogypsinoides spinosus	X		X				X	X	X	X	X		X	X	X	X			X	X
Calcarina spengleri		X	X		X						X									
C. delicata		X	X	X					X	X	X						X	X	X	X
***Rotalia* spp.**		X			X						X									
Amphistegina radiata	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	
Planorbulinella larvata			X	X												X				
Amphisorus hemprichii												X	X							
Sorites orbiculus			X		X				X			X								
Acervulina inhaerens	X	X	X	X	X				X							X				
Carpenteria proteiformis																X				
Lepidocyclina radiata						X	X									X				
Nephrolepidina rutteni						X	X		X		X									
N. martini							X													
Sphaerogypsina globulus	X	X	X	X	X															

Assemblage 19 (Table 15, part) is defined by the co-occurrence of *Calcarina spengleri* and *Calcarina delicate* in 11 samples, in which *Nephrolepidina rutteni* is reworked. Its correlation is tentative due to limited preservation. A similar association including *C. spengleri* in the Pleistocene Ryukyu Group, Japan, has a U/Th date of 300 Ka to 100 Ka (Matsumaru 1976; 1986). The type material is from Station TB17 of the Colasi Limestone, Tablas, which also yields planktonic foraminifera (pl. 49, figs. 1, 2, 8-10) of Pleistocene age, Zones N22-N23, which agree with assignment to Letter Stage Tertiary h due to occurrences of *Operculina complanata* and of the Pleistocene to Holocene species of *Calcarina spengleri* (Leupold and van der Vlerk 1931; Marks 1957). Assemblage 19 is correlated with the similar fauna with *C. spengleri* and *Cycloclypeus carpenteri* (but not *Calcarina delicata*) of the Ryukyu Limestone of Kagoshima and Okinawa (Matsumaru 1976).

Pleistocene to Holocene, Letter Stage Tertiary h.

NOTE: The last occurrence of "*Lepidocyclina*" in the Pacific Ocean. The boundary between Letter Stage Tertiary f3 and Tertiary g/h was defined by the upper limit of *Lepidocyclina* species in the type section in Lami Limestone of Sealark Hill, Viti Levu, Fiji, which Adams (1985) placed in the early Pliocene (Zanclian). Whipple (1934) described 12 species and one subspecies of "Old Miocene" (Tertiary e) larger foraminifera in 35 samples from the Lami Limestone, as well as a similar larger foraminiferal fauna from the Futuna Limestone in the Lau Islands, Fiji, assigned to Tertiary f. Whipple's specimens included *Lepidocyclina radiata* and *L. (Eulepidina) dilatata,* which compares exactly with the Ogasawara specimens of Matsumaru (1996), and which disappeared during Letter Stage Tertiary e5 in the Philippines (Table 16), and during Tertiary e3 in the Ogasawara Islands (Matsumaru 1996) and Taiwan (Hashimoto and Matsumaru 1975). In the same way, two other species in the Fiji fauna, *Cycloclypeus indopacificus* (identified by Adams et al. 1979 as *C. posindopacificus*) and *Eulepidina ephippioides*,

TABLE 16
Ranges of 192 species of larger foraminifera treated in this study with regard to Cretaceous-Tertiary Letter Stages and Philippine assemblages. The illustrations of the indicated taxa are indicated at right, including citations to previously published figures (M76 = Matsumaru 1976; M96 = Matsumaru 1996).

Species / Assemblage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Letter Stage	ms1	a0	a1	a2	a3	b	c	d	e1-2	e3	e4	e5	e5	f1	f1	f2	f3	g	h	Species illustrated:
Lepidorbitoides pembergeri	(X)																			Pl. 1: fig. 5
Lepidorbitoides campaniensis	X																			Pl. 1: figs 6-10
Lepidorbitoides bisambergensis	X																			Pl. 2: figs. 1-4
Lepidorbitoides minor	X																			Pl. 2: figs. 5-6
Orbitoides tissoti	X																			Pl. 3: figs. 9-10
Omphalocyclus macroporus	X																			Pl. 3: fig. 10; 4: 4-5
Simplorbites papyraseus	X																			Pl. 3: fig. 10
Siderolites calcitrapoides	X																			Pl. 4: fig. 7
Pseudorbitoides philippinensis, n. sp.	X																			Pl. 1: fig.10; 2: 4, 7-12
Sulcoperculina dickersoni	X																			Pl. 4: figs. 1-3
Sulcorbitoides pardoi	X																			Pl. 3: figs. 7-8
Orientorbitoides cebuensis, n. gen., n. sp.	X																			Pl. 3: figs. 11-12
Paleobaculogypsinoides catanduanensis n. gen, n. sp.	X																			Pl. 4: figs. 6a, 6b
Asterorbis rooki	X																			Pl. 3: figs. 1-2
Vaughania cubensis	X																			Pl. 3: figs. 3-6
Hashimotoina mindanaoensis, n. gen., n. sp.		X																		Pl. 5: figs. 8-11
Calcarina catanduanensis, n. sp.		X																		Pl. 6: figs. 3-8
Pseudochrysalidina spp.		X																		Pl. 5: figs. 3, 5
Pfendericonus mindanaoensis, n. sp.		X																		Pl. 4: figs. 8-9
Chrysalidina spp.		X																		Pl. 4: figs. 10-11
Coskinon rajkae		X																		Pl. 5: fig. 6
Broeckinella arabica		X	X																	Pl. 5: fig. 13
Coleiconus spp.		X	X																	Pl. 6: figs. 1-2
Pseudolituonella mindanaoensis, n. sp.		X	X																	Pl. 4: fig. 9; 5: 1-4
Rotalia trochidiformis		X	X																	Pl. 6: figs. 9-11
Idalina sinjarica		X	X																	Pl. 5: figs. 1, 5, 7
Kathina selveri		X	X																	Pl. 6: figs. 12-15; 9: 1
Miscellanea primitiva		X	X																	Pl. 7: figs. 5-8; 8: 17
Miscellanea globularis			X																	Pl. 7: figs. 1-4
Lockhartia haimei			X																	Pl. 8: figs. 17-20
Kathina major			X																	Pl. 6: figs. 16-17
Ranikothalia nuttalli			X																	Pl. 9: figs.1-5; 8: 10-11, 13-14
Ranikothalia sindensis			X																	Pl. 9: figs.6-7;9: 12, 15-16
Glomalveolina reicheri, n. sp.			X																	Pl. 7: fig. 16
Alveolina ellipsoidalis			X																	Pl. 11: fig. 1
Orbitosiphon tibetica			X																	Pl. 7: fig.17; 19: 1-17
Daviesina langhami			X																	Pl. 8: figs. 11-13
Lockhartia conditi			X	(X)																Pl. 8: figs. 14-16
Miscellanea miscella			X	(X)																Pl. 7: figs. 9-14
Daviesina danieli			X	(X)																Pl. 8: figs. 1-6
Alveolina vredenburgi			X	(X)																Pl. 11: figs. 5-6
Orbitoclypeus ramaraoi			X	(X)																Pl. 7: figs.19-20; 10: 1-9
Alveolina luzonensis, n. sp.			X	X																Pl. 5: fig.12; 11: 7-14
Alveolina subpyrenaica			X	X																Pl. 11: figs. 2-4
Asterocyclina incisuricamerata			X	X																Pl. 12: figs. 3-5
Asterocyclina stella			X	X	X	X														Pl. 12: figs.6: 7; 13: 12; 16: 9
Asterocyclina stellata			X	X	X	X														Pl. 12: figs.8-11; 29: 12-15; 30: 1
Operculina spp.			X	?	X	?	X	?	?	?	X									Pl. 36: fig. 13
Daviesina khatiyahi				(X)																Pl. 8: figs. 7-10
Glomalveolina levis				(X)																Pl. 7: fig. 15
Operculina custugensis				X																Pl. 12: fig.14; 13: 10; 16: 7-10
Nummulites globulus				X																Pl. 14: figs. 11-14
Nummulites burdigalensis				X																Pl. 15: figs. 8-13
Nummulites atacicus				X																Pl. 12: fig.19; 13: 12; 14: 5-11
Nummulites millecaput				X																Pl. 14: figs. 1-4
Alveolina amarasiensis				X																Pl. 12: figs. 1-2
Asterocyclina pinugayensis, n. sp.				X																Pl. 12: figs. 11-15
Assilina philippinensis, n. sp.				X																Pl. 12: figs. 16-19
Nummulites distans				X																Pl. 13: figs. 10-12
Nummulites amakusensis				X																Pl. 13: figs. 1-6
Nummulites hongoensis				X																Pl. 14: figs. 15-16
Nummulites junbarensis				X																Pl. 13: figs.7-9
Opertorbitolites douvillei				X																Pl. 5: fig. 12
Assilina exponens					X															Pl. 12: figs. 20-21
Nummulites gizehensis					X															Pl. 15: figs. 1-4
Nummulites perforatus					X															Pl. 15: figs. 14-15
Nummulites ptukhiani					X															Pl. 16: figs. 1-6
Nummulites striatus					X	X														Pl. 15: figs.5-7; 20: 13-15; 21: 1-3
Operculina schwageri					X	X														Pl. 16: figs.11-12; 22: 2-3; 29: 10
Fabiania cassis					?	X														Pl. 44: fig. 15
Operculina eniwetokensis						X														Pl. 21: figs. 14-15; 22: 1
Operculina saipanensis						X														Pl. 21: fig. 13
Nummulites fabianii						X														Pl. 20: figs. 1-6
Heterostegina aequatoria						X														Pl. 23: figs. 10-11
Cycloclypeus sp.						X														Pl. 20: fig. 4
Spiroclypeus granulosus						X														Pl. 25: figs. 7-9; 29: 6; 30: 8
Biplanispira absurda						X														Pl. 27: figs. 10-12
Biplanispira mirabilis						X														Pl. 26: figs. 13-15; 27: 1
Pellatispira madaraszi						X														Pl. 26: figs. 4-7; 13
Pellatispira orbitoidea						X														Pl. 20: fig. 12; 27: 2-5
Pellatispira provalei						X														Pl. 26: figs. 8-12
Pellatispira crassicolumnata						X														Pl. 27: figs. 6-9
Pellatispira inflata						X														Pl. 27: figs. 13-15
Eopellatispira mindoroensis, n. gen., n. sp.						X														Pl. 28: figs. 4-7
Mindoroella mindoroensis, n. gen., n. sp.						X														Pl. 23: fig.12; 28: 13-15; 29: 1-3
Baculogypsinella eocenica, n. gen., n. sp.						X														Pl. 28: figs. 8-12
Discocyclina dispansa						X														Pl. 29: figs. 4-5, 8, 10
Discocyclina llarenai						X														Pl. 29: figs. 6-8
Asterocyclina pentagonalis						X														Pl. 30: fig. 2
Orbitoclypeus pygmaeus						X														Pl. 29: figs. 7-12
Orbitogypsina mindoroensis, n. sp.						X														Pl. 45: figs. 5-6
Operculina subformai						X														Pl. 20: figs. 10-11
Nummulites incrassatus						X	X													Pl. 20: figs. 7-12
Heterostegina saipanensis						X	X													Pl. 23: figs. 12-13
Halkyardia minima						X	X	X												Pl. 44: fig. 7
Nummulites vascus						X	X	X									(continued)			Pl. 21: figs. 10-12; 29: 12

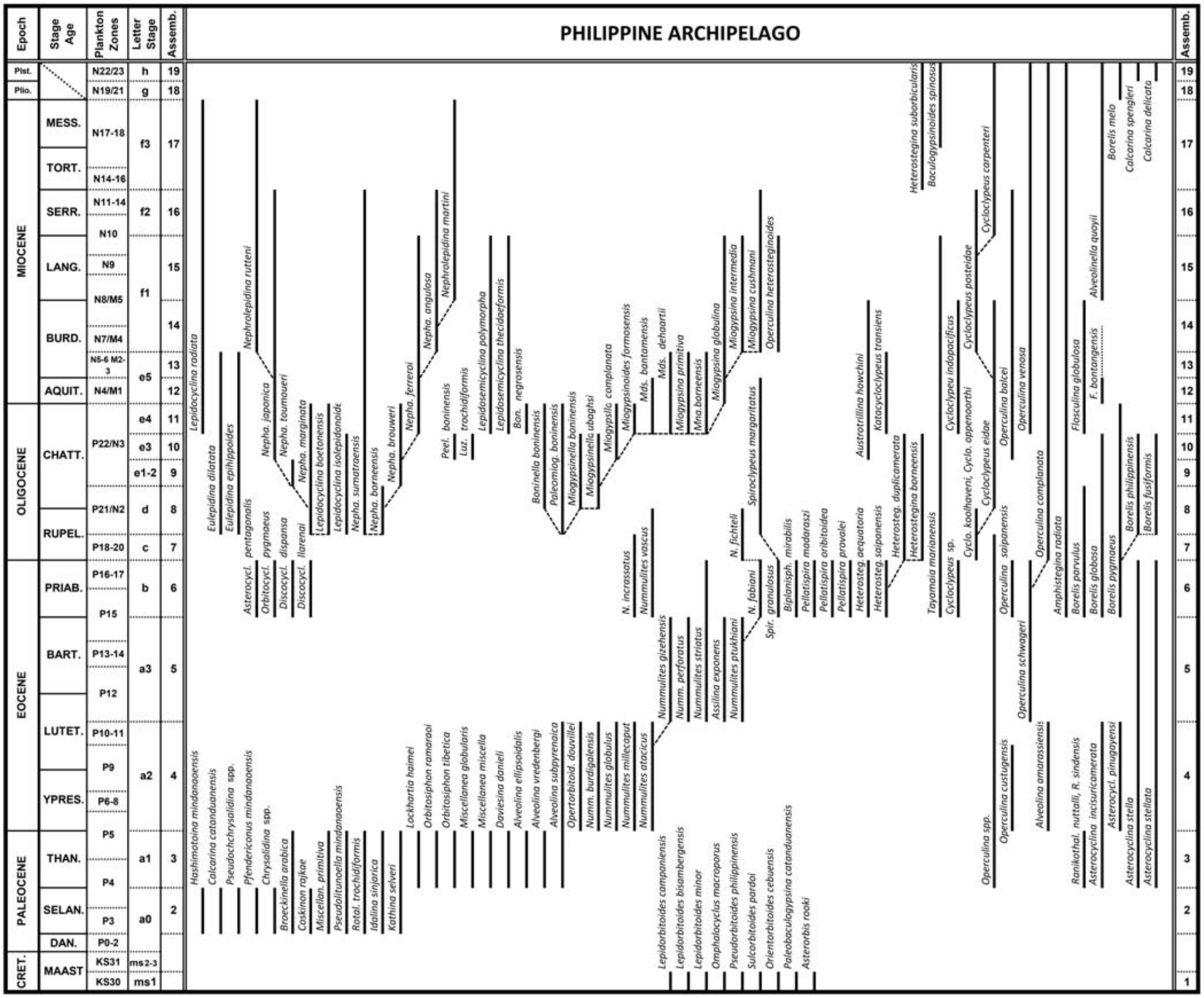
TABLE 16
continued.

Species / Assemblage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Letter Stage	ms1	a0	a1	a2	a3	b	c	d	e1-2	e3	e4	e5 low	e5 upp	f1 low	f1 upp	f2	f3	g	h	*Species illustrated:*
Borelis parvulus						X	X	X												Pl. 41: figs. 3-5
Borelis globosa						X	X	X	X	X										Pl. 41: figs. 6-9
Borelis pygmaeus						X	X	X	X	X	X									Pl. 41: figs. 11-15
Tayamaia marianensis						X	?	?	?	?	X	X	X	X						Pl. 44: figs. 12-13; 45: 4: 1-3
Orbitogypsina vesicularis						X	?	X	?	?	?	?	?	X	X					Pl. 44: figs. 14-15; 45: 1-2
Discogypsina vesicularis						X	?	X	X	X	X	?	X	X	X	X				Pl. 44: figs. 7-9
Amphistegina radiata						X	X	X	X	X	X	X	X	X	X	X	X	X	X	Pl. 32: fig. 4
Discocyclina spp.							(X)													(not illustrated)
Eorupertia boninensis							(X)			?	(X)		(X)							M96, p. 160: Pl. 59: figs. 1-3
Nummulites fichteli							X	X												Pl. 21: figs. 4-9
Halkyardia bikiniensis							X	X												Pl. 44: figs. 8-10
Cycloclypeus koolhoveni							X	X												Pl. 24: figs. 5-7
Cycloclypeus oppenoorthi							X	X												Pl. 24: figs. 8-9
Heterostegina duplicamera							X	X	X	X										Pl. 23: figs. 14-15; 36: 2: 5
Heterostegina borneensis							X	X	X	X	(X)									Pl. 24: figs. 1-3
Operculina complanata							X	X	X	X	X	X	X	X	X	X	X	X	X	Pl. 22: figs. 4-6; 43: 11
Planorbulinella larvata							X	X	X	X	X	X	X	X	X	X	X	X	X	Pl. 45: figs. 13-15; 46: 1
Fabiania spp.								(X)												(not illustrated)
Lepidocyclina pustulosa								(X)												Pl. 30: figs. 9-10
Linderina brugesi								(X)					(X)							Pl. 44: figs. 1-3
Nephrolepidina borneensis								X	X											Pl. 32: figs. 1-3
Lepidocyclina isolepidinoides								X	X	X										Pl. 21: fig.11; 23: 13; 25: 11; 31: 2, 7, 10-15
Borelis fusiformis, n. sp.								X	X	X										Pl. 42: figs. 4-9
Borelis philippinensis								X	X	X										Pl. 42: figs. 1-3
Miogypsinella boninensis								X	X	X										Pl. 36: figs. 2-6
Miogypsinella ubaghsi								X	X	X										Pl. 36: figs. 7-9
Boninella boninensis								X	X	X	X									M96, p. 48; Pl. 4: figs.1-4, 5, 8
Pararotalia mecatepecensis								X	X	X	X									Pl. 35: figs. 10-11
Lepidocyclina boetonensis								X	X	X	(X)									Pl. 30: figs. 11-15; 31: 1
Nephrolepidina marginata								X	X	X	X									Pl. 21: fig. 12; 31: 2-9
Paleomiogypsina boninensis								X	X	X	(X)	(X)								Pl. 35: figs.10, 12-15; 36: 1
Spiroclypeus margaritatus								X	X	X	X	X		(X)						Pl. 25: figs.10-15; 26:1-3; 36: 2
Neoplanorbulinella saipanensis								X	?	?	X	X	X		(X)					Pl. 46: figs. 2-4
Eulepidina dilatata								X	X	X	X	X	X							Pl. 34: figs. 13-15
Eulepidina ephippioides								X	X	X	X	X	X							Pl. 35: figs. 1-9
Cycloclypeus eidae								X	X	X	X	X	X	X	(X)					Pl. 24: figs. 10-12
Nephrolepidina sumatrensis								X	X	X	X	X	X	X	X	X				Pl. 33: figs. 1-6, 9; 44: 3
Sphaerogypsina globulus								X	X	X	X	?	?	X	X	X	?	X	X	Pl. 21: fig. 4; 32: 13; 45: 11-12
Operculina ammonoides								X	X	X	X	X	X	X	X	X	X	X	X	Pl. 22: figs. 7-9; 32: 13
Nephrolepidina tournoueri									X											Pl. 32: figs. 14-15
Nephrolepidina brouweri									X	X	X			(X)						Pl. 32: figs. 4-6
Praerhapydionina boninensis										X										Pl. 1: fig. 1
Borelis sp.										X										Pl. 1: figs. 2-3
Peelella boninensis										X										Pl. 44: figs. 4-6
Luzonella trochidiformis, n. gen., n. sp.										X										Pl. 37: figs. 11-13
Nummulites spp.										(X)										(not illustrated)
Pellatispira spp.										(X)										(not illustrated)
Miogypsinella complanata										X	X									Pl. 36: figs. 10-14; 37: 1
Austrotrillina howchini										X	X	X	X	X		(X)				M96, p. 214-216: Pl. 84: figs. 3-7
Operculina balcei										X	?	X	?	X	X	X				Pl. 22: figs. 10-15; 25: 12
Nephrolepidina japonica										X	X	X	X	X	X	X				Pl. 33: figs. 7-10
Sorites orbiculus										X	X	X	X	?	?	?	?	X	X	Pl. 1: fig. 4
Miogypsinoides formosensis											X									Pl. 36: fig. 15; 37: 2
Boninella negrosensis, n. sp.											X									Pl. 37: figs. 8-10
Miogypsinoides bantamensis											X	X								Pl. 37: figs. 3-7
Miogypsinoides dehaartii											X	X	X							Pl. 37: figs. 7: 14-15; 38: 1-4
Miogypsina primitiva											X	X	X							Pl. 38: figs. 5-12
Miogypsina borneensis											X	X	X							Pl. 38: figs. 13-15; 39: 1-2
Cycloclypeus indopacificus											X	X	X							Pl. 25: figs. 3-4
Katacycloclypeus transiens											X	X	X							Pl. 25: figs. 1-2
Kanakaia marianensis											X	X	X							Pl. 46: fig. 5
Nephrolepidina verbeeki											X	X	X							Pl. 34: figs. 4-5
Flosculinella globulosa											X	X	X	X						Pl. 43: figs. 7-10
Borodinia septentrionalis											X	?	?	X	X					Pl. 44: fig. 11
Nephrolepidina ferreroi											X	X	X	X	X					Pl. 32: figs. 7-13; 43: 10
Lepidosemicyclina indonesiensis											X	X	X	X	X					Pl. 40: figs. 4-5
Lepidosemicyclina polymorpha											X	X	X	X	X					Pl. 39: figs. 14-15; 40: 1-3
Lepidosemicyclina thecidaeformis											X	X	X	X	X	(X)				Pl. 39: figs. 6-8
Lepidocyclina radiata											X	X	X	X	X	X	X	(X)		Pl. 34: figs. 6-13
Operculina venosa											X	X	X	X	X	X	X	X	X	Pl. 23: figs. 1-6; 46: 6
Quasibaculogypsinoides primitiva, n. gen., n. sp.												X								Pl. 46: figs. 6-11
Orbitogypsina globulus												X								Pl. 45: fig. 10
Austrotrillina striata												X	X							M96, p. 216
Flosculinella bontangensis												X	X	X						Pl. 42: figs. 10-14
Flosculinella fusiformis												X	?	X						Pl. 42: fig. 15; 43: 1-6
Lepidosemicyclina musperi												X	?	X	X					Pl. 41: figs. 1-2
Miogypsina globulina												X	X	X	X					Pl. 38: fig. 8; 39: 3-5
Amphisorus hemprichii												X	?	X	X	?	?	X	?	Pl. 46: fig. 12
Operculina bartschi												X	?	?	?	?	?	X	X	M76, p. 412; Pl. 4: figs.12-14, 17
Peneroplis planatus												X	?	?	?	?	?	?	?	M96, p. 220: Pl. 86: figs. 1-5
Operculina heterosteginoides														X	X					Pl. 23: figs. 7-9
Miogypsina intermedia														X	X					Pl. 39: figs. 8-11
Miogypsina cushmani														X	X	X				Pl. 39: figs. 12-13
Nephrolepidina angulosa														X	X	X				Pl. 33: figs. 11-12
Nephrolepidina rutteni														X	X	X	X	(X)		Pl. 33: fig. 9; 34: 2-3
Cycloclypeus posteidae														X	X	X				Pl. 24: figs. 13-15
Pseudorotalia schroeteriana															X	?	?			Pl. 34: fig. 12
Nephrolepidina martini															X	X	X	(X)		Pl. 33: figs. 13-15; 34: 1
Alveolinella quoyii															X	?	?	X	X	Pl. 41: fig. 10; 43: 11-15
Cycloclypeus carpenteri																X	X	X	X	Pl. 25: figs. 5-6
Heterostegina suborbicularis																	X	X	X	Pl. 24: fig. 4
Baculogypsinoides spinosus																	X	X	X	Pl. 34: fig. 1; 46: 13
Calcarina spp.																	X			(not illustrated)
Borelis melo																		X	?	Pl. 41: fig. 10
Calcarina spengleri																			X	Pl. 46: fig. 14
Calcarina delicata																			X	Pl. 46: fig. 15

TABLE 17
Larger foraminifera assemblage zones of central and eastern Tethys. The Philippine assemblages in this paper are correlated to those of Turkey in the Bey Daglari Autochton (Matsumaru et al. 2010) and Haymana and Black Sea regions (Matsumaru 2016), NE India, Jaintia Hills, Meghalaya (Matsumaru and Sarma 2010), and Japan, Ogasawara Islands (Matsumaru 1996).

EPOCH		AGE / STAGE	PLANKTONIC FORAM ZONE	LETTER STAGE	Philippine Archipelago *(this paper)*	Turkey: Menderes-Taurus* *(Matsumaru et al, 2010)* Haymana-Black Sea *(Matsumaru, 2016)*	India: Jaintia Hills, Meghalaya *(Matsumaru and Sarma, 2010)*	Ogasawara, Bonin Islands *(Matsumaru, 1996)*
PLEIST.		GELAS.-CALABR.	N22-23	h	Assemblage 19			
PLIOCENE		ZANCL.-PIACENZ.	N19-21	g	Assemblage 18			
MIOCENE	Late	MESSINIAN	N17-18	f3	Assemblage 17			
		TORTONIAN	N15-16					
			N14					
	Middle	SERRAVALIAN	N11-13	f2	Assemblage 16			
		LANGHIAN	N10	f1	Assemblage 15			
			N9					
	Early	BURDIGALIAN	N8/M5		Assemblage 14			
			N7/M4					
			N5-6 M2-3	e5	Assemblage 13	Assemblage 3*		
		AQUITANIAN	N4/M1		Assemblage 12	Assemblage 2*		
OLIGOCENE	Late	CHATTIAN	P22/N3	e4	Assemblage 11	Assemblage 1*		
				e3	Assemblage 10			Assemblage V
				e1-2	Assemblage 9			
			P21/N2	d	Assemblage 8			Assemblage IV
	Early	RUPELIAN	P18-20	c	Assemblage 7			
EOCENE	Late	PRIABONIAN	P16-17	b	Assemblage 6		Assemblage 6	Assemblage III
	Middle	BARTONIAN	P15	a3	Assemblage 5		Assemblage 5	Assemblage II
			P13-14				Assemblage 4-2	
			P12					Assemblage I
		LUTETIAN	P10-11	a2	Assemblage 4	Assemblage 11		
			P9			Assemblage10	Assemblage 4-1	
	Early	YPRESIAN	P6-8			Assemblage 9	Assemblage 3-2	
			P5				Assemblage 3-1	
PALEOCENE	Late	THANETIAN		a1	Assemblage 3	Assemblage 8	Assemblage 2	
			P4				Assemblage 1	
	M.	SELANDIAN	P3	a0	Assemblage 2	Assemblage 7		
	E.	DANIAN	P0-2			Assemblage 5-6		
CRETACEOUS		MAASTRICHT.	KS31	ms3		Assemblage 4		
				ms2		Assemblage 3		
			KS30	ms1	Assemblage 1	Assemblage 2		
		CAMPANIAN	KS28-29	cm2				
			KS27	cm1		Assemblage 1		

TABLE 18
Biostratigraphic synthesis of range and relationship of 130 diagnostic larger foraminifera from the late Cretaceous (Maastrichtian) to Cenozoic (Pleistocene-Holocene) age/stage in the Philippine Archipelago (see also Matsumaru 2011, text-fig. 3).



that Whipple (1934) had named *Lepidocyclina* (*Eulepidina*) *formosa* disappeared in lower Miocene Tertiary e5 of the Philippines (table 16).

The carbonate platforms of the several terraces in Fiji rest on volcanic rocks that have been tectonically uplifted and faulted, so it is possible that the carbonate could contain a mixed fauna with the four species *Eulepidina dilatata, E. formosa (=E. epihippoides), Cycloclypeus posteidae* and *Lepidocyclina radiata.* There is no evidence in the type Lami Limestone whether *Lepidocyclina radiata* could have existed after the lower Pliocene, but it has not been found with *C. posteidae* in Tertiary f3 of the Philippines, although the three species *Lepidocyclina radiata, Nephrolepidina rutteni* and *N. martini* have been found reworked in association with *Cycloclypeus carpenteri* Brady in the Pliocene Tertiary g samples Cebu 2 and Cebu 46 on Cebu (Table 15). Van Vessem (1978) found *Lepidocyclina radiata* in a sample from the Sangkulirang area, East Borneo within Zone N19, together with examples of *Baculogypsina* limited to the Pleistocene and Holocene in Kagoshima and Okinawa Prefectures (Matsumaru 1976, 1986). The author has never found any specimens of *Lepidocyclina* from the carbonate rocks with Sr isotopic ages of c. 4.5 Ma or younger in the bore-holes and small islands of the Java Sea. In New Zealand and Australia, however, Chaproniere (1984) concluded placed the Tertiary f/Tertiary g boundary, as defined by the last occurrence of *Nephrolepidina* in Zone N15 (lower Tortonian).

SYSTEMATIC DESCRIPTION

The classification of foraminifera basically follows that of Loeblich and Tappan (1987).

Suborder ROTALIINA Delage and Herouard 1896
Superfamily ROTALIACEA Ehrenberg 1838
Family ROTALIIDAE Ehrenberg 1839
Subfamily PARAROTALIINAE Reiss 1963
Genus *Pararotalia* Y. Le Calvez 1949

Pararotalia mecatepecensis (Nuttall)
Plate 35, figures 10 left and center, 11

Rotalia mexicana Nuttall var. *mecatepecensis* NUTTALL 1932. p. 26, pl. 4, figs. 11-12. – BARKER and GRIMSDALE 1937, p. 167, pl. 6, fig. 7; pl. 7, figs. 7-9.
Rotalia mecatepecensis Nuttall. – HANZAWA 1957, p. 59-60, pl. 2, figs. 1-11.
Pararotalia sp. – MATSUMARU, MYINT THEIN and OGAWA 1993, p. 12, figs. 2-5-6.
Pararotalia mecatepecensis (Nuttall). – MATSUMARU 1996, p. 44, 46, pl. 3, figs. 1-7; pl. 52, fig. 1 left; Fig. 23-1. – MATSUMARU 2012, p. 623-646, figs. 3-4, 7, 9.
Pararotalia (PRBG, PRSN groups), MISHRA 1996, p. 136, pl. 1, figs. a-f; pl. 6, figs. a-h; pl. 8, figs. h, j-m.

Description: Test small, roughly circular or small ear lobe in outline, planoconvex to subglobular with the dorsal side slightly more vaulted and roughened than the ventral. Surface ornamented with numerous tubercles on the dorsal side, spirally developed with large umbilical plug and solid massive pillars filling the ventral side. Spherical to subspherical protoconch and reniform deuteroconch are followed by low trochospirally coiled subquadrate chambers in 1½ to 2 1/4 whorls. Septa imperforate, doubled in later whorls. Lateral layers are thicker over protoconch on the dorsal side than the ventral side, with solid and compound plug(s) and shell materials. Intraseptal canals are present, opening along the septal sutures and as spiral canals around the plugs. Aperture is a basal opening at the margin of the final chamber.

Dimensions: Diameter of test = 0.80 to 1.50 mm, thickness = 0.45 to 0.60 mm, diameter/thickness ratio = 1.48 to 2.04; diameter of protoconch = 73 × 73 and 80 × 78 µm in 2 specimens, diameter of deuteroconch = 64 × 36 and 70 × 50 µm; Distance and number of chambers in ½ whorl = 325 to 450 µm and 3 to 4, those in first whorl = 550 to 650 µm and 7 to 8, those in 1½ whorl = 660 to 875 µm and 13, and those in 2 whorl = 1000 µm and 18; diameter of solid plug = 150 to 175 µm.

Remarks: Pararotalia mecatepecensis (Nuttall), which occurs in assemblages 8 to 11 (table 16) and also the Minamizaki Limestone of Ogasawara Islands (Matsumaru 1996) is assigned to *Pararotalia*, following Loeblich and Tappan (1987, p. 659). It has aerial apertures and simple canals, and evolved into *Paleomiogypsina boninensis* Matsumaru with the development of subsidiary chambers near the periphery of the outer spiral chambers as well as preliminary equatorial chambers in the final whorl (Matsumaru 1996). The species with specimens possessing a few supplementary equatorial chambers was recorded by Cahuzac and Poignant (1991) in the Oligocene of the Aquitaine Basin of France, by Mishra (1996) in the Waiorian Stage (*Globorotalia opima nana* Zone) with *Miogypsinella complanata* in the Andaman Basin, India, and has also been found in the Upper Oligocene (Chattian) of Turkey (Matsumaru 2012).

Middle Oligocene, Tertiary d to uppermost Oligocene, Tertiary e4.

Superfamily ROTALIACEA Ehrenberg 1839
Family MIOGYPSINIDAE Vaughan 1928
Genus *Paleomiogypsina* Matsumaru 1996

Paleomiogypsia boninensis Matsumaru 1996
Plate 35, figures 10 right, 12-15; plate 38, figure 1

Paleomiogypsina boninensis MATSUMARU 1996, p. 56-58, pl. 8, figs. 1-2; pl. 9, figs. 1-14; pl. 32, fig. 7 (Text-fig. 23-2. – BOUDAGHER-FADEL, LORD, and BANNER 2000, p. 144, pl. 1, figs. 12-13. – GOVINDAN 2003, p. 67, pl. 4, figs. 17a-b. – MATSUMARU, SARI and OZER 2010, p. 448, 450, pl. 1, figs. 1-4.– MATSUMARU 2012, p. 623-646, figs. 3-4, 7, 9.
Miogypsinoides with a few equatorial chambers (MC, MCSM groups), MISHRA 1996, p. 136, pl. 1, figs. g-m; pl. 6, figs. i-o; pl. 8, figs. I, n; illustr. 1 b-c, 3d.

Description: Test subcircular to flabelliform, planoconvex with ventral side more convex than the dorsal. Low trochospiral coil with a few equatorial chambers, enlarged in the last whorl along the margin of the dorsal side and lobate in the periphery. Protoconch and deuteroconch; followed by subquadrate periembryonic chambers, centrally elevated on the spiral side and inflated around the umbilicus with pseudoumbilical shoulder. A few advanced ogival to rhombic equatorial chambers are present on the frontal side of spiral chambers. Equatorial chambers are simple, with stolons and canals. Lateral walls thick, compact and lamellar. Rudimentary lateral chambers are absent. The wall is calcareous and coarsely perforate. Dorsal pillars and umbilical plugs are present.

Dimensions: Diameter of test = 0.70 to 1.37 mm, thickness = 0.41 to 0.60 mm, diameter/thickness ratio = 1.71 to 2.17; diameter of protoconch = 79 × 68 µm; diameter of deuteroconch = 70 × 48 µm; ratio of deuteroconch/protoconch diameter = 0.89; distance across protoconch and deuteroconch = 146 µm; number of subquadrate chambers, 8 in first whorl, and 20 in second whorl; distance on frontal side between subquadrate chambers in last whorl = 104 × 160 to 121 × 195 µm; diameter of pillars = 80 × 100 µm; diameter of plugs = 80 to 178 µm.

Remarks: Paleomiogypsina boninensis Matsumaru, named from the Oligocene (Tertiary d to Tertiary e3) of the Ogasawara (Bonin) Islands, evolved from *Pararotalia mecatepecensis* and subsequently evolved into *Miogypsinella boninensis* (Matsumaru 1996), cf. table 18. It also is found in the Chattian of Turkey (Matsumaru 2012).

Middle Oligocene, Tertiary d to uppermost Oligocene, Tertiary e4.

Genus *Miogypsinella* Hanzawa 1940

Miogypsinella boninensis Matsumaru 1996
Plate 36, figures 2-6

Miogypsinella boninensis MATSUMARU 1996, p. 50-52, pl. 5, figs. 1-7; pl. 6, figs. 1-12; pl. 7, figs. 1-16 (Text-fig. 23-4. – BOUDAGHER-FADEL, LORD and BANNER 2000, p. 144, pl. 2, figs. 1-2, 4. – MATSUMARU 2012, p. 623 – 646, figs. 3-4, 7, 9.

Description: Test flabelliform and biconvex, ornamented with conical pillars on the dorsal side and umbilical plugs on the ventral side. Spherical protoconch and reniform deuteroconch near the apex are followed by subquadrate nepionic chambers in a trochoid spiral, becoming ogival to rhombic equatorial chambers in planispiral rows, partially on the distal margin of test. Lateral chambers are absent between spiral lamellae of whorls. Equatorial stolons, canals and umbilical plugs are present.

Dimensions: Megalospheric form, diameter of test = 1.14 to 1.60 mm, thickness = 0.57 to 0.73 mm, diameter/thickness ratio = 1.75 to 2.32; diameter of protoconch = 90 × 90 µm, diameter of deuteroconch = 95 × 108 µm, deuteroconch /protoconch diameter = 1.06; distance across both protoconch and deuteroconch = 181 µm; number of whorls = 2 ¼; number of nepionic chambers = 8 to 9 in first whorl, 21 in second whorl, and 23 in total number; AP angle between apical-frontal line and a line connecting center of protoconch and that of deuteroconch (Hanzawa 1957, p. 93) = 540 to 510; tangential × radial diameter of chambers = 102 × 136 to 147 × 160 µm; diameter of pillars = 80 to 113 µm; diameter of plugs = 147 to 160 µm. Microspheric form, diameter of test = 2.14 mm; number of whorls = 3 (or more?); tangential × radial diameter = 90 × 113 to 125 × 136 µm; diameter of pillars = 113 to 143 µm.

Remarks: Miogypsinella boninensis Matsumaru, found in Assemblages 8, 9, and 10 (table 18), is named from the Oligocene of Ogasawara Islands (Matsumaru 1996), and is similar to *M. grandipustula* Cole from Bikini (Cole 1954) and Eniwetok (Cole 1957), but differs in having more nepionic chambers, a large AP angle and small conical pillars. *Miogypsinella boninensis* evolved into *M. grandipustula* and further *M. grandipustula* evolved into *M. ubaghsi*, remarkably by decreasing nepionic chambers (Matsumaru 1996, p. 54, fig. 24). *Miogypsinella boninensis* also is found in the Chattian of Turkey (Matsumaru 2012).

Middle Oligocene, Tertiary d to upper Oligocene, Tertiary e3.

Miogypsinella ubaghsi (Tan Sin Hok 1936)
Plate 36, figures 7-8, 9 left

Miogypsinoides ubaghsi TAN SIN HOK 1936, p. 47-48, pl. 1, figs. 1-7. – TAN SIN HOK 1936, p. 95, text-figs. 11-12. – COLE 1954, p. 603-604, pl. 221, figs. 5, 9-18; pl. 222, figs. 13-15. – COLE 1957, p. 770-771, pl. 243, figs. 10-11, 13-19. – MOHIUDDIN, OGAWA and MATSUMARU 2000, p. 199, figs. 7-2, 8-2, 8-3. – MATSUMARU 2012, p. 623-646, figs. 4, 7.

Description: Test flabellate, biconvex. Subspherical protoconch and reniform deuteroconch near the apex are followed by subquadrate nepionic chambers in low trochoid spirals, becoming rows of ogival to rhombic equatorial chambers on the distal side with crenulated test margin. Lateral chambers are generally absent or rudimentary between spiral lamellae. Equatorial stolons, canals and umbilical plugs are present.

Dimensions: Diameter of test = 1.27 to 1.95 mm, thickness = 0.61 to 1.00 mm, diameter/thickness ratio = 1.73 to 3.00; diameter of protoconch = 113 × 90 µm, diameter of deuteroconch = 102 × 45 µm, deuteroconch/protoconch diameter = 0.90; distance across both protoconchand deuteroconch = 147 µm; number of whorls = 1 3/4; number of nepionic chambers = 8 in first whorl, 15 to 16 in 1½ whorl and 18 to 21 in total; AP angle = 360 to 357; tangential × radial diameter = 90 × 113 to 250 × 227 µm; diameter of pillars = 68 to 113 µm; diameter of plugs = 90 to 270 µm.

Remarks: This species in Assemblages 8, 9, and 10, is here reassigned to *Miogypsinella* from *Miogypsinoides,* despite its resemblance to descendant *Miogypsinoides complanata* (Schlumberger) in its trochoid nepionic spiral. *Miogypsinella ubaghsi* was found in limestone on the Komahashi-Daini Seamounts (Matsumaru in Mohiuddin et al. 2000)), confirming that *Miogypsinella boninensis* from Ogasawara Islands could have locally evolved into *Miogypsinella ubaghsi* (Matsumaru 1996).

Middle Oligocene,Tertiary d to upper Oligocerne,Tertiary e3.

Miogypsinella complanata (Schlumberger 1900)
Plate 36, figures 10-14; plate 37, figure 1

Miogypsinoides complanata SCHLUMBERGER 1900, p. 300, pl. 2, figs. 13-16; pl. 3, figs. 18-21.
Miogypsinella complanata (Schlumberger). – HANZAWA 1940, p. 766-767, fig. 1.
Miogypsinella sanjosensis HANZAWA 1940, p. 766-767, fig. 3.
Miogypsina (*Miogypsinoides*) *complanata* Schlumberger. – DROOGER and MAGNE 1959, p. 273-277, pl. 2, figs. 1-3. – RAJU 1974, p. 78, pl. 1, figs. 6-8 (non 9); pl. 3, figs. 3-6 (non 7). – MISHRA 1996, p. 158, pl. 1, figs. n-p; pl. 2, figs. a-b, d-e, k; pl. 6, figs. q, s-t (non r); pl. 7, fig. a; pl. 8, figs. a-c, f-g.
Miogypsinoides comnplanatus Schlumberger. – HANZAWA 1962, p. 153-154, 157, pl. 7, fig. 11, text-fig. 5.
Miogypsina (*Miogypsinoides*) *formosensis* Yabe and Hanzawa. – MISHRA 1996, p. 158, 201, pl. 6, fig. r.
Miogypsinella complanata (Schlumberger). – MATSUMARU, SARI, and ÖZER 2010, p. 450, 452, pl. 1, figs. 5-7. – MATSUMARU 2012, p. 623-646, fig. 9.

Description: Test flabellate and biconvex. Subspheric protoconch and reniform deuteroconch dear the apex are followed by subquadrate nepionic chambers in a low trochospire, becoming rhombic equatorial chambers are arranged toward the distal margin. Rudimentary lateral chambers are generally absent, and stolons, canals and umbilical pillars are present.

Dimensions: Diameter of test = 1.23 to 1.65 mm, thickness = 0.50 to 0.60 mm, diameter/thickness ratio = 2.50 to 3.30; diameter of protoconch = 90 × 82 µm, diameter of deuteroconch = 80 × 45 µm; number of nepionic chambers = 9 in the first whorl, 15 in 1½ whorl, and 19 in total; Hanzawa (1957)'s AP angle = 420º; tangentail × radial diameter = 90 × 120 to 112 × 136 µm.Diameter of pillars = 75 to 86 µm.

Remarks: Miogypsinella complanata (Schlumberger) in Assemblages 10 and 11 is recognized by the rotaloid juvenile form and number of nepionic chambers, transitional between *Miogypsinella ubaghsi* with rotaloid juvenile chambers and *Miogypsinoides formosensis* without (Matsumaru 1996, p. 39, fig. 24). Specimen (fig. 11) is similar to the schizont form in Menderes-Taurus Platform, Turkey (Matsumaru et al. 2010, pl. 1, fig. 5).

Upper Oligocene, Tertiary e3 to Tertiary e4.

Luzonella Matsumaru, **n. gen**.
Type species: *Luzonella trochidiformis* Matsumaru, n. sp.

Etymology: refers to Luzon Island, Philippines.

Diagnosis: Test small and flabelliform, discoidal, with rough frontal margin. Embryonic chambers are not placed in the apical portion of test, but are positioned eccentrically. Subspheric protoconch and kidney shaped deuteroconch are followed by subquadrate nepionic chambers, originating from the single primary auxiliary chamber, forming a high trochospire. Mature ogival to rhombic equatorial chambers are planispirally arranged towards the distal margin. Lateral chambers are absent, but a few vacuoles are seen. Stolons and canals are present, and the wall is calcareous and thickly lamellar. Monospecific, late Oligocene.

Remarks: Luzonella resembles *Miolepidocyclina* Silvestri in shape, but lacks lateral chambers. It resembles *Miogypsinoides* Yabe and Hanzawa in this regard, but differs in the trochoid spire of nepionic chambers, and in the eccentric position of embryonic chambers. *Miogypsinella* Hanzawa also has trochoid nepionic spires, but the embryonic chambers are not disposed eccentrically.

Luzonella trochidiformis Matsumaru, **n. sp**.
Plate 37, figures 11-13

Holotype (fig. 12): Saitama Univ. Coll. no. 8895; paratype (fig, 13) Saitama Univ. Coll. no. 8896.

Etymolog: refers to the trochoidal spire.

Type locality: Station BG9, Bontoc, North Luzon (text-fig. 2).

Description: Test small, flabelliform and discoidal with more or less equally inflated central portion on both dorsal and ventral sides, with rough and blunt periphery. Spherical protoconch and reniform deuteroconch are eccentrically positioned, followed by subquadrate nepionic chambers in a high trochoidal spiral. Numerous rows of ogival to rhombic equatorial chambers are developed in the distal portion. There are no lateral chambers, and the wall is calcareous and lamellar.

Dimensions: Diameter of test = 0.68 to 1.30 mm, thickness = 0.31 mm, diameter/thickness ratio = 2.97; in 3 specimens, diameter of protoconch = 68 × 68, 68 × 68, and 68 × 68 µm; diameter of deuteroconch = 68 × 46, 76 × 52, and 80 × 56 µm; deuteroconch/protoconch ratio =1.06, 1.12, and 1.18; distance across protoconch and deuteroconch = 119, 125, and 150 µm; number of whorls, 1 ¾ to 2; number of nepionic chambers 11 to 12 in first whorl 22 in second whorl and 24 in total number; AP angle, 410 to 330; tangential × radial diameter) = 83 × 90 to 160 × 136 µm.

Remarks: Luzonella trochidiformis, n. sp., appears to give rise to *Miolepidocyclina burdigalensis* (Gümbel) with *ecuadorensis*-type nepionic chamber and one primary auxiliary chamber, as seen in the Burdigalian Karakustepe Formation of Turkey (Matsumaru et al. 2010, pl. 4, fig. 9).

Upper Oligocene, Tertiary e3.

Genus *Miogypsinoides* Yabe and Hanzawa 1928

Miogypsinoides formosensis Yabe and Hanzawa 1928
Plate 36, figure 15; plate 37, figure 2

Miogypsina (Miogypsinoides) dehaartii van der Vlerk var. *formosensis* YABE and HANZAWA 1928, p. 535, text-figs 1a-b. – YABE and HANZAWA 1930, p. 32-33, pl. 3, figs. 4-5; pl. 4, figs. 3-4; pl. 7, fig. 12; pl. 9, fig. 9; pl. 11, figs. 1-6, 12. – TAN SIN HOK 1936, p. 49.
Miogypsinoides formosensis Yabe and Hanzawa.– HANZAWA 1957, p. 93, pl. 15, figs. 10, 20-21. – HANZAWA 1962, p. 157, pl. 5, figs. 7-8. – MATSUMARU, SARI, and OZER 2010, p. 452, pl. 1, figs. 8-10; pl. 2, fig. 1; pl. 5, fig. 8 upper. – MATSUMARU 2012, p. 623-646, figs. 7, 9.

Description: Test fan-shaped, irregular in outline. Spherical protoconch and reniform deuteroconc are followed by planispiral nepionic chambers, with equatorial chambers developed towards the distal margin. Lateral layers are placed above and below the single equatorial layer. Stolons and canals are present.

Dimensions: Diameter of test = 1.48 to 1.60 mm, thickness = 0.89 mm, diameter/thickness ratio = 1.79; diameter of protoconch = 135 × 135 µm, diameter of deuteroconch = 130 × 52 µm, deuteroconch/protoconch ratio = 0.96; distance across both protoconch and deuteroconch = 204 µm. Number of whorls, 21½ ; number of nepionic chambers, 8 in first whorl, and 14 or 16 total in 2 specimens; AP angle = 215º or 315º; tangential × radial diameter = 136 × 102 to 204 × 204 µm; diameter of pillars = 56 to 68 µm.

Remarks: The spiral chambers always develop from the frontal field of the test under the line connecting the centers of embryonic chambers. The eighth nepionic chamber is adjacent to the deuteroconch (fig. 15). In Taiwan, *Miogypsinoides formosensis* occurs in levels belonging to the main interval of the *Globigerinoides primordius* Zone N4, correlative with the *Triquetrorhadulus carinatus* nannoplankton zone (Huang and Cheng 1983), in the Oligocene – Miocene transition. In the Philippines, *Miogypsinoides formosensis* is associated with *Miogypsinoides bantamensis* Tan Sin Hok (Table 9), which evolved from the former due to reduction of nepionic chambers (text-fig. 28).

Upper Oligocene, Tertiary e4.

Miogypsinoides bantamensis (Tan Sin Hok 1933)
Plate 37, figures 3-6, 7 left

Miogypsina bantamensis TAN SIN HOK 1933, in Koolhoven 1933; p. 26 sample U895.S., Klindjau, East Borneo.
Miogypsinoides complanata (Schlumberger) forma *bantamensis* TAN SIN HOK 1936, p. 48-50, pl. 1, fig. 13.
Miogypsinoides bantamensis (Tan Sin Hok). – HANZAWA 1940, p. 782-783, pl. 39, figs. 15-19; pl. 41, figs. 24-26. –Hanzawa 1957, p. 91, pl. 15, figs. 4-6. – COLE 1957, p. 338-339, pl. 110, figs. 8-18; pl. 111, figs. 1-2, 4 (non 3). – MATSUMARU, SARI and OZER 2010, p. 454-456, pl. 2, figs. 2-6. – MATSUMARU 2012, p. 623-646, figs. 4, 7, 9.
Miogypsinoides lateralis HANZAWA 1940, p. 783, pl. 39, figs. 10-14.
Miogypsinoides complanata (Schlumberger) var. *mauretanica* BRÖNNIMAN 1940, p. 77-80, pl. 7, figs. 7-14; pl. 8, fig. 18; pl. 9, figs. 1-2; pl. 11, figs. 9-17.
Miogypsina (*Miogypsinoides*) *bantamensis* (Tan Sin Hok). – RAJU 1974, p. 79-80, pl. 1, figs. 10, 12-13 (non 11). – ADAMS and BELFORD 1974, p. 496-497, pl. 73, figs. 8-11. – MISHRA 1996, p. 201, pl. 2, figs. g-j, l-p; pl. 3, figs. a-c; pl. 4, figs. c, h; pl. 7, figs. b, o-p; pl. 8, figs. d-e.
Miogypsinoides dehaartii (van der Vlerk). – COLE 1957, p. 339-340, pl. 111, figs. 8, 10. – COLE 1957, p. 769, pl. 243, fig. 1.

Description: Test is fan-shaped, biconvex, with irregular margins. Subspherical protoconch on apical side and reniform deuteroconch on frontal side are followed by planispiral nepionic chambers that develop from the apical field above the the centers of the embryonic chambers; ogival to rhombic equatorial chambers are arranged towards the distal margin. There are no lateral chambers, and stolons, canals and umbilical pillars are present.

Dimensions: Diameter of test = 1.10 to 1.65 mm, thickness = 0.40 to 0.50, diameter/thickness ratio = 3.3 to 4.0; diameter of protoconch = 145 × 160 µm, diameter of deuteroconch = 102 × 68 µm. Number of nepionic chambers, 14; AP angle, 150º to 180º; tangential × radial diameter, 125 × 110 to 130 × 150 µm.

Remarks: The A2 form (gamont) is also known from Turkey (Matsumaru et al. 2010, pl. 2, figs. 4,5), together with the A1 form (schizont) (*idem.*, figs. 2-3) not found in the Philippines.

Upper Oligocene, Tertiary e4 to lower Miocene, Tertiary e5 lower.

Miiogypsinoides dehaartii (Van der Vlerk 1924)
Plate 37, figures 7 right, 14-15; plate 38, figures 1-4

Miogypsina dehaartii VAN DER VLERK 1924, p. 429-432, text-figs. 1-3. – DROOGER 1953, p. 110-114; pl. 1, figs. 15-19; pl. 2, figs. 1-4. – COLE 1954, p. 602, pl. 220, figs. 1-8.
Miogypsina cupulaeformis ZUFFARDI-COMERCI 1929, p. 142, pl. 9, figs. 12-13, 20. – DROOGER 1953, p. 114-115, pl. 1, figs. 20-23.
Miogypsina verrucosa ZUFFARDI-COMERCI 1929, p. 143, pl. 9, figs. 8-10, 14-15.
Miogypsinoides dehaartii (Van der Vlerk) var. *pustulosa* HANZAWA 1940, p. 780-782, pl. 39, figs. 20-21; pl. 40, figs. 2-28; pl. 41, fig. 13.
Miogypsinoides dehaartii (Van der Vlerk). – COLE 1969, p. C10-12, pl. 1, figs. 2-4, 7-8, 10, 15 (non figs. 1, 5-6, 9, 11-14, 16-20). – MATSUMARU et al. 1993, p. 5-8, Figs. 2-1, 3-2 left, 3-3-5.
Miogypsina (Miogypsinoides) dehaartii Van der Vlerk. – RAJU 1974, p. 80-81; pl. 3, fig. 8; pl. 4, figs. 2-4. – ADAMS and BELFORD 1974, p. 497, pl. 73, fig. 12 (non figs. 13-14). – CHAPRONIERE 1984, p. 46-47, pl. 7, figs. 7a-b; pl. 8, figs. 1-3; pl. 17, figs. 15-17 (Text-fig. 17-1b, 2e (non 1a). – MATSUMARU, SARI, and OZER 2010, p. 456, pl. 2, figs. 7-10; pl. 3, fig. 6. – MATSUMARU 2012, p. 623-646, pl. 2, fig. 12; figs. 4, 7, 9.
Miogypsina (Miogypsinoides) indica RAJU 1974, p. 81, pl. 3, figs. 9-11; pl. 4, figs. 5-7.

Description: Test fan shaped, biconvex, with irregular to rounded outline. The surface is smooth, locally covered with conical pillars. Spherical to subspherical protoconch and reniform deuteroconch are followed by planispiral nepionic chambers, with deuteroconch on the apical portion of test or sometimes beside protoconch away from the apex. Ogival to rhombic equatorial chambers are arranged towards the distal margin. The wall is calcareous and thick, and lateral walls are lamellar without lateral chambers.

Dimensions: Megalospheric specimens, diameter of test = 0.96 to 1.68 mm, thickness = 0.50 to 0.59 mm, diameter/thickness ratio = 1.92 to 2.84; in five specimens, diameter of protoconch = 100 × 90 to 200 × 200 µm, deuteroconch = 120 × 60 to 260 × 120 µm, deuteroconch /protoconch diameter = 0.93 to 1.30; distance across both protoconch and deuteroconch = 200 to330 µm. Number of nepionic chambers, 6 to 8 total; AP angle, 40 to 20; equatorial chambers tangential × radial diameter, 70 × 80 to 150 × 160 µm, that of equatorial chambers 80 × 70 to 140 × 130 µm; diameter of pillars = 30 to 50 µm. Microspheric specimens, diameter of test = 2.09 to 4.35 mm, thickness = 1.45 mm; diameter/thickness ratio = 3.00; equatorial chambers tangential × radial diameter = 100 × 90, to 150 × 140 µm; diameter of pillars = 80 to 120 µm.

Remarks: The author has previously suggested (1996, p. 43, fig. 24) that *Miogypsinoides dehaartii* s.s. (*M. dehaartii* var. *pustulosa* Hanzawa 1940) evolved from *Miogypsinoides bantamensis* (Tan Sin Hok), considered as *M. dehaarti* s.l., anf that *Miogypsinoides dehaarti* s.s. then gave rise to *Miogypsina borneensis* Tan through *Miogypsina primitiva* Tan (table 18). Adams and Belford (1974) observed that *Miogypsinoides dehaartii* in the lower Miocene of Christmas Island graded from *M. bantamensis* in the basal Miocene.

Upper Oligocene, Tertiary e4 to lower Miocene, Tertiary e5 lower.

Genus *Boninella* Matsumaru 1996

Boninella negrosensis Matsumaru, **n. sp**.
Plate 37, figures 8-10

Etymology: refers to type location on Negros Island.

Type locality: Station 7682906, Escalante Formation, Negros Island (text-fig. 18).

Holotype (fig. 8): Saitama Univ. Coll. no. 9010; paratype (fig.10), no. 9011.

Description: Test fan-shaped, biconvex, with dorsal side more convex, usually inflated near the apical portion. The ventral side is covered with plugs, with stout conical pillars on both sides. Subspherical protoconch and reniform deuteroconch are set apart from the apex, with deuteroconch on the distal side and protoconch on the apical side. The embryonic cells are followed by large subquadrate nepionic chambers in 1¼ to 1½ coils together with 1¼ coils of secondary small arcuate chambers in a low trochospire; the secondary nepionic chambers may not be visible in the equatorial plane. 6 to 12 rows of ogival to rhombic equatorial chambers are spread from the front side of the embryonic chambers. Stolons and canals are present; the wall is calcareous and the lateral walls are thick, compact and lamellar, but lateral chambers are absent.

Dimensions: Megalospheric specimens, diameter of test = 0.94 to 1.55 mm, thickness = 0.51 to 0.73 mm, diameter/thickness ratio = 1.77 to 2.12; in 3 specimens the diameter of protoconch = 104 × 95, 109 × 117, and 120 × 104 µm, deuteroconch = 139 × 100, 143 × 96, and 120 × 64 µm, deuteroconch/protoconch diameter = 1.34, 1.31, and 1.00; distance across both protoconch and deuteroconch = 214, 213, and 185 µm. Number of whorls 1¼ to 1½; number of primary nepionic chambers, 7 in first whorl and 12 total; number of secondary nepionic chambers, 8 in first whorl and 14 total; AP angle = 180 to 120; tangential × radial diameter of nepionic chambers = 92 × 84 to 111 × 157 µm, that of secondary nepionic chambers = 36 × 20 to 74 × 46 µm, that of equatorial chambers = 87 × 46 to 103 × 138 µm; diameter of pillars = 70 to 80 µm. Microspheric specimens, diameter of test = 1.57 to 2.11 mm, thickness = 0.48 to 0.82 mm, diameter/thickness ratio = 2.57 to 3.27; tangential × radial diameter of equatorial chambers = 75 × 84 to 147 × 160 µm; diameter of pillars = 136 to 160 µm.

Remarks: The primary nepionic spirals are also a diagnostic feature of *Miogypsinoides bantamensis* (Tan Sin Hok), but the new species has a lower spire and secondary nepionic spirals or their traces. Previous workers identified this form as *Miogypsinoides* or *Miolepidocyclina* (i.e. Tan Sin Hok 1936; Hanzawa 1940; Brönnimann 1940; Cole 1969; Adams and Belford 1974, Raju 1974; Govindan 2003). Drooger (1993) recognized intercalary chambers in *Heterosteginoides panamensis* Cushman and *H. ecuadorensis* (Tan), but the new species differs in its secondary nepionic spirals. It is similar to *B. boninensis* Matsumaru, but differs in its well-developed equatorial chambers in the frontal side of test.

Uppermost Oligocene, Tertiary e4.

Genus *Miogypsina* Sacco 1893

Miogypsina primitiva Tan Sin Hok 1936
Plate 38, figures 5-12

Miogypsina primitiva TAN SIN HOK 1936, p. 53, pl. 1, figs. 14-16. – TAN SIN HOK 1936, p. 88, figs. 1-3. – MATSUMARU, SARI, and OZER 2010, p. 456, pl. 3, figs. 1-5, 7-8. – MATSUMARU 2012, p. 623-646, figs. 2, 7, 9.
Miogypsina (Miogypsina) gunteri COLE 1938, p. 42-43, pl. 6, figs. 10-12, 14; pl. 8, figs. 1-2, 4-9 (non fig. 3). – COLE 1957, p. 321-322,

pl. 26, figs. 1-4, 8-9; pl. 27, fig. 1. – COLE and APPLIN 1961, p. 133, pl. 7, figs. 8, 11. – RAJU 1974, p. 81-82, pl. 1, figs. 14-18.
Miogypsinodella primitiva (Tan Sin Hok) – BOUDAGHER-FADEL, LORD, and BANNER 2000, p. 145-146, pl. 2, figs. 8-11.

Description: Test fan-shaped, biconvex, varying from asymmetrical less elevated dorsal side covered with plugs and pillars to symmetrical and apically inflated with conical pillars. Subspherical protoconch and reniform deuteroconch partly separated from the apical border with deuteroconch directly or laterally below protoconch. Subquadrate nepionic chambers make a single planispiral coil, and ogival to rhombic equatorial chambers spread from the frontal side of the nepionic whorl. Rudimentary lateral chambers are present among thick lateral lamellae and increase towards the surface. Wall calcareous, thick and compact, and lateral walls are traversed by pillars.

Dimensions: Megalospheric specimens, diameter of test = 1.10 to 1.49 mm, thickness = 0.26 to 0.44 mm, diameter/thickness ratio = 2.76 to 5.54; in 3 specimens, diameter of protoconch = 130 × 122, 148 × 95, and 158 × 104 µm, deuteroconch = 131 × 105, 127 × 106, and 140 × 40 µm, f deuteroconch /protoconch diameter = 1.01, 0.86, and 0.88; distance across both protoconch and deuteroconch = 230, 234, and 160 µm. Number of nepionic chambers, 7 to 9 in total; AP angle, 160 to 60; tangential × radial diameter of nepionic chambers = 87 × 78, to 105 × 96 µm; tangential × radial diameter of equatorial chambers = 73 × 93, to 106 × 114 µm; length ×heighyt of lateral chambers = 43 × 3 to 87 × 39 µm; thickness of roofs and floors = 6 to 43 µm; number of lateral chambers in tiers between pillars over equatorial layer = 4 to 8; diameter of pillars = 26 to 87 µm. Microspheric specimens, diameter of test = 3.25 mm, thickness = 0.56 mm, diameter/thickness ratio = 5.80; diameter of pillars = 43 to 114 µm.

Remarks: Differs from *Miogypsinoides bantamensis* in having lateral chambers. *M. gunteri* Cole 1938, from Florida is considered as a junior synonym. Hanzawa (1940) placed both names in *Miogypsinopsis,* but Cole (1957) then suppressed *Miogypsinopsis* in favor of *Miogypsina,* and Boudagher-Fadel et al. (2000) proposed to place *Miogypsina primitive* in the new genus *Miogypsinodella* without considering the priority of *Miogypsinopsis* Hanzawa. *Miogypsina primitiva* is important as a transitional form between *Miogypsinoides* and *Miogypsina*, documenting evolution of the thick lateral lamellae of *Miogypsinoides* into thin roofs and floors of lateral chambers of *Miogypsina* (cf. figs. 9-12). *Miogypsina primitiva* evolved from *Miogypsinoides dehaartii* and evolved into *Miogypsina borneensis* through the reduction of nepionic spirals and development of lateral chambers (table 18).

Upper Oligocene, Tertiary e4 to lowermost Miocene, Tertiary e5 lower.

Miogypsina borneensis Tan Sin Hok 1936
Plate 38, figures 13-15; plate 39, figures 1-2

Miogypsina borneensis TAN SIN HOK 1936, p. 53-54, pl. 1, figs. 18-19; pl. 2, figs. 1-2. – TAN SIN HOK 1936, p. 88, 90, text-figs. 7, 13. – TAN SIN HOK 1937, p. 90, pl. 1, figs. 1-2. – HANZAWA 1940, p. 783-784, pl. 41, figs. 11-23. – MATSUMARU, SARI, and ÖZER 2010, p. 456, 458, pl. 3, figs. 9-10; pl. 4, figs. 1-2.
Miogypsina (Miogypsina) tani DROOGER 1952, p. 26-27, pl. 2, figs. 20-22 (non 23-24); pl. 3, figs. 2a-b; tables 1-2. – RAJU 1974, p. 82, pl. 1, figs. 26-28, 30 (non 29); pl. 5, fig. 5. – MISHRA 1996, p. 202, pl. 3, figs. k-l; pl. 4, fig. c; pl. 7, fig. g, m.
Miogypsina (Miogypsina) borneensis Tan. – COLE 1954, p. 598-599, pl. 220, figs. 9-21.
Miogypsina borneensis Tan. – VAN DER VLERK 1966, p. 422-423, 427, pl. 1, figs. 4-6; pl. 2, fig. 2. – MATSUMARU 2012, p. 623-646, pl. 2, figs. 1-3; figs. 7, 9.
Miogypsina globulina (Michelotti). – MATSUMARU 1968, p. 341-343, pl. 36, fig. 2-6 (non pl. 35, figs. 1-6; pl. 36, fig. 1).

Description: Test fan-shaped, biconvex with dorsal side more convex. The surface is smooth or showing conical pillars. Spherical to subspherical protoconch and reniform deuteroconch are followed by semicircular to ogival nepionic chambers in a planispiral coil, and ogival to rhombic equatorial chambers on the front side. Lateral chambers are developed as open cavities, arranged irregularly in lateral layers on both sides of the equatorial layer. Wall is calcareous and lamellar, with pillars and tranverse lateral layers.

Dimensions: Megalospheric specimens, diameter of test = 1.36 to 2.08 mm, thickness = 0.52 to 0.75 mm, diameter/thickness ratio = 2.56 to 3.20; in 7 specimens of Tertiary e4 to Tertiary e5, range of protoconch diameters = 82 × 82 to 110 × 120 µm, deuteroconch = 83 × 46 to 133 × 80 µm, ratio of deuteroconch/protoconch diameter = 0.89 to 1.43; distance across both protoconch and deuteroconch = 152 to 202 µm; number of nepionic chambers = 5 to 7; AP angle = 50 to 10. In 6 specimens from Tertiary f1, diameter of protoconch range = 72 × 82 to 168 × 159 µm, deuteroconch = 92 × 68 to 168 × 106 µm, ratio of deuteroconch/protoconch diameter = 1.00 to 1.31; distance across both protoconch and deuteroconch = 177 to 284 µm; number of nepionic chambers = 5 to 7; AP angle =30º to 10º; tangential × radial diameter of nepionic chambers = 61 × 45 to 75 × 62 µm, equatorial chambers = 87 × 92 to 150 × 95 µm; length × height of lateral chambers = 83 × 26 to 105 × 21 µm; thickness of roofs and floors = 8 to 24 µm; number of lateral chambers in tiers over embryonic chambers = 5; diameter of pillars = 43 to 83 µm. Microspheric forms, diameter of test = 2.56 mm; thickness = 0.86 mm; form ratio = 2.98; diameter of pillars = 111 to 138 µm.

Remarks: Tan Sin Hok (1936) synonymized *Miogypsina thecidaeformis* Rutten 1911 with *Miogypsina borneensis,* but Hanzawa (1940, p. 783-784) disputed this. *Miogypsina borneensis* is a senior synonym of *M. tani* Drooger 1952 (Matsumaru et al. 2010). *Miogypsina borneensis* evolved from *Miogypsina primitiva* through nepionic retardation and evolved into *Miogypsina globulina* with secondary nepionic chambers.

Upper Oligocene, Tertiary e4 to lowermost Miocene, Tertiary e5 lower.

Mioypsina globulina (Michelotti 1841)
Plate 38, figure 8 right; plate 39, figures 3-5

Nummulites globulina MICHELOTTI 1841, p. 297, pl. 3, fig. 6.
Nummulites irregularis MICHELOTTI 1841, p. 297, p. 3, fig. 5.
Miogypsina globulina (Michelotti). – SCHLUMBERGER 1900, p. 329-330, pl. 2, fig. 8. – MATSUMARU 1968, p. 341-343, pl. 35, figs. 1-6; pl. 36, fig. 1 (non figs. 2-6). – MATSUMARU 1971, p. 174-176, pl. 25, figs. 1-22.
Miogypsina irregularis (Michelotti). – SCHLUMBERGER 1900, p. 328-329, pl. 2, figs. 1-7, 9-10; pl. 3, fig. 17. – BRÖNNIMANN 1940, p. 88-94, pl. 8, figs. 1-11; pl. 11, figs. 1, 4. – DROOGER 1952, p. 54-55, pl. 2, figs. 25-29 (non 25).
Miogypsina kotoi HANZAWA 1931, p. 154, pl. 25, figs. 14-18. – HANZAWA 1935, p. 23-25, pl. 3, figs. 1-40 (parts). – TAN SIN HOK 1937, p. 31-32, pl. 1, figs. 1-5. – MATSUMARU 1982, p. 53-54, figs. 1-14.

Miogypsina (*Miogypsina*) *thecidaeformis* (Rutten). – COLE 1957, p. 771-772, pl. 244, figs. 1-2, 4-7, 11-14.

Miogypsina (Miogypsina) globulina (Michelotti). – DROOGER and SOCIN 1959, p. 420-422, pl. 1, figs. 5-6; table 2. – RAJU 1974, p. 82-83, pl. 2, figs. 1-4; pl. 5, figs. 6-7; pl. 6, fig. 1. – CHAPRONIERE 1984, p. 42-43, pl. 6, figs. 5a-b; pl. 6, figs. 14-15 (Text-fig. 16-1b-c (non 1a, 1d).

Miogypsina globulina (Michelotti). – MATSUMARU 1968, p. 341-343, pl. 35, figs. 1-6; pl. 36, fig. 1 (non pl. 36, figs. 2-6). – MATSUMARU 1971, p. 174-176, pl. 25, figs. 1-22. – MATSUMARU and TAKAHASHI 2004, p. 17-26, pl. 1, figs. 1-4. – MATSUMARU 2012, p. 623-646, pl. 1, figs. 1-5; figs. 7, 9.

Description: Test fan-shaped, biconvex or oval in lateral view, with ornamentation of conical pillars. Spherical to subspherical protoconch and reniform deuteroconch are followed by two principal auxiliary chambers of unequal size and primary and secondary nepionic spirals that meeting symmetrically along the outer side of protoconch, but not along the outer side of deuteroconch. Ogival to rhombic equatorial chambers are proximally disposed. Lateral chambers are open cavities arranged regularly in tiers on both sides of equatorial layer, with stolons and canals in chamber walls. The wall is calcareous and lamellaer, with pillars transversing the lateral layers.

Dimensions: Diameter of test = 1.02 to 2.41 mm, thickness = 0.48 to 0.82 mm, diameter/thickness ratio = 1.69 to 2.94; in 11 specimens from Tertiary e5, diameter of protoconch ranges from 80 × 80 to 140 × 130 µm, deuteroconch = 100 × 70 to 140 × 80 µm, deuteroconch /protoconch diameter = 1.09 to 1.42; distance across both protoconch and deuteroconch = 154 to 211 µm; degree of symmetry in two nepionic spirals (Drooger's V = 200 α/β), V value = 15 to 45; angle in equatorial plane between apical-frontal line and line connecting centers of embryonic chambers (γ value) = 10 to 40. In 12 specimens from Tertiary f1, range in diameter of protoconch = 112 × 105 to 175 × 150 µm, deuteroconch = 100 × 44 to 175 × 100 µm, ratio of deuteroconch/protoconch diameter = 0.89 to 1.45, distance across protoconch and deuteroconch = 166 to 259 µm; V value = 20 to 46; γ value = 15 to 45; tangential × radial diameter of nepionic chambers = 43 × 26 to 131 × 105 µm, that of equatorial chambers = 75 × 100 to 136 × 136 µm; length ×height of lateral chambers = 113 × 22 to 136 × 45 µm; thickness of roofs and floors = 10 to 45 µm; number of lateral chambers in tiers over equatorial layer = 4 to 6; diameter of pillars = 45 to 135 µm.

Remarks: Miogypsina globulina (Michelotti) is the senior synonym of *Miogypsina irregularis* (Michelotti) according to Drooger and Socin (1959), and occurs in India (Raju 1974) and in the Burdigalian stratotype in France, with dimensions consistent with those noted above.

Lower to middle Miocene, Tertiary e5 to Tertiary f1.

Miogypsina intermedia Drooger 1952
Plate 39, figures 8 upper, 9-11

Miogypsina (Miogypsina) intermedia DROOGER 1952, p. 35-36, pl. 2, figs. 30-34; pl. 3, figs. 4a-b (Text-fig. 16; table 2. – MATSUMARU 2012, p. 623-646, pl. 1, figs. 6-8; figs. 7, 9.

Description: Test fan-shaped, biconvex or oval in outline, ornamented with conical pillars. Embryonic chambers are followed by two unequal principal auxiliary chambers; primary and secondary nepionic spirals are meet the symmetrically along the outer side of protoconch, but not along the deuteroconch, and never at the apex of the test. Ogival to rhombic equatorial chambers on the frontal side of test are covered by regular tiers of rectangular lateral chambers. The wall is calcareous and lamellar, with pillars traversing the lateral layers.

Dimensions: Diameter of test = 0.82 to 4.69 mm, thickness = 0.70 to 0.90 mm, diameter/thickness ratio = 2.74 to 5.21; diameter of protoconch in 3 specimens of Tertiary f1 lower stage = 79 × 75, 104 × 96 and 128 × 104 µm, deuteroconch = 75 × 31, 104 × 40 and 144 × 56 µm, ratio of deuteroconch/protoconch diameter = 0.95, 1.00 and 1.13; distance across both protoconch and deuteroconch = 135, 157 and 210 µm; V value = 59, 65 and 67; γ value = 10, 20 and 10. In 7 specimens from Tertiary f1, diameter of protoconch = 136 × 136 to 163 × 159 µm, deuteroconch = 135 × 140 to 204 × 90 µm, ratio of deuteroconch/protoconch diameter = 0.86 to 1.25; distance across protoconch and deuteroconch = 236 to 307; V value = 50 to 67, γ value = 25 to 50; tangential × radial diameter of nepionic chambers = 52 × 26 to 131 × 114 µm; equatorial chambers = 78 × 114 to 136 × 136 µm; length ×height of lateral chambers = 79 × 20 to 133 × 23 µm; thickness of roofs and floors = 4 to 15 µm; number of lateral chambers in tiers over equatorial layer = 4 to 6; diameter of pillars = 15 to 80 µm.

Remarks: Miogypsina intermedia Drooger (1952, p. 35-37), as the name implies, has V values differing only slightly from those of its ancestor *Miogypsina globulina* (Michelotti) and those of its descendant *Miogypsina cushmani* Vaughan.

Middle Miocene, Tertiary f1.

Miogypsina cushmani Vaughan 1924
Pl. 39, figures 12-13

Miogypsina cushmani VAUGHAN 1924, p. 802, 813, pl. 36, figs. 4-6. – TAN SIN HOK 1937, p. 92-95, pl. 1, figs. 6-11; pl. 2, fig. 19; pl. 3, figs.3-9, 14; pl. 4, fig. 14. – DROOGER 1952, p. 37-39, 56, pl. 2, figs. 40-44, text-fig. 16; table 2. – MATSUMARU 2012, p. 623-646, pl. 1, fig. 9; fig. 7.

Miogypsina (Miogypsina) cushmani Vaughan. – RAJU 1974, p. 83-84, table 4.

Miogypsina (Lepidosemicyclina) droogeri Mohan and Tewari. – RAJU 1974, p. 85-86, pl. 2, figs. 5-7, 9-11 (non fig. 8); pl. 5, figs. 8, 11 (non fig. 10).

Description: Test fan-shaped, biconvex or oval, ornamented with conical pillars. Protoconch and deuteroconch are followed by two unequal sized principal auxiliary chambers, each generating primary and secondary nepionic spirals the chambers of nwhich meet symmetrically along the outer wall of the protoconch, but not along the deuteroconch, and never meet at the apex. Ogival, rhombic and short hexagonal equatorioal chambers on the frontal side are covered by regular tiers of rectangular lateral chambers. The wall is calcareous and lamellar, with pillars are traversing the lateral layers.

Dimensions: Diameter of test = 1.40 to 2.41 mm, thickness = 0.43 to 0.82 mm, diameter/thickness ratio = 2.94 to 3.26; in 5 specimens from Tertiary f1, diameter of protoconch= 78 × 70 to 133 × 127 µm, deuteroconch = 65 × 40 to 204 × 86 µm, ratio of deuteroconch / protoconch diameter = 0.83 to 1.56; distance across both protoconch and deuteroconch = 131 to 257 µm, V value = 70 to 92, γ value = 15 to 50; tangential × radial diameter of nepionic chambers = 52 × 43 to 114 × 96 µm; equatorial chambers = 78 × 78 to 90 × 113 µm; lateral chambers length × height = 68 × 26 to 133 × 24 µm; thickness of roofs and floors =

6 to 8 μm; number of lateral chambers in tiers over equatorial layer = 4 to 6; diameter of pillars = 30 to 72 μm.

Remarks: Miogypsina cushmani Vaughan differs from its ancestor *Miogypsina intermedia* Drooger in its larger V value. Raju (1974) described accessory auxiliary chambers around the deuteroconch in specimens identified as *Miogypsina droogeri* Mohan and Tewari 1958, but this is a diagnostic feature of *Miolepidocyclina excentrica* Tan Sin Hok 1937, while the type of *Miogypsina droogeri* is a specimen of *Miogypsina cushmani.*

Middle Miocene, Tertiary f1 to Tertiary f2.

Genus *Lepidosemicyclina* Rutten 1911

Lepidosemicyclina polymorpha Rutten 1911
Plate 39, figs. 14-15; plate 40, figs. 1-3

Lepidosemicyclina polymorpha RUTTEN 1911, p. 16 (1137)-17(1138).
Miogypsina polymorpha (Rutten). – RUTTEN 1912, p. 207-209, pl. 12, figs. 6-9. – DROOGER 1953, p. 106-108, pl. 1, figs. 1-4, 31. – MATSUMARU 2012, p. 623-646, fig. 7.

Description: Test large, fan-shaped with apex sharply protruding over a strongly undulating frontal margin. Spherical to subspherical protoconch and reniform deuteroconch are followed by unequal principal auxiliary chambers, each with primary and secondary nepionic spirals that meet symmetrically along the outside of protoconch, and less so along the deuteroconch. Ogival to elongate hexagonal equatorial chambers on the frontal side are covered by regulkar tiers of lateral chambers. Chamber walls have stolons and canals, calcareous and lamellar, and pillars traverse the lateral layers

Dimensions: Diameter of test = 2.55 to 7.30 mm, thickness of test = 0.80 to 1.20 mm, diameter/thickness ratio = 4.69 to 6.08; diameter of protoconch = 225 × 200 μm, diameter of deuteroconch = 250 × 325 μm, Ratio of deuteroconch/protoconch diameter = 1.11, distance across both protococnch and deuteroconch = 500 μm; V value = 24; γ value = 30º; tangential × radial diameter of nepionic chambers = 80 × 75 to 225 × 140 μm; equatorial chambers = 50 × 100 to 75 × 150 μm; length × height of lateral chambers = 30 × 10 to 90 × 20 μm; thickness of roofs and floors = 4 to 10 μm; number of lateral chambers per tiers = 6 to 8; diameter of pillars = 40 to 60 μm.

Remarks: The type of Rutten's *Miogypsina polymorpha* from East Borneo (Drooger 1953) is characterized by the strongly undulating test with sharply protruding apical portion, together with V and γ measurements and chamber dimensions the same as those noted above.

Upper Oligocene, Tertiary e4 to middle Miocene, Tertiary f1.

Lepidosemicyclina thecidaeformis Rutten 1911
Plate 39, figures 6-7, 8 lower

Lepidosemicyclina thecidaeformis RUTTEN 1911, p. 14 (1135)-15 (1136). – MATSUMARU, SARI, and ÖZER 2010, p.460, pl. 4, figs. 3-4. – MATSUMARU 2012, p. 623-646, pl. 2, figs. 5-7; figs. 7, 9.
Miogypsina thecidaeformis (Rutten). – RUTTEN 1912, p. 204-207, pl. 12, figs. 1-5. – DROOGER 1953, p. 109-110, pl. 1, figs. 10-14, 32.
Miogypsina (Lepidosemicyclina) thecidaeformis (Rutten). – RAJU 1974, p. 84-85, pl. 6, figs. 2-4.

Description: Test fan-shaped, unequally biconvex with slightly rounded and smooth dorsal side and more conves ventral side, ornamented with pillars. Protoconch and deuteroconch are followed by two unequal sized principal auxiliary chambers, each with primary and secondary nepionic spirals that meeting symmetrically along the outer side of protoconch wall, but less so along the outside of deuteroconch wall. Ogival to short hexagonal equatorial chambers on the frontal side of test are covered by regular tiers of lateral chambers. The wall is calcareous and lamellar, with pillars traversing lateral layers.

Dimensions: Diameter of test = 0.86 to 2.30 mm, Thicknss of test = 0.52 to 0.70 mm, diameter/thickness ratio = 2.71; diameter of protoconch = 76 × 48, 104 × 100 and 136 × 100 μm of 3 specimens, diameter of deuteroconch = 92 × 55, 136 × 72 and 159 × 125 μm, ratio of deuteroconch/protoconch diameter = 1.21, 1.31 and 1.17; distance across both protoconch and deuteroconch =110, 186 and 240 μm; V value = 40, 39 and 23; γ value = 30º, 60º and 35º; tangential × radial diameter of nepionic chambers= 52 × 65 to 114 × 92 μm; equatorial chambers = 70 × 84 to 85 × 105 μm; length × height of lateral chambers = 31 × 8 to 50 × 13 μm; thickness of roofs and floors = 4 to 11 μm; number of lateral chambers per tier = 6; diameter of pillars = 40 to 68 μm.

Remarks: The original material of *L. thecidaeformis* from East Borneo has V values ranging from 21 to 52 with a mean of 37 (Drooger 1953) and the probable topotype illustrated by Cole (1957, p. 771, pl. 244, fig. 11) appears to have a V value of 43. While *Lepidosemicyclina thecidaeformis* thus has the same V value as *Miogypsina globulina* (Michelotti), it differs in its short hexagonal equatorial chambers, as it also does from *L. polymorpha.*

Upper Oligocene to middle Miocene, Letter Stages Tertiary e4 to Tertiary f1.

Lepidosemicyclina indonesiensis (Tan Sin Hok 1936)
Plate 40, figures 4-15

Miogypsina indonesiensis TAN SIN HOK 1936, p. 54-55, pl. 2, figs. 3-6. – TAN SIN HOK 1936, p. 91, text-fig. 4. – TAN SIN HOK 1936, p. 112, 114, 118, 121. – TAN SIN HOK 1937, p. 88-92, 95-97, pl. 1, figs. 12, 14.
Miogypsina cushmani var. *indonesiensis* Tan. TAN SIN HOK 1937, p. 88-92, 95-97, pl. 1, figs. 12-14; pl. 3, figs. 1-2; pl. 4, figs. 1-12.
Miogypsina (Miogypsina) indonesiensis Tan. – COLE 1954, p. 599-600, pl. 219, figs. 1-15; pl. 220, fig. 22.

Description: Test large, fan-shaped and biconvex, ornamented with conical pillars. Protoconch and deuteroconch are normally followed by two nearly equal principal auxiliary chambers, each with primary and secondary nepionic spirals that meet symmetrically under the midpoint of outer side of protoconchal wall, and along outer side of deuteroconchal wall, meeting at the symmetry chamber. Sometimes, **neotenous** specimens (figs. 10-15) with only one proloculum form adult megalospheric forms. Ogival, elongated rhombic, elongated hexagonal, or spatulate equatorial chambers on the front of the test are covered by regular tiers of lateral chambers. The wall is calcareous and lamellar, with pillars traversing the lateral layers.

Dimensions: Megalospheric specimens, diameter of test = 2.11 to 3.89 mm, thickness = 0.57 to 1.05 mm; diameter/thickness ratio = 3.10 to 5.02; in four specimens, diameter of protoconch = 137 × 116 to 254 × 193 μm, deuteroconch = 152 × 112 to 351 × 180 μm, ratio of deuteroconch/protoconch diameter = 1.11 to 1.50; distance across protoconch and deuteroconch = 193 to 390 μm, V value = 100 in all cases; γ value = 0 to 5; tangential × radial diameter of nepionic chambers = 43 × 35 to 90 × 68 μm;

tangential × radial diameter of equatorial chambers = 80 × 120 to 90 × 160 µm; length × height of lateral chambers = 68 × 6 to 80 × 13 µm; thickness of roofs and floors = 6 to 18 µm; diameter of pillars = 68 to 90 µm (max. 636 µm). Microspheric specimens, diameter of test = 4.55 to 10.00 mm, thickness = 0.57 to 0.73 mm, diameter/thickness ratio = 3.86 to 13.70; diameter of pillars = 90 to 136 µm.

Remarks: Miogypsina antillea (Cushman 1919) and *M. neodispansa* (Jones and Chapman 1900) also have nearly equal sized primary auxiliary chambers and similar V values, but lack the deuterochonchal nepionic spirals. *Lepidosemicyclina polymorpha* Rutten and *Miogypsina bifida* Rutten have elongate hexagonal and spatulate equatorial chambers, but also lack the nepionic morphology.

Upper Oligocene to middle Miocene, Letter Stages Tertiary e4 to Tertiary f1.

Family CALCARINIDAE Schwager 1876

Quasibaculogypsinoides Matsumaru, **n. gen**.
Type species: *Quasibaculogypsinoides primitive* Matsumaru, n. sp.

Etymology: resemblance to *Baculogypsinoides* Yabe and Hanzawa 1930.

Diagnosis: Calcarinid genus characterized by subglobose test, biconvex or planoconvex without protruding radial spines, many chambers are in a low trochospiral coil with mural pores in the proximal side. Canals are present in the lateral walls and intrasepta, connecting with spiral chambers. Two or three layers of small acervuline-like chamberlets are present on the ventral side of test, between thick, fibrous umbilical plugs and lamellar chamber walls. Chamberlets arer absent on the dorsal side except for faint cavities between pillars and thick lamellae. The chamber walls and lamellar consist of two layers, with the inner one thin and finely perforate, and the outer one thick and traversed by vertical canals. Monospecific, early Miocene.

Comparison: Differs from *Baculogypsinoides* Yabe and Hanzawa 1930 in lacking spines and having two or three layers of acervuline-like chamberlets on the ventral side.

Quasibaculogypsinoides primitiva Matsumaru, **n. sp**.
Plate 46, figures 6 left, 7-11

Etymology: refers to evolutionary level in *Baculogypsinoides* lineage.

Type locality: Station HR206, along the Bugsan River, Mindoro Islandland (text-fig. 14).

Holotype (fig. 7): megalospheric specimen. Saitama Univ. Coll. no. 8875.

Description: Test subglobose or planoconvex without radial spines. The calcarinine form consists of a spherical to subspherical proloculus followed by many early chambers in a low trochoid spire of 2 or 2½ whorls, covered by 4 or 5 layers of lateral chamberlets on the ventral side, superposed more or less radially and irregularly in the acervuline manner. These layers are traversed by several umbilical plugs or conical pillars. The wall is calcareous and coarsely perforate.

Dimensions: Diameter of test = 0.64 to 0.85 mm, thickness = 0.38 to 0.67 mm, diameter/thickness ratio = 1.03 to 1.47; diameter of proloculus = 60 × 70 to 70 × 70 µm; thickness of proloculus wall = 13 to 18 µm; number of chambers and apical distance in first half whorl = 5 and 202 µm; first whorl = 9 and 447 µm; 1½ whorl, 13 and 632 µm; and those in second whorl, 19 or 20 and 772 µm 20; tangential/radial diameter of spiral chambers = 88 × 78 to 150 × 166 µm; length × height of lateral chamberlets = 35 × 11 to 52 × 14 µm; thickness of roofs and floors =12 to 18 µm; diameter of umbilical plugs = 44 to 70 µm.

Lower Miocene, Tertiary e5 lower.

Genus *Baculogypsinoides* Yabe and Hanzawa 1930

Baculogypsinoides spinosus Yabe and Hanzawa 1930
Plate 46, figure 13

Calcarina tetraedra GÜMBEL 1868 (1870), p.656, pl. 75 figs. 97a-b.
Siderolites tetraedra (Gümbel). – CUSHMAN 1921, p.358-359, pl. 75, fig. 5; pl. 76, figs. 1-5. – YABE and HANZAWA 1925, p. 45-46, pl. 9, figs. 2-3; pl. 10, figs. 1,4.
Baculogypsina tetraedra (Gümbel). – HOFKER 1927, p. 48. pl. 23, figs. 1- 5;pl. 24, figs. 2-7, 9.
Baculogypsinoides spinosus YABE and HANZAWA 1930, p. 45, pl. 2, fig. 7; pl. 9, fig. 13. – HANZAWA 1952, p. 4-7, pl. 1, figs. 1, 3-5, 7; pl.2, figs. 9, 12-15. – HOFKER 1970, p. 75-76, pl. 45, figs. 2-8. – MATSUMARU 1976, p. 412, pl.2, figs. 4-5, 8, 10-12, 16.

Description: Test subglobular with coarsely perforated walls, with solid radial portion producing large bluntly pointed spines. Spherical to subspherical proloculus and many early chambers in trochoidal arrangement, overlain by 2 or 3 radial layers of chamberlets in the acervuline manner. The wall is calaraeous and perforated.

Dimensions: Diameter of test = 0.69 to 2.42 mm, thickness of test = 0.42 to 0.60 mm, diameter/thickness = 1.24 to 1.83; diameter of proloculus = 54 × 53 to 90 × 90 µm; thickness of proloculus wall =18 µm. Number of chambers and apical distance in first half whorl =5 and 132 µm; first whorl = 10 and 368 µm; 1½ whorl = 526 µm.

Remarks: Baculogypsinoides spinosus occurs in an association (tab. 11) regarded as Tertiary f3 due to occurrence of *Nephrolepidina rutteni.*

Upper Miocene, Tertiary f3 (tab. 14) to Recent, Tertiary h (tab. 15).

Eopellatispira Matsumaru, **n. gen**.
Type species: *Eopellatispira mindoroensis* Matsumaru, n. sp.

Etymology: precursor to *Pellatispira*

Diagnosis: calcarinid genus characterized by a biconvex lenticular test with a few radial hispid spines, large dorsal papillae and smaller ventral papillae, and 2 to 3 trochospiral whorls. The interlamella spaces are present between pillars. The wall is calcareous, with with thin finely perforate inner lamellae and thicker coarsely perforate outer lamellae. Pillars appear near the surface. Canals are present on the outer lamellae, marginal crest and intrasepta. Radial spines project beyond the front of the test and foramina are present at the base of septa. Monospecific, late Eocene.

Comparison: differs from *Calcarina* d'Orbigny in the outer marginal crest, and differs from *Pellatispira* Boussac in having radial spine and trochospirally coiled chambers. *Eopellatispira* evolves into *Pellatispira* in becoming planispiral without spines.

Eopellatispira mindoroensis Matsumaru, **n. sp**.
Plate 28, figures 4-7

Etymology: refers to type area.

Type locality: Station MD 111, Caguray Formation, Mindoro Island (text-fig. 14).

Holotype (fig. 4): microspheric specimen. Saitama Univ. Coll. no. 8870; paratype (fig. 5), megalospheric specimen, no. 8871.

Description: Megalospheric test is small and lenticular with few thin radial spines. Subspherical protoconch and reniform deuteroconch; followed by a few trochospirally arranged chambers. Chamber walls are consisting of inner thin layer with fine pores and outer thick layer with the marginal crest. The marginal crest has coarse pores and fused into canals which are originated in interlamellar hollows. Lateral chamberlets are existed at the ventral side. Spines are placed more or less irregularly and communicated with canals. Microspheric test is minute proloculus and slightly trochospirally coiled of chambers with simple septa. Chamber wall is monolamellar in the infant stage and then inner thin and outer thick lamella in the adult stage. Spines are beginning to be formed after 1½ whorl.

Dimensions: Megalospheric specimens. Diameter of test = 1.10 to 1.24 mm, thickness = 0.39 to 0.43 mm, diameter/thickness ratio = 2.79 to 3.18; diameter of protoconch = 96 × 78 µm, diameter of deuteroconch = 122 × 92 µm, Ratio of deuteroconch/protoconch diameter = 1.27; distance across both protoconch and deuteroconch = 192 µm; mumber of chambers in first half whorl = 5, in first whorl = 10, 1½ whorl = 17, and in 2nd whorl = up to 25; number of spines = 1 or 2, diameter of pillars = 90 to 147 µm. Microspheric specimen: Diameter of test = 2.36, diameter of proloculus = 40 × 40 µm; number of chambers in first half whorl = 5, in first whorl = 10, in 1½ whorl = 15, in 2nd whorl = 21, in 2½ whorl = 29, and in 3rd whorl = 37(?)

Upper Eocene, Tertiary b.

Baculogypsinella Matsumaru, **n. gen**.
Type species: *Baculogypsinella eocenica* Matsumaru, n. sp.

Etymology: refers to inclusion in baculogypsinoid foraminifera.

Diagnosis: A calcarinid genus characterized by lenticular bicomnvex test with radial hispid spines and papillae on dorsal and ventral sides. The inner whorls are low trochoidal to planispiral primary chambers, and the adult outer whorls begin with several distal chambers covered with three to four layers of lateral chambers. Pillars are present. Monospecific, lateEocene.

Comparison: Differs from *Baculogypsina* Sacco in a smaller test with hispid spines.

Baculogypsinella eocenica Matsumaru, **n. sp.**
Plate 28, figures 8-12

Etymology: refers to type area.

Type locality: Station MD 101, along the Caguray River, Mindoro Island (text-fig. 14).

Holotype (fig. 8): A microspheric specimen, Saitama Univ. Coll. no. 8912; paratype (fig, 9), a megalospheric specimen, no. 8913

Description: Test small, thickly lenticular to oval, with radial hispid spines on chamber walls. Megalospheric embryonic chambers are biloculine, while microspheric proloculus is minute; in 1¼ low trochoidal to planispiral whorls of primary chambers in in the megalospheric form and about 2 whorls in the microspheric form. Outer whorls begin with several distal chambers covered with three to four layers of lateral chambers. The wall is calcareous, compact and coarsely perforate. Canals are present in the thickened wall of spiral chambers and in the spines. Pillars are present.

Dimensions: In megalospheric specimens, diameter of test = 0.93 to 1.36 mm, thickness = 0.61 to 0.64 mm, diameter/thickness ratio = 1.45 to 2.00; diameter of protoconch = 102 × 81 and 136 × 136 µm in 2 specimens, diameter of deuteroconch =90 × 50, and 159 × 79 µm, ratio of deuteroconch/protoconch diameter = 0.88 and 1.17; distance across both protoconch and deuteroconch = 136 and 225 µm; 5 chambers in first half whorl, 9 in first whorl, 13 in 1½ whorls; diameter of pillars = 56 to 80 µm. In microspheric specimens, diameter of test = up to 1.52 mm; diameter of proloculus = 56 × 56 µm; 5 chambers in first half whorl, 9 in first whorl, 15 in 1½ whorls.

Remarks: Specimens in Assemnblage 6 differ from *Baculogypsina sphaerulata* (Parker and Jones) in smaller test and hispid spines.

Late Eocene, Tertiary b.

Mindoroella Matsumaru, **n. gen**.
Type species: *Mindoroella mindoroensis* Matsumaru, n. sp.

Etymology: refers to genotype occurrence on Mindoro Island.

Diagnosis: A calcarinid genus characterized by biconvex, thick lenticular to oval test with a few radial spines. On a few low trochospitral coils the outer whorls begin with several distal planispiral chambers. The wall is calcareous, compact and coarsely perforate, with canals and outer radial spines. Pillars are absent. Monospecific, late Eocene.

Comparison: Differs from *Calcarina calcar* d'Orbigny in having several chambers distally arranged after low trochospiral primary chambers.

Mindoroella mindoroensis Matsumaru, **n. sp.**
Plate 23, figure 12 lower; plate 28, figures 13-15; plate 29, figures 1-2, 3 right

Etymology: refers to type area.

Type locality: Sample locality MD 70, Caguray Formation, Mindoro Island (text-fig. 14).

Holotype (fig.15): Saitama Univ. Coll. no. 8873; paratype (fig. 14), no. 8874.

Description: Test is thick lenticular to oval with a few radial spines. Protoconch and deuteroconch are followed by low trochospiral primary chambers, with several distal chambers added planispirally. Canals are present in the spiral chamber walls, with foramina in the basal septa.

Dimensions: Diameter of test =0.92 to 1.63 mm, thickness = 0.57 mm, diameter/thickness ratio = 2.28; diameter of protocnch = 70 × 64 µm (A1) and 75 × 65 µm (A2), diameter of deuteroconch = 56 × 46 µm (A1) and 75 × 65 µm (A2), ratio of deuteroconch/protoconchal diameter = 0.8 to 1.0; distance across both protoconch and deuteroconch = 110 to 130 µm. In (A2) forms, 5 chambers in first half whorl, 9 in first whorl, 15 in 1½ whorl; in (A1) forms, 5 in first half whorl, 9 in first whorl, 15 or 16 in 1½ whorl and 21 or 22 in second whorl; diameter of pillars = 45 to 80 µm.

Upper Eocene, Tertiary b.

Genus *Calcarina* d'Orbigny 1826

Calcarina delicata Todd and Post 1954
Plate 46, figure 15

Calcarina delicata Todd and Post 1954 – MATSUMARU 1976, p. 408, 411, pl. 2, figs. 1-3, 6-7, 9, 13.

Remarks: This species occurs in Pleistocene to Holocene consolidated strata from Bondoc, SE Luzon, Panay, Tablas, and Leyte islands, locally in association with *Calcarina spengleri* (Gmelin).

Pleistocene-Holocene, Tertiary h.

Calcarina spengleri (Gmelin) 1788
Plate 46, figure 14

Calcarina spengleri (Gmelin). – MATSUMARU 1976, p. 411, pl. 2, figs. 14-15, 17-26.

Remarks: This species occurs in Pleistocene to Holocene rocks in association with *Calcarina delicata* Todd and Post (Table 15) in Luzon and Tablas islands.

Pleistocene-Holocene, Tertiary h

Superfamily ACERVULINACEA Schultz 1854
Family ACERVULINIDAE Schultz 1854
Genus *Orbitogypsina* Matsumaru 1996

Orbitogypsina vesicularis Matsumaru 1996
Plate 44, figures 14, 15 left; plate 45, figures 1-3

Orbitogypsina vesicularis MATSUMARU 1996, p.192, 194, pl. 75, figs. 1-3; pl.76, figs. 1-8.

Description: Test discoidal, rounded, to lenticular, sharp edged. Subspherical protoconch and reniform deuteroconch are followed by trochospiral to planispiral nepionic chambers and arcuate equatorial chambers in alternating cyclic positions, both chambers with stolons. Lateral chambers are subrectangular cavities forming encrustations in the early stage and regular tiers in the adult stage. The wall is calcareous, and lamellar, coarsely perforate in the outer lamella and imperforate in the inner lamella.

Dimensions: Diameter of test = 1.20 to 2.20 mm, thickness = 0.43 to 0.48, diameter/thickness ratio = 2.41 to 5.00; diameter of protoconch = 60 × 45 to 105 × 96 µm, diameter of deuteroconch = 75 × 40 to 140 × 62 µm; tangential × radial diamter of primary auxiliary chamber = 40 × 40 to 78 × 44 µm; accessory auxiliary chamber = 57 × 52 µm; equatorial chambers = 52 × 35 to 114 × 44 µm; length × height of lateral chambers = 68 × 23 to 75 × 36 µm.

Remarks: Orbitogypsina vasicularis Matsumaru of also occurs in upper Eocene and lower Oligocene in the Ogasawara Islands (Matsumaru 1996).

Upper Eocene, Tertiary b (tab. 4) to middle Miocene, Tertiary f1 (tab. 12).

Orbitogypsina mindoroensis Matsumaru, **n. sp.**
Plate 45, figures 5-6

Etymology: refers to type area.

Type section: Station MD111, Caguray Formation on Bugsanga River, Mindoro Island.

Holotype (figs. 5, 6), Saitama Univ. Coll. no. 9012.

Description: Test discoidal with rather sharp periphery. Embryonic and nepionic chambers are obscure in the transverse section. Equatorial chambers are rectangular in transverse section, variably sized, and connected by stolons. Spacious, rectangular or arcuate lateral chambers with thin roofs and floors form regular tiers over the equatorial layer. Wall calcareous, lamellar and coarsely perforate in the outer lamellae and imperforate in the inner lamellae. Characteristically stout pillars are present throughout the test.

Dimensions: Diameter of test = 1.31 mm, thickness = 0.45 mm, diameter/thickness ratio = 2.11; length × height of equatorial chambers = 40 × 30 to 80 × 80 µm; lateral chambers = 40 × 14 to 60 × 20 µm. Lateral chambers in tiers over equatorial layer = 6 to 7, roofs and floors = 4 to 8 µm thick; diameter of pillars = 40 to 72 µm.

Remarks: The single specimen differs from *Orbitogypsina vesicularis* Matsumaru 1996, in its stout pillars throughout the test and the thin roofs and floors of lateral chambers.

Upper Eocene, Tertiary b.

Superfamily NUMMULITACEA de Blainville 1827
Family PELLATISPIRIDAE Hanzawa 1937
Genus *Biplanispira* Umbgrove 1937

Biplanispira mirabilis (Umbgrove 1937)
Plate 26, figures 6 upper, 13 right, 14-15; plate 27, figure 1

Heterospira mirabilis UMBGROVE 1937, p. 155-159, pl. 1, figs. 1-11.
Biplanispira mirabilis (Umbgrove) 1937, p. 309. – CRESPIN 1938, p. 6, pl. 2, figs. 9-18. – COLE and BRIDGE 1953, p. 22-23, pl. 6, figs. 9-19. – COLE 1957, p. 334, pl. 99, figs. 1, 4-6 (non figs. 2-3); pl. 100, fig. 1 (non figs. 2-3). – HANZAWA 1957, p. 51, pl. 9, figs. 1-3, 7 (non figs. 4-6); pl. 10, fig. 1; pl. 12, fig. 3. – MATSUMARU 1996, p. 114, pl. 37, figs. 1-3, 5 (non fig. 4). – HOTTINGER, ROMELO, and CAUS 2001, p. 50-52, pl. 15, figs. 10-11; pl. 16, figs. 1-6; pl. 17, figs. 1-7.

Description: Test thick, lenticular, with bluntly rounded periphery, ornamented by rounded papillae evenly scattered over the whole test. Spherical protoconch and reniform deuteroconch are followed by regularly coiled primary chambers with secondary coils lying above and below the primary whorls. The primary and secondary chambers radiate from the center in the equatorial section. Secondary chambers that develop after the early stage are characteristically clearly visible towards the periphery in vertical section. The wall is calcareous and bilamellar, with with thin finely perforate inner lamella and thick coarsely perforate outer lamella. Canals are present, but no marginal cord. Pillars and surface chambers are present.

Dimensions: Diameter of test = 2.84 to 4.04 mm, thickness = 1.14 to 2.20 mm, Form ratio of diameter/thickness = 1.83 to 2.50; diameter of protoconch = 160 × 160 µm, diameter of deuteroconch = 225 × 143 µm, deuteroconch/protoconch ratio = 1.41; distance across both protoconch and deuteroconch = 325 µm; 5 chambers in first half whorl, 11 in first whorl, 19 in 1½ whorl; diameter of pillars = 45 to 227 µm.

Remarks: Also found in the upper Eocene of Saipan (Cole and Bridge 1953; Hanzawa 1957) and Ogasawara Islands (Matsumaru 1996). *Biplanispira mirabilis* evolves from *B. absurda* Umbgrove by adding well developed secondary whorls.

Upper Eocene, Tertiary b.

Biplanispira absurda Umbgrove 1938
Plate 27, figures 10-12

Pellatispira crassicolumnata UMBGROVE 1928, p. 66-67, fig. 79? (non figs. 75-78, 80).
Biplanispira absurda UMBGROVE 1938, p. 85-89, figs. 1-17. – HANZAWA 1957, p. 52, pl. 11, figs. 1-5; pl. 12, figs. 4-5. – MATSUMARU 1996, p. 110,112, pl. 35, figs. 1-4; pl. 36, figs. 1-6. – HOTTINGER, ROMERO, and CAUS 2001, p. 52-54, pl. 8, fig. 6; pl. 18, figs. 1, 3 (non figs. 2, 4); pl. 19, figs. 2-3 (non figs. 1, 4) (Text-fig. 6D.
Biplanispira mirabilis (Umbgrove). – HANZAWA 1957, p. 51, pl. 9, figs.4-6 (non figs. 1-3, 7; pl. 10, fig. 1; pl. 12, fig. 3).
Biplanispira mirabilis forma *depressa* HANZAWA 1957, p. 51, pl. 10, figs. 3a-d.

Description: Test large discoidal to thin lenticular, occasionally with inflated periphery, ornamented with coarse papillae. Subspherical protoconch and reniform deuteroconch are followed by planispiral primary chambers of about 1½ whorls, after which the chambers are subdivided into secondary, radial chambers. The wall is calcareous and bilamellar, with with thin finely perforate inner lamella and thick coarsely perforate outer lamella; there are marginal canals but no cord, as well as surface chamber and pillars.

Dimensions: Diameter of test = 4.13 to 7.28 mm, thickness = 9.84 to 1.08 mm, diameter/thickness ratio = 4.91 to 6.74; diameter of protoconch = 318 × 310 µm, diameter of deuteroconch = 318 × 160 µm, deuteroconch/protoconch ratio = 1.0; distance across both protoconch and deuteroconch = 510 µm. There are 5 chambers in first half whorl, 11 in first whorl, 22 in 1½ whorl. Diameter of pillars = 68 to 204 µm.

Remarks: The species is known from Borneo, Saipan (Hanzawa 1957) and Ogasawara Islands (Matsumaru 1996). Cole (1957, p. 333) synonymized it with with *B. fulgeria* (Whipple). Because of wide variation, it is difficult to distinguish it from *P. fulgeria* in equatorial and vertical sections, but the synonymy is not confirmed. Hottinger et al. (2001) incorrectly identified *Biplanispira absurda* as a form with both secondary and tertiary spiral chambers, characters diagnostic of its probable descendant *Serraia cataloniensis* Matsumaru 1999.

Upper Eocene, Tertiary b.

Genus *Pellatispira* Boussac 1906

Pellatispira inflata Umbgrove 1928
Plate 27, figures 13-15; plate 28, figures 1-3

Pellatispira inflata UMBGROVE 1928, p. 63, figs. 42-56.
Biplanispira mirabilis (Umbgrove). – COLE 1957, p. 334, pl. 99, fig. 3 (non figs. 1-2, 4-6); pl. 100, figs. 2-3 (non fig. 1).
Biplanispira inflata HANZAWA 1957, p. 52, pl. 8, figs. 3, 5-6; pl. 9, fig. 8.
Pellatispira tumida HASHIMOTO 1975, p. 137-138, pl. 13, figs. 1-9; pl. 16, figs. 4-8.
Vacuolispira inflata (Umbgrove 1928). – HOTTINGER, ROMERO and CAUS 2001, p. 50, pl. 13, figs. 7-8; pl. 15, fig. 9 (Text-figs. 8-10.

Description: Test globular or inflated lenticular, ornamented with small to large round papillae that cover spiral evolute chambers. Subspheric protoconch and reniform deuteroconch are followed by regular whorls of primary chambers that slowly increase in height with growth, and finally bifurcate in the equatorial plane into two series, on one side winding through equatorial pores in the growth direction to the primary chambers and on the other side connecting in the opposite direction through tubular pores. The wall is calcareous and bilamellar, with with thin finely perforate inner lamella and thick coarsely perforate outer lamella. Canals are present, but no marginal cord, and pores between pillars and surface chambers are also present.

Dimensions: Diameter of test = 2.60 to 4.31 mm, thickness = 1.64 to 3.15 mm, diameter/thickness ratio = 1.25 to 1.31, rarely exceeding 1.60; in three specimens, diameter of protoconch = 245 × 250, 272 × 204, and 272 × 227 µm, deuteroconch = 263 × 204, 322 × 227, and 313 × 209 µm, deuteroconch/protoconch diameter = 1.07, 1.15, and 1.18; distance across both protoconch and deuteroconch = 477, 445, and 490 µm. There are 5 chambers in first half whorl, 11 in first whorl, 21 in 1½ whorl, and 34 in second whorl. Number of whorls = up to 3½; diameter of pillars = 104 to 181 µm.

Remarks: The present form evolved from *P. crassicolumnata* Umbgrove, and is distinguished from related forms by prominent pillars and the lack of a sutural depression.

Upper Eocene, Tertiary b.

Pellatispira provalei Yabe 1921
Plate 26, figures 8-12

?Calcarina sp. DOUVILLÉ 1905, p. 451.
Assilina madaraszi PROVALE 1908, p. 66-70, pl. 4, figs. 21-24; pl. 5, figs. 1-4.
Pellatispira madaraszi var. *provalei* YABE 1921, p. 108, pl. 20, figs. 6a-c (non *P. madaraszi* var. *douvillei* Yabe). – UMBGROVE 1928, p. 59-60, figs. 27-33.
Pellatispira crassicolumnata Umbgrove. COLE and BRIDGE 1953, p. 21-22, pl. 15, figs. 3-7.
Pellatispira provalei Yabe. – COLE 1957, p. 333, pl. 96, figs. 1-2, 6; pl. 98, figs. 1-12. – MATSUMARU 1996, p. 116, 118, pl. 39, figs. 1-5. – HOTTINGER, ROMERO, and CAUS 2001, pl. 46, pl. 10, figs. 1-8.
Pellatispira aff. *P. provalei* Yabe. – HOTTINGER, ROMERO, and CAUS 2001, p. 46-48, pls. 1-6 (SEM); pl. 9, figs. 1-7 (Text-fig. 7.

Description: Test discoidal to lenticular with rather blunt periphery, ornamented by densely papillate and spiral sutural depression. Subspherical protoconch and reniform deuteroconch are followed by planispirally arranged primary chambers of 1 to 2½ whorls that bifurcate in the equatorial plane into two irregular evolute series that on one side wind forward through equatorial pores to primary chambers and on the other side pass in the opposite direction through tubular pores (or loopholes). These secondary chambers vary in size. The wall is calcareous and bilamellar, with with thin finely perforate inner lamella and thick coarsely perforate outer lamella. There are canals are present but no marginal cord, and surface chambers and pillars are present.

Dimensions: diameter of test = 2.81 to 4.72 mm, thickness = 0.60 to 1.26 mm, form ratio of diameter/thickness = 2.91 to 5.75; in 13 specimens diameter of protoconch = 150 × 156 to 340 × 310 µm, deuteroconch = 156 × 120, 166 × 97 to 447 × 238 µm, deuteroconch/protoconch diameter = 0.91 to 1.33; distance across both protoconch and deuteroconch = 253 to 577 µm. There are 4 to 5 chambers in first half whorl, 10 to 12 in first whorl, 17 to 21 in 1½ whorl, 25 to 31 in second whorl, 36 to 46 in 2½ whorl, and 56 to 57 in third whorl. Diameter of pillars = 68 to 181 µm.

Remarks: Differs from ancestral *Pellatispira madaraszi* (Hantken) in its bifurcate secondary chambers after 2¼ to 2½ planispiral whorls.

Upper Eocene, Tertiary b.

Pellatispira crassicolumnata Umbgrove 1928
Plate 27, figures 6-9

Pellatispira crassicolumnata UMBGROVE 1928, p. 66-67, figs. 75-80. – COLE and BRIDGE 1953, p. 21-22, pl. 15, 3-7.

Description: Test thick lenticular and sometimes inflated in the central boss with rounded periphery. Subspherical protoconch and reniform deuteroconch are followed by about 1½ to 2 planispiral whorls of primary chambers. The wall is calcareous and bilamellar, with thin finely perforate inner lamella and thicker coarsely perforate outer lamella. Canals are present, but no marginal coard, and stout pillars.

Dimensions: Diameter of test = 1.50 to 2.30 mm, thickness = 0.80 to 1.10 mm, diameter/thickness = 1.88 to 2.09, diameter of protoconch = 140 × 130 µm, deuteroconch = 180 × 175 µm, distance across both protoconch and deuteroconch = 305 µm; chamber number and apical distance in first half whorl, 3 to 4 and 600 to 650 µm; first whorl, 8 to 9 and 750 to 950 µm; 1½ whorl, 15 to 17 and 1200 to 1350 µm; second whorl, 26 and 1630 µm. Pillar diameter = 140 to 175 µm.

Remarks: This species was transferred by Umbgrove (1938) to his new species *Biplanispira absurda,* and by Cole (1957) to *P. provalei* Yabe 1921, but the type of *crassicolumnata* illustrated by Umbgrove (see synonymy) does not have the secondary chambers of *absurda* or the fibrous keel of *provalei. P. crassicolumnata* evolved from *P. orbitoidea* (Provale), with a thicker lenticular test and elimination of sutural depression.

Upper Eocene, Tertiary b.

Pellatispira madaraszi (Hantken 1876)
Plate 26, figures 4-5, 6 center, 7, 13 left

Nummulites madaraszi HANTKEN 1876, p. 86-87, pl. 16, fig. 7.*
Pellatispira douvilleii BOUSSAC 1906, p. 91, pl. 2, figs. 10-13.
Pellatispira madaraszi (Hantken). – BOUSSAC 1906, p. 92-93, pl. 2, fig. 14. – YABE 1921, p. 106-108, pl. 19, figs. 1-8; pl. 20, figs. 1, 4-6. – SILVESTRI 1939, p. 95-97, pl. 32, figs. 6-7; pl. 34, fig. 11. – HANZAWA and HASHIMOTO 1970, p. 219-220, pl. 35, figs. 1-9. – MATSUMARU 1971, p. 153-154, pl. 59, figs. 12-14. – HOTTINGER, ROMERO and CAUS 2001, p. 44-46, pl. 7, figs. 1-4; pl. 8, figs. 1-5 (Text-figs. 3-5A, 6A-C.

Description: Test discoidal, ornamented with papillae and spiral sutural depression. Subspheric protoconch and reniform deuteroconch are followed by 3 1/4 planispiral whorls of primary chambers. The wall is calcareous and bilamellar, with thin finely perforate inner lamella and thicker coarsely perforate outer lamella. Pillars and canals are present, but no marginal cord.

Dimensions: Diameter of test = 3.45 to 4.77 mm, thickness = 0.60 to 0.93 mm, diameter/thickness ratio = 4.15 to 5.75; diameter of protoconch = 184 × 179 µm, deuteroconch = 228 × 112 µm, deuteroconch/protoconch diameter = 1.23; distance across both protoconch and deuteroconch = 305 µm; there are 5 chambers in first half whorl, 10 in first whorl, 18 in 1½ whorl, 28 in second whorl, 40 in 2½ whorl and 55 in third whorl. Pillar diameter = 90 to 180 µm.

Remarks: The typical form is characterized by its discoidal test and 3 tightly coiled evolute whorls with 55 chambers

Upper Eocene, Tertiary b.

Pellatispira orbitoidea (Provale 1908)
Plate 20, figures 12 left and right; plate 27, figures 2-5

Assilina madaraszi var. *orbitoidea* PROVALE 1908, p. 71, pl. 5, fig. 5.
Pellatispira orbitoidea (Provale). UMBGROVE 1928, p. 60-61, figs. 2-3, 5, 7, 9, 11-26, 34-41. – COLE 1957, p. 333, pl.96, figs. 3-5, 7-9; pl. 97, figs. 1-12; pl. 99, figs. 7-11. – HANZAWA 1957, p. 53, pl. 7, figs. 1-7 (non fig. 8). – MATSUMARU 1996, p. 114-116, pl. 38, figs. 1-5.
Pellatispira rutteni UMBGROVE 1928, p. 20-21, figs. 57-61. – COLE and BRIDGE 1953, p. 22, pl. 6, figs. 1-8. – HANZAWA 1957, p. 53-54, pl. 8, figs. 1-2, 7-8.

Description: Test thick lenticular with inflated central boss, ornamented with scattered round papilla; spiral sutural depression absent. Spherical to subspherical protoconch and reniform deuteroconch are followed by 3½ planispiral, tightly coiled whorls of primary chambers. The wall is calcareous and bilamellar, with thin finely perforate inner lamella and thick coarsely perforate outer lamella. Surface chambers, pillars and canals are present, but no marginal cord.

Dimensions: Diameter of test = 1.92 to 3.84 mm, thickness = 0.83 to 1.84 mm; diameter/thickness ratio = 2.20 to 3.10; in three specimens, diameter of protoconch = 125 × 125, 204 × 206, and 230 × 282 µm, deuteroconch = 165 × 147, 226 × 147, and 278 × 156 µm, deuteroconch/protoconch = 1.30, 1.11, and 1.21; distance across both protoconch and deuteroconch = 288, 365, and 330 µm. Number of chambers in first half whorl = 5, first whorl = 10, 1½ whorl = 16; pillar diameter = 90 to 160 µm.

Remarks: This species may be difficult to distinguish from *Pellatispira madaraszi* in the same samples*,* suggesting that it evolved from *P. madaraszi* with the acquisition of sutural depressions.

Upper Eocene, Tertiary b.

Family NUMMULITIDAE de Blainville 1827
Genus *Nummulites* Lamarck 1801
NOTE: The diagnostic surface ornamentation of *Nummulites* is difficult to observe in the thin sections. Classification here is primarily based on the "apical-frontal line" distance, or apical distance, between the embryonic center and the whorl margin (Matsumaru 2005, fig. 2).

Nummulites incrassatus de la Harpe 1883
Plate 20, figures 7-9, 10 left, 11 right, 12 center

Nummulites boucheri DE LA HARPE 1879, p. 110, pl. 1, fig. 4: 1-10.
Nummulites vasca Joly and Leymerie var. *incrassata* DE LA HARPE 1883, p. 177, pl. 7, figs. 27-28. – MONTANARI 1961, p. 575-576, pl. 1, figs. 1, 3, 4-5, 8-9; pl. 2, figs. 13, 15-16.
Nummulites incrassatus de la Harpe. – BIEDA 1963, p. 184-185, pl. 5, 10-12; pl. 6, figs. 1-3. – NEMKOV 1967, p. 220-224, pl. 29, figs. 8-18, pl. 30, figs. 1-5. – BLONDEAU 1972, p. 145, pl. 22, figs. 6-13.

Description: Test globular to inflated, lenticular, with a smooth surface is smooth and closely coiled, but gradually expanding whorls. Subspheric protoconch and reniform deuteroconch are followed by numerous falciform chambers, higher than wide. Septa are straight, radial and gently curved towards the periphery. The wall is calcareous and lamellar. Central pustules are not solid, but composed of radiating pillars of shell materials.

Dimensions: Diameter of test = 1.34 to 1.82 mm, thickness = 1.10 to 1.81 mm, diameter/thickness ratio = 1.4 to 1.8; in three specimens, diameter of protoconch = 120 × 102, 122 × 113 and 127 × 97 µm in 3 specimens, deuteroconch = 147 × 90, 143 × 80 and 143 × 81 µm. The number of chambers and apical distance of first half whorl is 5 to 6 and 188 to 227 µm, first whorl 12 to 13 chambers and 545 to 602, 1½ whorl 18 to 21 chambers and 727 to 795 µm, 2nd whorl 27 to 32 chambers and 954 to 1045 µm, 2½ whorl 39 to 443 chambers and 1159 to 1318 µm, 3rd whorl 50 to 59 chambers and 1340 to 1659 µm, and 3½ whorl 72 chambers and 1772 µm.

Remarks: Nummulites incrassatus is found from the Eocene of Poland and the Northern *Nummulites* Province of the Soviet Union (Nemkov 1967) as well as Assemblages 6 and 7 in the Philippines.

Upper Eocene to lower Oligocene, Tertiary b to Tertiary c.

Nummulites vascus Joly and Leymerie 1848
Plate 21, figures 10, 11 right and 12 upper

Nummulites vasca nobis, JOLY and LEYMERIE 1848, p. 38, 67; pl. 1, figs. 15-17; pl. 2, fig. 7.
Nummulites vasca Joly and Leymerie. – D'ARCHIAC and HAIME 1853, p. 145, pl. 9, figs. 11a-d, 12.
Nummulites vascus Joly and Leymerie. – BOUSSAC 1911, p. 35-37, pl. 3, figs. 17-18. – NEMKOV 1967, p. 224-228, pl. 30, figs. 6-16. – SCHAUB, 1981, p. 123-124, pl. 53, figs. 1-6; tab. 15e.

Description: Test thick, lenticular with a smooth surface and straight radial septal filaments and slightly bifurcate towards the periphery, with a round central plug. Spiral bands exhibit granules. The spire is regularly coiled. Embryonic chambers are obscure in oblique section,but followed by many falciform chambers, higher than wide. Septa are straight and radial, but gently curved towards the periphery. The spiral walls are uniformly thick, calcareous and lamellar. Pillars are present.

Dimensions: Diameter of test = 1.35 to 1.75 mm, thickness =0.60 to 0.65 mm, diameter/thickness form ratio = 2.46 to 2.34; number of whorls = 3 or more; diameter of central plug = 0.20 to 0.35 mm; diameter of pillars = 80 to 110 µm.

Remarks: Differs from its ancestor *Nummulites incrassatus* de la Harpe in its larger large form ratio.

Upper Eocene to lower Oligocene, Tertiary b to Tertiary d.

Nummulites fabianii (Prever 1905)
Plate 20, figures 1-6

Bruguieria fabianii PREVER 1905, p. 1805, 1825.
Nummulites fabianii Prever. – BOUSSAC 1911, p. 79, pl. 1, figs. 6, 13; pl. 4, figs. 9, 10. – BLONDEAU 1972, p. 156, pl. 30, figs. 1-5. – SCHAUB 1981, p. 126-128, fig. 88, pl. 49, figs. 57-69; pl. 50, figs. 1-4; tab. 15i.
Camerina fichteli (Michelotti). – COLE 1963, p. E13-14, pl. 1, figs. 1-17; pl. 2, figs. 7, 9, 11-13, 15, 17.
Camerina djokjokarta (Martin) – COLE 1963, p. E12, pl. 2, figs. 5-6, 8, 10, 14, 16, 18.

Description: Test thick, lenticular, closely coiled, and smooth with reticulate mesh, central plugs and isolated and combined granules. Subspherical protoconch and reniform deuteroconch and followed by many nearly square to lozenge-shaped chambers, slightly wider than high. Septa are straight and radial, but a little curved back at the periphery. The alar prolongation of chambers is narrow. The wall is calcareous, lamellar, and finely perforate.

Dimensions: Megalospheric form, diameter of test = 2.62 to 3.62 mm, thickness = 1.14 to 2.05 mm, diameter/thickness ratio = 1.3 to 1.8; in three specimens the diameter of protoconch = 260 × 200, 272 × 250 and 336 × 330 µm, deuteroconch = 310 × 150, 263 × 118 and 340 × 150 µm. Chambers and apical distance in first half whorl, 4 to 5 and 318 to 454 µm; first whorl, 9 and 818 to 1068; 1½ whorl 15 to 17 and 981 to 1363 µm; 2nd whorl, 21 to 25 and 1227 to 1681 µm; 2½ whorl, 29 to 33 and 1409 to 2000 µm; 3rd whorl, 38 to 43 and 1545 to 2295 µm; 3½ whorl, 48 to 53 and 1681 to 2590 µm; 4th whorl, 6t0 to 65 and 1863 to 2568 µm; 4½ whorl, 71 to 77 and 2000 to 2863 µm; 5th whorl, 2181 to 3318 µm; 5½ whorl, 2363 µm; 6th whorl, 2522 µm. Width of chambers = 215 to 370 µm; height = 170 to 340 µm. Microspheric form, diameter of test = 6.88 mm, thickness = 2.3 mm, diameter/thickness ratio =3.0.

Remarks: The species described by Cole (1963) as *Camerina* (= *Nummulites*) *fichteli* from the Eocene (Tertiary b) to Oligocene (Tertiary d) of Guam is actually the A1 (schizont) and A2 (gamont) forms of *N. fabianii*, and the latter is also misidentified as *N. djokjokarta* in the same paper. In addition, although the illustration of Bursh's (1947) *Nummulites intermedius-fichteli* from Molucca is too small, his description appears to be of *Nummulites fabiani* instead.

Upper Eocene, Tertiary b.

Nummulites fichteli Michelotti 1841
Plate 21, figures 4-9

Nummulites fichteli MICHELOTTI 1841, p. 296, pl. 3, fig. 7. – SCHAUB 1981, p. 128-130, pl. 50, figs. 5-18, tableau 15k, l.
Nummulites intermedia D'ARCHIAC 1846, p. 199. – D'ARCHIAC 1850, p. 416, pl. 9, figs. 23-24. – NEMKOV 1967, p. 193-196, pl. 25, figs. 1-14. – BLONDEAU 1972, p. 156, pl. 31, figs. 1-10.
Camerina subbrongniarti VERBEEK 1874, p. 152, pl. 2, figs. 10-27. – DOORNINK 1932, p. 269-271.
Camerina intermedia (d'Archiac). – DOORNINK 1932, p. 285-286, pl. 4, figs. 4-11; pl. 5, fig. 1, text-fig. A.
Camerina divina DOORNINK 1932, p. 299, pl. 9, figs. 5-10.
Camerina absurda DOORNINK 1932, p. 299-300, pl. 9, figs. 11-17, text-fig. 1.
Camerina fichteli (Michelotti). – CAUDRI 1934, p. 72-81.

Description: Test large and lenticular, smooth with a reticulate mesh, central plugs and isolated and combined granules on the spiral band. The spire is closely to widely coiled. Subspherical protoconch and reniform deuteroconch are followed by rhomboidal chambers much wider than high. Septa are straight and radial, slightly curved towards the periphery. Chambers have spacious alar prolongations Wall is calcareous, lamellar and finely perforated.

Dimensions: Megalospheric form, diameter of test = 1.0 to 5.7 mm, thickness = 0.45 to 1.18 mm, diameter/thickness ratio = 1.88 to 2.62; in 6 specimens, diameter of protoconch = 147 × 122, 263 × 254, 272 × 215, 340 × 327 and 727 × 409 µm; deuteroconch= 154 × 104, 272 × 204, 295 × 113, 322 × 164, 340 × 113 and 609 × 254 µm. Chamber number and apical distance in first half whorl, 5 to 6 and 327 to 600 µm; first whorl, 9 to 10 and 786 to 1431 µm; 1½ whorl, 15 to 16, 1863 µm; 2nd whorl, 22 and 1272 to 2318 µm; 2½ whorl, 29 and 1500 to 2863 µm; 3rd whorl, 38 and 1818 to 3227 µm; 3½ whorl, 2045 to 3727 µm; 4th whorl = 2363 to 4681 µm; 4½ whorl, 2590 to 5272 µm; 5th whorl = 2772 to 5455 µm; 5½ whorl = 2863 to 5700 µm. Microspheric form, diameter of test = 7.00 to 7.14 mm, thickness = 1.20 to 1.23 mm, diameter/thickness ratio = 5.80.

Remarks: Doornink (1932) divided the highly variable reticulate *Nummulites* into four species (see synonymy), but they are here returned to *Nummulites fichteli* based on the consistent internal structure and external character.

Lower Oligocene, Tertiary c to Tertiary d.

Genus *Operculina* d'Orbigny 1826
NOTE: *Operculina* species in the west Pacific region fall into three groups: one with close and regular coiling (*Operculina ammonoides* group), and another with gradually expanded coiling after the first 2 or 2½ whorls (*Operculina complanata* group). The third group, so far un-named, has gradually widened whorls but not expanded coiling, as in *O. eniwetokensis, O. subformai,* and *O. saipanensis*.

Operculina subformai (Provale 1908)
Plate 20, figures 10 right, 11 left

Nummulites (*Gumbelia*) *subformai* PROVALE 1908, p. 64-66, pl. 4, figs. 16-20.
Operculina subformai (Provale). – COLE 1957, p. 755-756, pl. 232, figs. 1-6. – COLE 1963, p. 16, pl. 2, figs. 1-4. – MATSUMARU 1996, p. 62, 64, pl. 12, figs. 1-6; pl. 13, figs. 1-6.

Description: Test inflated lenticular and evenly biconvex, smooth, with umbonal pillars of shell fragments on the central boss. The spire is involute and then gradually evolute from 1½ whorls. Septa are crescentic towards the periphery. The wall is calcareous and lamellar.

Dimensions: Diameter of test = 1.43 to 1.82 mm, thickness = 1.05 mm, diameter/thickness ratio = 1.36 to 1.70; diameter of proloculus in axial section = 129 × 159 µm; apical distance first half whorl = 240 µm, first whorl = 568 µm, 1½ whorl = 727 µm, second whorl = 909, 2½ whorl = 1204 µm, 3rd whorl = 1545 µm, 3½ whorl = 1818 µm, and 4th whorl = 2068 µm. Diameter of umbonal plug = 125 to 200 µm.

Remarks: Also known from the upper Eocene (Tertiary b) of Ogasawara Islands (Matsumaru 1996).

Upper Eocene, Tertiary b (tab. 4).

Operculina eniwetokensis Cole 1957
Plate 21, figures 14-15; plate 22, fig. 1

Operculina eniwetokensis COLE 1957, p. 756, pl. 232, figs. 15-23. – COLE 1963, p. E16, pl. 5, figs. 11-12, 25.

Description: Test small, biconvex, thin lenticular and smooth. The spire changes from involute to slightly evolute after 1½ whorls. Spherical to subspherical protoconch and reniform deuteroconch are followed by many chambers. Radial septa are recurved at a third of their length towards the periphery. Wall is calcareous and lamellar.

Dimensions: Diameter of test = 1.23 to 1.48 mm, thickness = 0.32 mm, diameter/thickness ratio = 3.84; in 4 specimens, diameter of protoconch = 30 × 26, 54 × 54, 55 × 41 and 68 × 65 µm, deuteroconch = 20 × 10, 58 × 33, 56 × 32 and 77 × 45 µm; chamber number and apical distance in first half whorl, 5 and 48 to 136 µm; first whorl, 8 to 9 amd 136 to 318 µm; 1½ whorl, 13 to 15 and 240 to 545 µm; 2nd whorl, 18 to 21 and 384 to 727 µm; 2½ whorl = 24 to 28 and 592 to 1113 µm, and 3rd whorl = 1159 to 1480 µm.

Upper Eocene, Tertiary b.

Operculina complanata (Defrance 1822)
Plate 22, figures 4-6; plate 43, fig. 11

Lenticulites complanata DEFRANCE 1822, p. 453.
Operculina complanata (Defrance). – BRADY 1884, p. 743, pl. 112, figs. 3-5, 8. – NEWTON and HOLLAND 1902, p. 13-14, pl. 1, figs. 3, 5, pl. 2, fig. 3. – YABE 1918, p. 120-121, pl. 17, figs. 1-6 (non fig. 7). – COLE 1959, p. 361, pl. 29, fig. 16, pl. 31, figs. 2-4. – MATSUMARU 1996, p. 59-62, pl. 11, figs. 1-5.
Operculina complanata (Defrance) var. *granulosa* Leymerie. – BRADY 1884, p. 743, pl. 112, figs. 6-10.
Operculina gaimairdi d'Orbigny. – YABE and HANZAWA 1925, p. 51, pl. 6, fig. 16; pl. 7, fig. 19.
Operculina complanata (Defrance) var. *japonica* HANZAWA 1935, p. 19-22, pl. 1, figs. 4-28.
Operculina bartschi CUSHMAN 1921, p. 376-377, text-fig. 13. – YABE and HANZAWA 1925, p. 52, pl. 6, figs. 6-12; pl. 7, figs. 11-12. – COLE 1945, p. 277-278, pl. 12, figs. H-K, pl. 14, fig. I. – COLE 1959, p. 360-361, pl. 28, fig. 16.
Operculina bartschi Cushman var. *punctata* YABE and HANZAWA 1925, p. 52-53, pl. 6, figs. 13-15; pl. 7, figs. 15-18.
Planoperculina complanata (Defrance). – HOTTINGER 1977, p. 101-105, pl. 39, figs. 1-6, pl. 40, figs. 1-6, text-figs. 39-41C-E.

Description: Test large, complanate and usually compressed, but sometimes slightly inflated in the central boss. The surface is smooth, occasionally ornamented with granules on curved sutures or lateral surfaces. Subspherical protoconch and reniform deuteroconch are followed by many crescent shaped chambers, in coils that change from involute in the first whorl to graduaually evolute and expanded. Radial septa are mostly recurved halfway towards the periphery. Canals are present at chamber walls and septa. Wall is calcareous, lamellar, and finely perforate.

Dimensions: Earlier (Tertiary c) specimens have diameter of test = 2.29 to 4.20 mm, thickness = 0.61 to 0.94 mm, diameter/thickness ratio = 3.32 to 6.28; in six specimens,.diameter of protoconch = 112 × 88 to 160 × 158 µm; deuteroconch = 144 × 88 to 177 × 104 µm, ratio of deuteroconch/protoconch diameter = 0.76 to 1.54; chamber number and apical distance in first half whorl, 4 to 6 and 216 to 333; first whorl, 9 to 10 and 645 to 936 µm; 1½ whorl, 14 to 18 and 853 to 1685 µm; 2nd whorl, 22 to 27 and 978 to 2720 µm; 2½ whorl, 33 and 2662 µm and 33; diameter of pillars = 34 to 45 µm. In more recent (Tertiary d to Tertiary h) specimens with small embryo (A1 schizont), diameter of test = 2.20 to 4.20 mm, thickness = 0.40 to 0.50 mm, ratio of dianeter/thickness = 4.40 to 8.25; diameter of protoconch = 56 × 56, 64 × 52 and 73 × 78 µm in 3 specimens, deuteroconch = 68

× 25, 67 × 21 and 100 × 64 µm, ratio of deuteroconch/protoconch diameter = 1.21, 1.05 and 1.37; chamber number and apical distance in first half chamber, 5 to 6 and 96 to 195 µm; first whorl, 8 to 10 and 272 to 482 µm; 1½ whorl, 14 to 17, 329 to 636 µm; 2nd whorl, 18 to 24 and 500 to 955 µm; 2½ whorl, 26 to 31 and 704 to 1591 µm; 3rd whorl, 33 to 40 and 1000 to 2182 µm; 3½ whorl, 45 to 50 and 1409 to 2182 µm; 4th whorl, 56 to 62 and 2318 to 2288 µm. Those with normal sized embryonic chambers (A2 gamont) have diameter of protoconch = 136 × 114, 147 × 120 and 166 × 166 µm in 3 specimens, deuteroconch = 130 × 55, 141 × 88 and 147 × 73 µm, ratio of deuteroconch/protoconch diameter = 0.96, 0.96 and 0.89; chamber number and apical distance in first half whorl, 5 to 6 and 222 to387 µm; first whorl, 10 to 11 and 456 to 931 µm; 1½ whorl, 15 to 20 and 636 to 1318 µm; 2nd whorl, 23 to 32 and 1155 to 1772 µm; 2½ whorl, 32 to 34 and 2023 to 2272 µm; 3rd whorl, 45 and 3182 µm. Pillar diameter = 36 to 46 µm.

Remarks: This long-ranging species is also known from the Oligoceneof Ogasawara Islands in both schizont and gamont form (Matsumaru 1994; 1996).

Lower Oligocene, Tertiary c to Recent, Tertiary h.

Operculina heterosteginoides (Hofker 1933)
Plate 23, figures 7-9

Heterostegina operculinoides HOFKER 1927, p. 66-71, pl. 34, figs. 1, 6 (non pl. 34, figs. 2, 5)
Operculina heterosteginoides HOFKER 1933, p. 148-149, pl. 6, figs. 1-2.
Heterostegina heterosteginoides (Hofker). – HOFKER 1971, p. 76-79, pl. 108, figs. 7-17.
Planoperculina heterosteginoides (Hofker). – HOTTINGER 1977, p. 105-107, pl. 42-44, text-figs. 7B, 42A-C.

Description: Test complanate, lemticular, compressed to thin with slight inflation of the central portion, ornamented with granules on curved sutures and lateral surfaces. Spherical protoconch and reniform deuteroconch are followed by many crescent shaped chambers that gradually change from involute in first to 1½ whorl to evolute and expanding after 2 whorls. The radial septa are recurved at both ends. Incomplete chamberlets are formed by secondary septula. A septal flap is visible, and canals are present in chamber walls and septa. Wall is calcareous, lamellar and finely perforate.

Dimensions: Diameter of test = 2.75 to 3.41 mm, thickness = 0.80 mm, diameter/thickness ratio = 4.26; diameter of protoconch = 68 × 68 µm, diameter of deuteroconch = 91 × 38 µm; chamber number and apical distance in first half whorl, 5 and 159 µm; first whorl, 9 and 386 µm; 1½ whorl, 15 and 523 µm; 2nd whorl, 21 and 932 µm; 2½ whorl, 29 and 1500 µm; 3rd whorl, 40m and 2750 µm.

Remarks: Operculina heterosteginoides is an intermediate form between the genera *Operculina* and *Heterostegina*

Middle Miocene, Tertiary f1.

Operculina ammonoides (Gronovius, 1781)
Plate 22, figures 7-9

Nautilus ammonoides GRONOVIUS, 1781, p. 282, pl. 19, figs. 5-6.
Operculina ammonoides (Gronovius). – BRADY 1884, p. 745, pl. 112, figs. 1-2. – CUSHMAN 1914, p. 37, pl. 14, fig. 7. – HERON-ALLEN and EARL 1915, p. 737. – CUSHMAN 1921, p. 382. – CHAPMAN and PARR 1938, p. 290-292, pl. 17, figs. 12-16 (Text-fig. 5. – HANZAWA 1939, p. 229-230, pl. 15, figs. 1-3 (non figs. 4-5); pl. 16, figs. 4-7 (non fig. 3). – COLE 1959, p. 356-360, pl. 28, figs. 1-11; pl. 29, figs.3-10, 12, 15; pl. 30, figs. 2-8; pl. 31, figs. 5-7. – HOTTINGER 1977, p. 89-92, pl. 2, figs. A-B; pl. 3, figs. B-F; pl. 4-7, 12; pl. 13, fig. B; pl 14, figs. 3-4, 7-9 (non figs. 1-2) (Text-figs. 35A-D, 36A-B, D, F (non figs. C, E, G-K). – HASHIMOTO and MATSUMARU 1978, p. 93, pl. 12, figs. 1-6, 8 upper.
Operculina discoidalis (d'Orbigny). – CUSHMAN 1921, p. 379-380.
Operculina discoidalis (d'Orbigny) var. *involuta* CUSHMAN 1921, p. 380-381, text-fig. 16.
Operculina elegans CUSHMAN 1921, p. 381-382, pl. 97, fig. 3.
Operculina gaimairdi d'Orbigny. – CUSHMAN 1924, p. 50, pl. 17, fig. 7.
Operculina venosa (Fichtel and Moll). – CUSHMAN 1924, p. 50-51, pl. 17, fig. 7. – HANZAWA 1935, p. 23, pl. 1, figs. 31-41.

PLATE 20

Figs. 1-3 from Station MD 104; fig. 4, Station MD 117; figs. 5-6, Station MD 116; Mindoro; figs. 10, 11, Station CT 38; figs. 8, 12, Station CT 19; figs. 7, 9, Station CT 39; Catanduanes; figs.13, 14, Station BG 6A, and fig. 15, Station h2505; Bontoc, Luzon.

1-6 *Nummulites fabianii* (Prever) 1 left. Equatorial section. 1 right, 2, 3, 4 right, 5, oblique sections. 6, tangential section, parallel to equatorial section. 1-3, 5-6, ×10; 4, × 5.

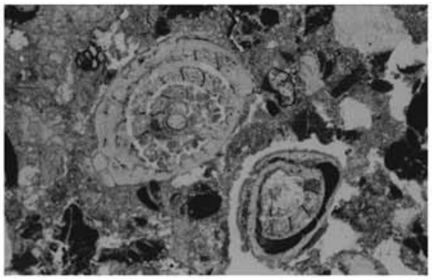
4 *Cycloclypeus* spp. 4 left, tangential section, ×5.

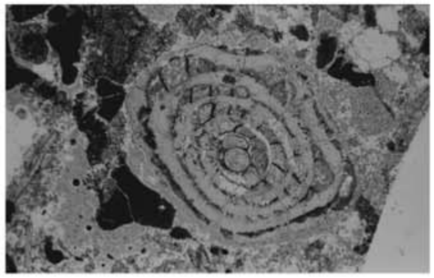
7-12 *Nummulites incrassatus* de la Harpe. 7-9, 10 left, 11 right, oblique sections. 12 center, equatorial section.. 7-11, ×20. 12, ×10.

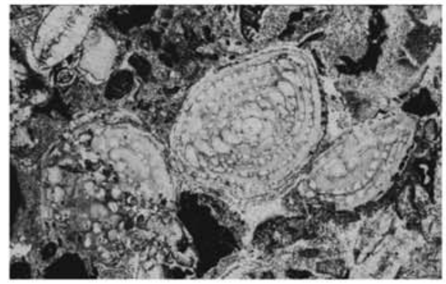
10, 11 *Operculina subformai* (Provale). oblique sections, ×20.

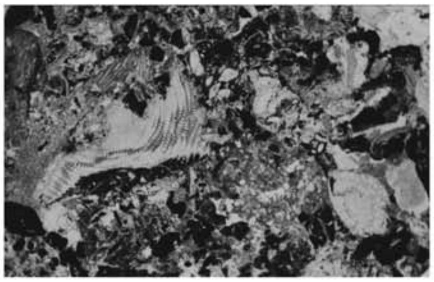
12 *Pellatispira orbitoidea* (Provale). 12 left, 12 right, oblique sections, ×10.

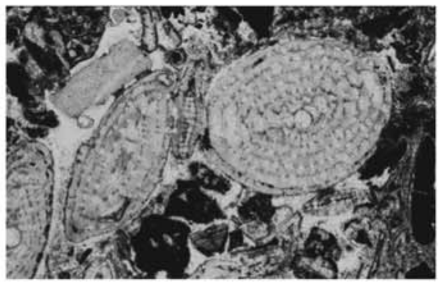
13-15 *Nummulites striatus* Bruguiere. 13, 14, equatorial sections, ×10. 15. axial section, ×20. Reworked from upper Eocene, Tertiary b.

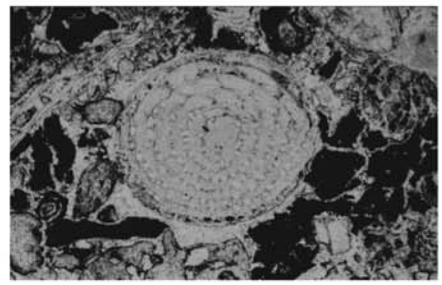

1

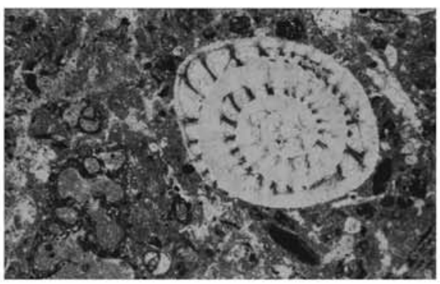

2


3


4

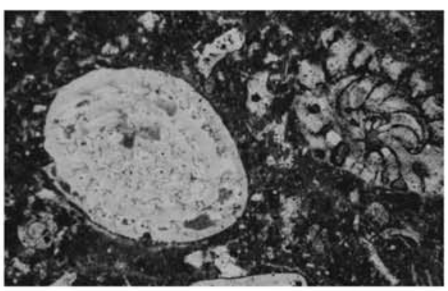

5

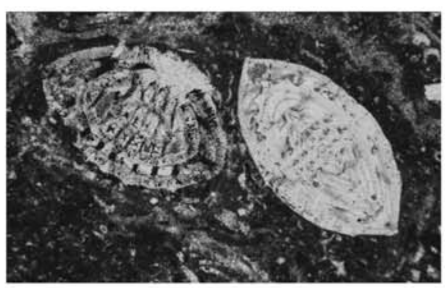

6

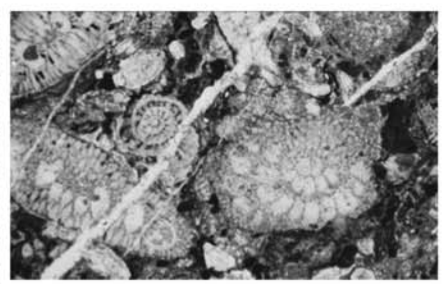

7

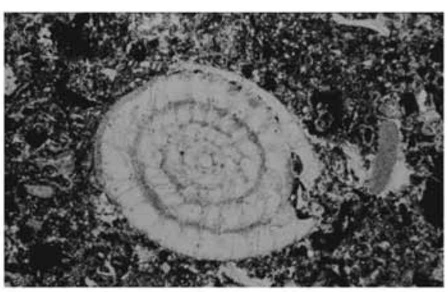

8

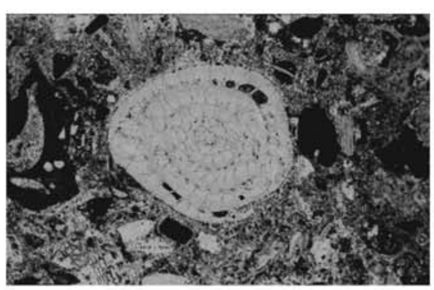

9

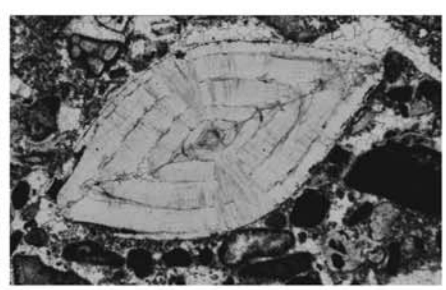

10


11


12


13


14


15

Operculina (Operculinella) venosa Fichtel and Moll. – YABE and HANZAWA 1925, p. 49-51, pl. 5, figs. 1-27; pl. 6, figs. 1-5; pl. 7, figs. 1-10. – YABE and HANZAWA 1929, p. 185-186, pl. 21, figs. 8-9; pl. 22, figs. 1-2. – YABE and HANZAWA 1930, p. 40-41, pl. 1, fig. 8?; pl. 2, fig. 11; pl. 8, fig. 5; pl. 9, figs. 10-13; pl. 10, fig. 10; pl. 13, figs. 1-2; pl. 14, fig. 7; pl. 16, fig. 2-5.
Operculinoides bikiniensis COLE 1954, p. 574, pl. 204, figs. 19-23.
Paleonummulites cumingii (Carter). – EAMES, BANNER, BLOW, CLARK and SMOUT 1962, p. 50, pl. 11, figs. C=E.
Camerina ammonoides (Gronovius). – COLE 1961, p. 118-120, pl. 14, figs. 1-17, 23 (non figs. 20-22); pl. 15, figs. 2-6, 11 (non figs. 7-10).
Operculina bikiniensis (Cole). – HOTTINGER 1977, p. 89, pl. 14, figs. 10-14 (Text-figs. 35E-R.

Description: Test biconvex, with close-coiled and involute inner whorls becoming slightly evolute to rather evolute with alar projections, not complanate. The surface is smooth or with granules on central portion or septal sutures. Spherical to subspherical protoconch and reniform deuteroconch are followed by many crescent shaped chambers. The septa are radial, with a third of length recurved gradually. Canals are present. Wall is calcareous, lamellar and finely perforate.

Dimensions: A2 gamont form: diameter of test = 1.40 to 3.23 mm, thickness = 0.33 to 0.85 mm, diameter/thickness ratio = 3.23 to 7.06; in 6 specimens, protoconch diameters 57 × 56 to 113 × 90 µm, deuteroconch = 64 × 43 to 118 × 66 µm, deuteroconch/protoconch diameter = 1.00 to 1.32; chamber number and apical distance in first half whorl, 5 to 6 and 105 to 215 µm; first whorl, 9 to 11 and 270 to 556 µm; 1½ whorl, 14 to 18 and 416 to 825 µm; second whorl, 20 to 26 and 603 to 1375 µm; 2½ whorl, 29 to 35 and 894 to 2125 µm; third whorl, 40 to 45 and 1200 to 1840 µm; pillar diameter = 48 to 100 µm. A1 schizont form: diameter of test = 0.94 to 1.08 mm; protoconch diameter = 22 × 22 and 26 × 26 µm, deuteroconch = 32 × 20 and 36 × 22 µm; deuteroconch/protoconch diameter ratio = 1.45 and 1.38; chamber number and apical distance in first half whorl, 6 and 45 to 160 µm; first whorl, 10 and 125 to 148 µm; 1½ whorl, 16 to 17 and 204 to 252 µm; second whorl, 23 and 328 to 431 µm; 2½ whorl, 29 to 31 and 472 to 613 µm; third whorl, 35 to 38 and 623 to 818 µm; 23½ whorl, 41 to 47 and 915 to 1068 µm.

Lower Oligocene to Recent, Tertiary d to Tertiary h.

Operculina venosa (Fichtel and Moll 1798)
Plate 23, figures 1-6; plate 46, figure 6 right

Nautilus venosus FICHTEL and MOLL, 1798, pl. 8, figs. E-h.
Amphistegina cumingii CARPENTER 1859, p. 32, pl. 5, figs. 13-17.
Nummulites cumingii (Carpenter). – BRADY 1884, p.749, pl. 112, figs. 11-13 (Text-fig. 22.
Operculinella cumingii (Carpenter). – YABE 1918, p. 122-126, pl. 17, figs. 8-12. – HANZAWA 1939, p. 228-229, pl. 15, figs. 6-8; pl. 16, figs. 1-2, 10.
Operculina venosa (Fichtel and Moll). – CUSHMAN 1921, p. 383-384. – COLE 1959, p. 361-363, pl. 28, figs. 12-14, 17-18; pl. 29, figs. 1-2, 11, 13-14; pl. 30, figs. 1, 9-10; pl. 31, fig. 1.
Operculinella venosa (Fichtel and Moll). – CHAPMAN and PARR 1938, p. 293, pl. 17, figs. 22 (Text-fig. 7.
Operculina sp. HANZAWA 1939, p. 229, pl. 15, figs. 9, 11; pl. 16, figs. 8-9.
Operculina ammonoides (Gronovius) HANZAWA 1939, p. 229-230, pl. 15, figs. 4-5 (non figs. 1-3); pl. 16, fig. 3 (non figs. 4-7).
Camerina ammonoides (Gronovius). – COLE 1961, p. 118-120, pl. 14, figs. 20-22 (non figs. 1-17, 23); pl. 15, figs. 7-10 (non figs. 2-6, 11).
Camerina venosa (Fichtel and Moll). – COLE 1961, p. 114-118, pl. 14, figs. 18-19.
Operculina subglobosa HANZAWA and HASHIMOTO 1970, p. 221, pl. 36, figs. 1-5.

Description: Test biconvex, thick lenticular to subglobose with or without flange, smooth except for umbonal plugs in the center. The involute spire becomes evolute in the last whorl. Some septal sutures are limbate. Subspherical protoconch and reniform deuteroconch are followed by many rhomboidal chambers. The septa are radial, outer third slightly recurved. Long alar prolongations of chambers are oriented towards the axial plug. Canals are present in chamber walls and septa. Wall calcareous, lamellar and finely perforate.

Dimensions: Diameter of test = 1.39 to 2.33 mm, thickness = 0.80 to 1.60 mm, diameter/thickness = 1.42 to 2.26; in 5 specimens, diameter of protoconch = 67 × 60 to 90 × 80 µm,

---

PLATE 21

Figs. 1-3, Station 74329, Mt. Kahra, Ishigaki-Jima, Japan; from upper Eocene (Tertiary b) Miyara Formation (Matsumaru 1971); fig. 4, Station 7442623, Cebu; figs .5-9, Station WR 202, fig. 10, Station MD 83, and figs. 11-12, Station 11469, Mindoro; fig. 13 Station BG 7, and figs. 14-15, Station BG 12, Bontoc, North Luzon.

1-3 *Nummulites striatus* Bruguiere. 1, 2, oblique sections. 3, tangential section, all ×20.

4-9 *Nummulites fichteli* (Michelotti). 4, tangential section. 5, 7, oblique sections. 6, equatorial section. 8, 9, axial sections: upper, microspheric; lower, megalospheric specimen. 4, 7-9, ×10; 5, × 5; 6,, ×20.

4 *Sphaerogypsina globulus* (Reuss) 4 right, equatorial section, ×10.

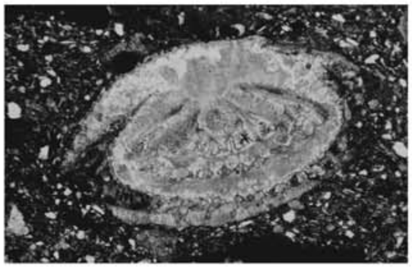
10-12 *Nummulites vascus* Joly and Leymerie. 10, 11 right, oblique sections. 12 upper, transverse section, all ×20.

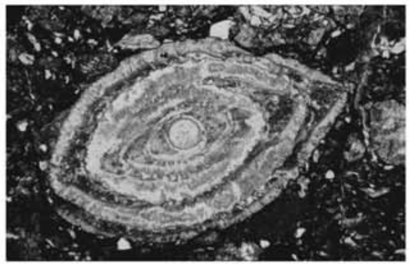
11 *Lepidocyclina isolepidinoides* van der Vlerk. 11 left, oblique section, ×20.

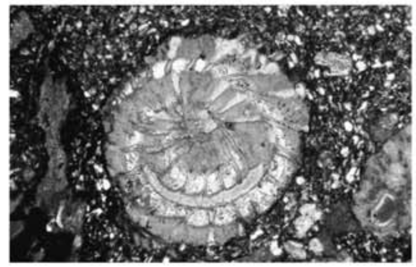
12 *Nephrolepidina marginata* (Michelotti). 12 lower, axial section of megalospheric specimen, ×20.

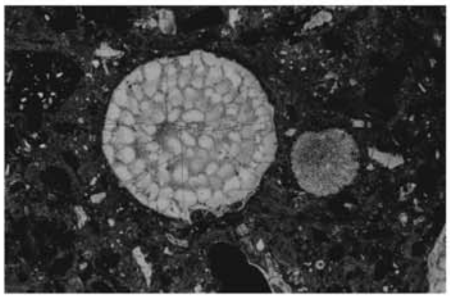
13 *Operculina saipanensis* Cole. Equatorial section., ×20.

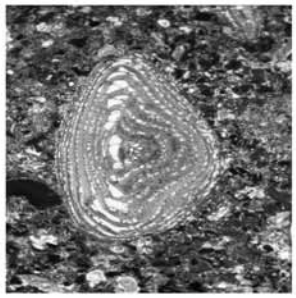
14, 15 *Operculina eniwetokensis* Cole. 14, equatorial section of broken specimen. 15, oblique section. Both ×20.

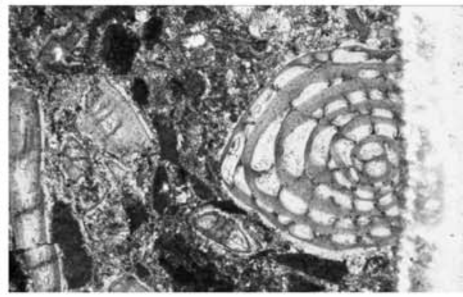

1

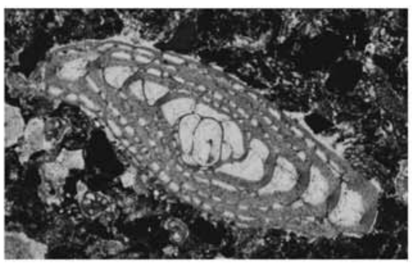

2

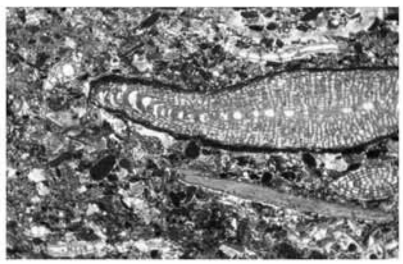

3


4

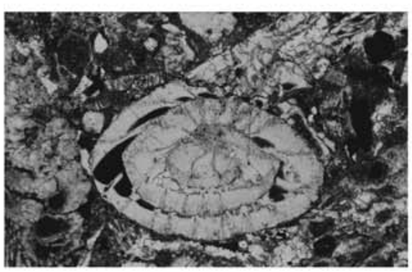

5

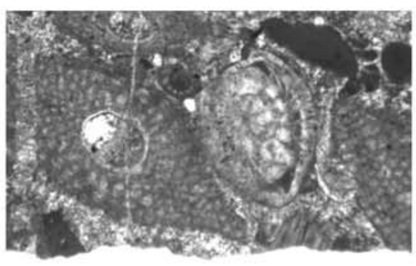

6

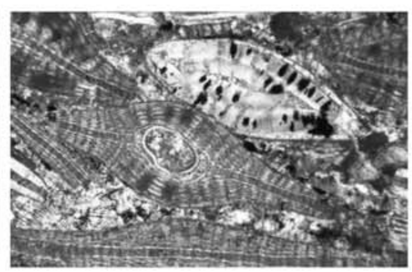

7

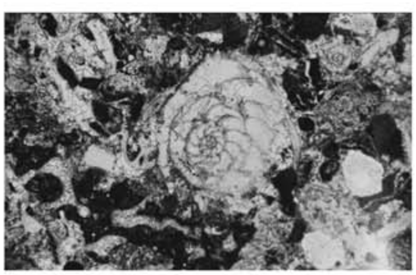

8

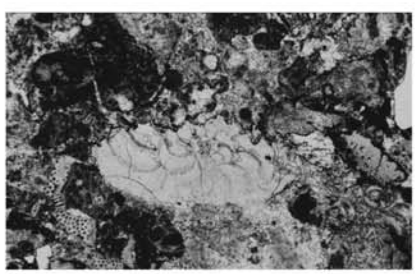

9

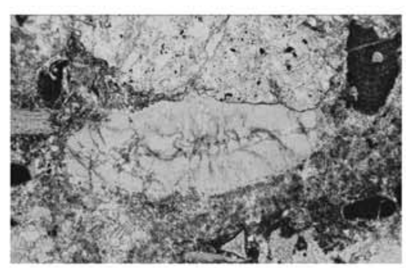

10


11


12


13


14


15

deuteroconch = 76 × 26 to 95 × 57 µm, deuteroconch/ protoconch diameter ratio = 1.00 to 1.37. Chamber number and apical distance in first half whorl, 5 and 129 to 167 µm; first whorl, 9 to 10 and 334 to 477 µm; 1½ whorl, 14 to 16 and 489 to 659 µm; second whorl, 19 to 23 and 700 to 931 µm; 2½ whorl, 26 to 32 and 918 to 1250 µm; 3rd whorl, 33 to 43 and 1177 to 1495 µm; 3½ whorl, 41 to 53 and 1422 to 1498 µm; 4th whorl, 67 and 1845 µm; 4½ whorl, 81 and 2170 µm; pillar diameter = 60 to 125 µm; diameter of umbonal plugs = 210 to 275 µm.

Remarks: This long-ranging species belongs to the *O. ammonoides* group due to the similar growth pattern, but with a distinctive form ratio.

Upper Oligocene to Recent, Tertiary e4 to Tertiary h.

Operculina balcei Hashimoto and Matsumaru 1978
Plate 22, figures 10-15; plate 25, figure 12 right

Operculina balcei HASHIMOTO and MATSUMARU 1978, p. 93-94, pl. 12, figs. 6 left-8 lower; pl. 13, figs. 1-4, 8.

Description: Biconvex test is thick and lenticular with a wide flange, smooth and devoid of ornamentation apart from raised sutural ridges. The spire becames gradually less involute until the third whorl, abruptly becoming evolute in the fourth whorl. Spherical to subspherical protoconch and reniform deuteroconch are followed by many chambers. The septa are radial, abruptly recurved at their distal ends. Chambers have thin lateral walls and alar prolongations to the apical portion of test. Wall is calcareous, lamellar and finely perforate.

Dimensions: Diameter of test = 1.20 to 2.77 mm, thickness = 0.55 to 0.77 mm, diameter/thickness ratio = 2.18 to 3.90; in 5 specimens, diameter of protoconch = 52 × 48 to 95 × 90 µm; deuteroconch = 60 × 46 to 100 × 60 µm, deuteroconch/ protoconch diameter ratio = 1.05 to 1.13; chamber number and apical distance in first half whorl, 5 to 6 and 104 to 182 µm; first whorl, 8 to 10 and 264 to 523 µm; 1½ whorl, 14 to 19 and 368 to727 µm; second whorl, 21 to 28 and 568 to 977 µm; 2½ whorl, 27 to 39 and 882 to 1364 µm; 3rd whorl, 37 to 50 and 1227 to 1832 µm; 3½ whorl, 47 to 63 and 1614 to 2545 µm; 4th whorl, 74 to 78 and 2360 to 2818 µm. pillar diameter = 68 to 90 µm; diameter of umbilical plugs = 114 to 136 µm.

Remarks: More evolute in the fourth whorl than the closely similar *O. bikiniensis* and *O. rectilata.*

Upper Oligocene to middle Miocene, Tertiary e3 to Tertiary f1.

Operculina saipanensis Cole 1957
Plate 21, figure 13

Operculina saipanensis COLE 1957, p. 331, pl. 102, figs. 15-16. – COLE 1957, p. 755-756, pl. 232, figs. 7-14 (non pl. 233, figs. 31-32).

Description: Test small, evenly lenticular and biconvex. The spire becomes gradually evolute after the 1½ whorl. Spherical protoconch and reniform deuteroconch are followed by many chambers. The septa are radial with outer third recurved. Wall is calcareous and lamellar

Dimensions: Diameter of test = 1.4 to 1.5 mm, thickness = 0.7 mm, diameter/thickness ratio = 2.0 to 2.1; diameter of protoconch = 36 × 36 µm, diameter of deuteroconch = 45 × 28 µm. Chamber number and apical distance in first half whorl, 3 and 100 µm; first whorl. 9 and 240 µm; 1½ whorl, 16 and 450 µm; 2nd whorl, 23 and 650 µm; 2½ whorl, 30 and 880 µm; 3rd whorl, 38 and 1150 µm; 3½ whorl, 1500 µm(?).

Remarks: Differs from *Operculina eniwetokensis* Cole, found together in the Eocene of Eniwetok and Saipan, in having a smaller proloculus and more coils. It is very likely that *eniwetokensis*, with its larger proloculus and fewer coils, may be the A2 (gamont form) of *O. saipanensis,* whose type has the A1 (schizont) form.

Upper Eocene, Tertiary b. Specimens in lower Oligocene Tertiary c samples (tab. 5) are reworked.

PLATE 22

All × 20 except fig. 10, × 10: Fig. 1, Station BG 12, figs.4-6, Station B 128, figs, 10,11, Station 120; fig. 12, Station BG1; Luzon; fig. 2, Station MD 115, fig. 3, Station TR 2-005, and figs 13-15, Station H106; Mindoro; figs. 7-8, Station PP 61, Palawan; fig. 9, Station 21760, South Cebu (Alcantala 1980, fig. 2).

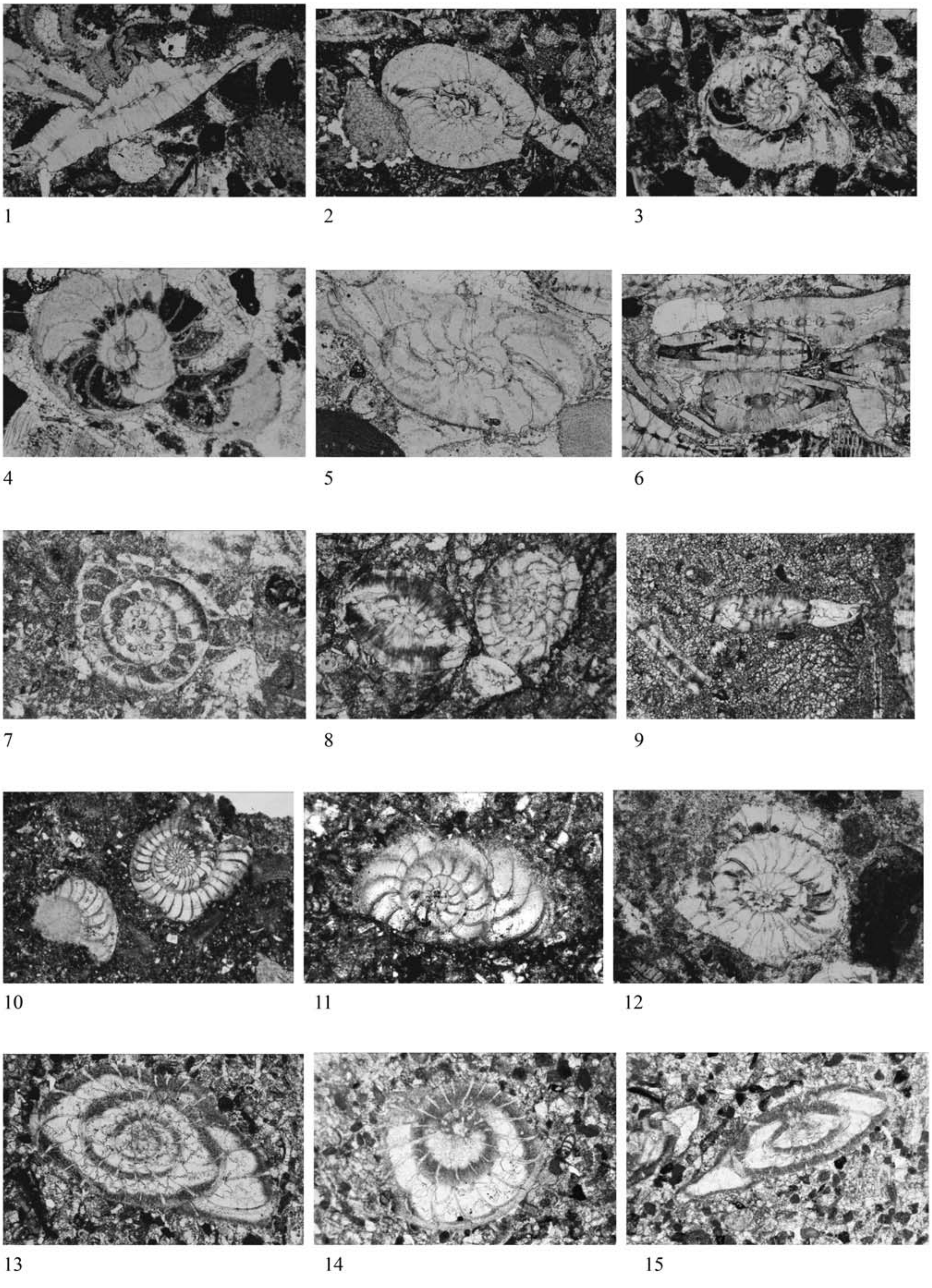
1 *Operculina eniwetokensis* Cole. oblique section.

2-3 *Operculina schwageri* Silvestri. Equatorial sections.

4-6 *Operculina complanata* (Defrance). 4-5, equatorial sections. 4. A1 form (schizont), 5. A2 form (gamont). 6. axial and transverse sections.

7-9 *Operculina ammonoides* (Gronovius). 7, 8 right, equatorial sections: A2 (gamont) and A1 (schizont), resp. 8 left, oblique section, A2 (gamont). 9, axial section.

10-15 *Operculina balcei* Hashimoto and Matsumaru. 10 right, 11,12, equatorial sections. 10 left, tangential section. 13-15, oblique sections.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Genus *Spiroclypeus* Douvillé 1905

Spiroclypeus granulosus Boussac 1906
Plate 25, figures 7-9; plate 30, figure 8 lower

Spiroclypeus granulosus BOUSSAC 1906, p. 96-97, pl. 2, figs. 15-18, pl. 3, fig. 19. – BIEDA 1963, pl. 17, figs. 9-11. – HOTTINGER 1977, p. 114, figs. 48H-H. – MATSUMARU 1996, p. 102, 104, pl. 31, figs. 1-5.
Spiroclypeus vermicularis TAN 1937, p. 187-190, pl. 1, figs. 7-8, pl. 2, figs. 6-10, pl. 3, figs. 13-23, pl. 4, figs. 11-18. – COLE and BRIDGE 1953, p. 18, pl. 14, fig. 7. – COLE 1957b, p. 764, pl. 238, figs. 1-6, 8-12. – HANZAWA 1957, p. 47-48, pl. 4, figs. 2-7, pl. 5, fig. 15.

Description: Test large, lenticular, with a long flange and evolute spire. Spherical to subspherical protoconch and reniform deuteroconch are followed by one or two operculinoid chambers, then numerous crescentic chambers with alar prologations. Septa are strongly curved and divided by numerous secondary septula into chamberlets. Lateral chamberlets are formed by backward folding of the proximal lateral wall. Spiral wall is thick, calcareous, lamellar and finely perforated. Pillars are present throughout the test. A marginal cord and stolons are present.

Dimensions: In megalospheric form, diameter of test = 1.68 to 4.89 mm, thickness = 0.68 to 1.00 mm, diameter/thickness ratio = 2.5 to 1.0; in 7 specimens, diameter of protoconch = 118 × 113 to 318 × 215 µm; deuteroconch = 136 × 34 to 318 × 80 µm; chamber number and apical distance in first half whorl, 5 to 6 and 204 to 454 µm; first whorl, 11 to 14 and 545 to 1159 µm; 1½ whorl, 21 to 27 and 897 to 1909 µm; 2^{nd} whorl, 37 to 42 and 1477 to 3113 µm; 2½ whorl, 56 and 2840 µm; number of chambers in a tier in axial section =6 to 8; thickness of roofs and floors = 22 to 68 µm; pillar diameter = 68 to 136 µm. Microspheric form, diameter of test = 2.91 to 8.64 mm, thickness = 1.31 mm, diameter/thickness ratio = 6.6.

Remarks: Also known from the upper Eocene of Haha-Jima, Ogasawara (Matsumaru 1996).

Upper Eocene, Tertiary b.

Spiroclypeus margaritatus (Schlumberger 1902)
Plate 25, figures 10, 11 right and lower, 12 left, 13-15; plate 26, figures 1-3

Heterostegina margaritatus SCHLUMBERGER 1902, p. 252-253, pl. 7, fig. 4.
Spiroclypeus orbitoideus DOUVILLÉ 1905, p. 460-462, pl. 14, figs. 1-6. – TAN SIN HOK 1937, p. 183-184, pl. 1, figs. 2-4; pl. 2, figs. 1-13; pl. 3, figs. 1-7 (non figs. 8, 24); pl. 4, fig. 1. – COLE 1957, p. 332-333; pl. 95, figs. 6-12. – MATSUMARU 1976, p. 200, pl. 1, figs. 8, 10. – HASHIMOTO, MATSUMARU and SUGAYA 1981, p. 59, pl. 13, fig. 8.
Spiroclypeus leupoldi VAN DER VLERK 1925, p. 14-15, pl. 2, fig. 16; pl. 5, figs. 41, 48. – YABE and HANZAWA 1929, p. 188, pl. 24, fig. 9. – Cole 1954, p. 577-578, pl. 208, figs. 1-19. – HANZAWA 1957, p. 45-46, pl. 5, figs. 7-13. – MATSUMARU 1974, p. 108, pl. 15, figs. 2-4, 10, 13-15, 21-23, 28. – MATSUMARU 1976, p. 199-200, pl. 1, figs. 4-7, 14-15, 21, 23-24. – HASHIMOTO, MATSUMARU and ALCANTALA 1982, p. 34-36, pl. 10, figs. 18-20, pl. 11, figs. 1-7, 9.
Spiroclypeus wolfgangi VAN DER VLERK 1925, p. 15-16, pl. 2, fig. 15; pl. 5, figs. 39, 49. – TAN SIN HOK 1937, p. 183, pl. 1, fig. 1.
Spiroclypeus yabei VAN DER VLERK 1925, p. 16, fig. 19; pl. 5, figs. 40, 50. – TAN SIN HOK 1937, p. 183, pl. 1, figs. 5-6; pl. 3, figs. 10-11; pl. 4, figs. 8-10 (Text-fig. 1. – COLE 1954, p. 580-581, pl. 207, figs. 1-14; pl. 208, figs. 20-26. – COLE 1957, p. 764, pl. 239, figs. 9-10.
Spiroclypeus tidoenganensis VAN DER VLERK 1925, p. 16-17, pl. 1, fig. 12; pl. 5, figs. 42, 47. – TAN SIN HOK 1937, p. 183, pl. 1, fig. 10; pl. 2, figs. 4-5; pl. 3, fig. 12; pl. 4, figs. 2-5, 19-21. – HANZAWA 1957, p. 46-47, pl. 3, figs. 1-6; pl. 4, figs. 8-10. – COLE 1957, p. 332, pl. 95, figs. 13-15. – MATSUMARU 1976, p. 200, pl. 1, figs. 3, 9, 12, 18-20, 22; pl. 6, fig. 15. – HASHIMOTO and MATSUMARU 1978, p. 85-86, pl. 11, fig. 2. –HASHIMOTO, MATSUMARU and SUGAYA 1981, p. 60-61, pl. 13, figs. 9, 12.
Spiroclypeus margaritatus (Schlumberger). – YABE and HANZAWA 1925, p. 627-630, pl. 2, fig. 10; pl. 3, figs. 8-9; pl. 4, figs. 3-8 (Text-figs. 1-4. – YABE and HANZAWA 1929, p. 187, pl. 23, figs. 1, 3-4; pl. 24, figs. 1-5. – KRIJNEN 1931, p. 89, pl. 1, figs. 1-3. – TAN SIN HOK 1937, p. 187-193, pl. 2, fig. 12; pl. 3, fig. 9; pl. 4, figs. 6-7. – HANZAWA 1940, p. 789-790, pl. 42, figs. 3-9. – COLE 1954, p. 578-580, pl. 206, figs. 10-25; pl. 207, figs. 15-16. – MATSUMARU 1974, p. 108, pl. 15, figs. 16, 24, 26. – HASHIMOTO and MATSUMARU 1975, p. 122, pl. 13, figs. 11-12. – HASHIMOTO, MATSUMARU and SUGAYA 1981, p. 59-60, pl. 13, fig. 3. –

PLATE 23

All × 20 except figs. 9, 13 × 10: Figs 1, 2, 4, 5, from Station TB 45, Tablas;
fig. 3, Station PRS 7 and figs. 7, 8, Station 120; mid Luzon;
fig. 6, Station HR 206; figs. 10, 11, Station TR 2-005; fig. 12, Station MD 83; and fig. 13, Station 11477; Mindoro;
fig. 9, Station Abuta 47, Abuta Limestone, Japan (Matsumaru 1967, fig. 4); figs. 14, 15, Station B 128, NE Luzon.

1-6 *Operculina venosa* (Fichtel and Moll). 1, tangential section. 2, 4, 5, oblique sections. 3, equatorial section. 6, axial section.

7-9 *Operculina heterosteginoides* (Defrance). 7, tangential section. 8-9, equatorial sections.

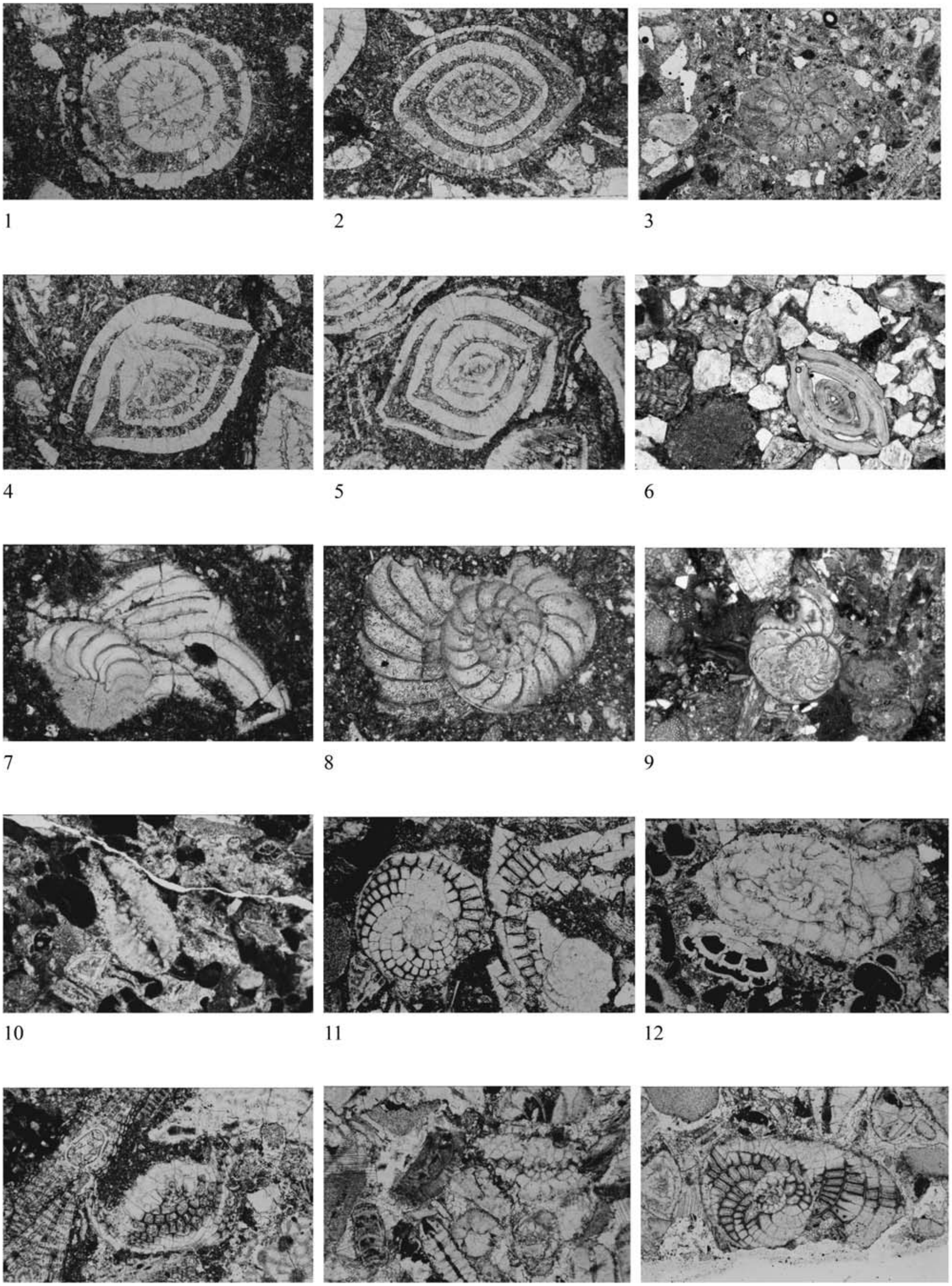
10, 11 *Heterostegina aequatoria* Cole. 10, oblique section. 11 left, equatorial section. 11 right, tangential section.

12, 13 *Heterostegina saipanensis* Cole. 12 upper, equatorial section of broken specimen, ×20. 13 right, oblique section, 13. Reworked specimens.

12 *Mindoroella mindoroensis*, n. gen., n. sp. 12 lower, oblique section.

13 *Lepidocyclina isolepidinoides* van der Vlerk. 13 left, axial sectons.

14,15 *Heterostegina duplicamera* Cole. Equatorial sections (14, broken).


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

HASHIMOTO, MATSUMARU and ALCANTALA 1982, p. 34-36, pl. 11, fig. 8. – MATSUMARU, MYINT and OGAWA 1993, p. 10-11, figs. 2-1-9, 3-1. – MATSUMARU 1996, p. 104-108, pl. 32, figs. 1-8; pl. 33, figs. 1-9.

Spiroclypeus margaritatus (Schlumberger) var. *umbonata* YABE and HANZAWA 1929, p. 187-188, pl. 124, figs. 5-8.

Spiroclypeus higginsi COLE 1939, p. 185, pl. 23, figs. 10-15; pl. 24, fig. 13. – HANZAWA 1957, p. 45, pl. 5, figs. 1-6, 14. – COLE 1957, p. 333, pl. 95, figs. 1-5; pl. 109, fig. 16. – COLE 1957, p. 763-764, pl. 239, figs. 11-12, 14. – MATSUMARU 1974, p. 108, pl. 15, figs. 1, 5, 8, 18-19. – MATSUMARU 1976, p. 109, pl. 1, fig. 2, 11, 16-17.

Description: Test large, thin to thick lenticular, with eccentric umbonal area surrounded by a sloping flange, smooth with small pillars in the central portion and occasional large umbonal pillars. Spherical to subspherical protoconch and reniform deuteroconch are followed by one or two operculine chamber(s) succeeded by numerous chambers divided by secondary septula into rectangular heterostegine chamberlets. Lateral chambers are low, slitlike cavities between very thick roofs and floors, with others as overlapping, deep rectangular cavities between thin roofs and floors, in regular tiers between pillars. The wall is calcareous and lamellar.

Dimensions: Diameter of test = 2.32 to 6.54 mm, thickness = 1.14 to 1.98 mm, diameter/thickness ratio = 1.60 to 4.84; in 10 specimens, diameter of protoconch = 146 × 123 to 400 × 320 µm, deuteroconch diameter = 181 × 71 to 396 × 192 µm, deuteroconch/protoconch diameter ratio = 0.65 to 1.24, distance across protoconch and deuteroconch = 218 to 525 µm. Chamber number and apical distance in first half whorl, 5 and 187 to 544 µm; first whorl, 9 10 11 and 749 to 1900 µm; 1½ whorl, 15 to 20 and 957 to 2360 µm; 2nd whorl, 27 to 34 and 2018 to 3160 µm; length × height of lateral chambers = 150 × 10 to 209 × 64 µm; thickness of roofs and floors of lateral chambers = 18 to 136 µm; pillar diameter = 80 to 182 µm.

Remarks: Some of the wide morphological variations resemble other species of the genus (Matsumaru 1996), but the embryonic chambers (see illustrations) are characteristic. Specimens from sample MA11, Bondoc Peninsula (tab. 9) are regarded as reworked.

Lower Oligocene (Rupelian), Tertiary d to early Miocene (Aquitanian), Tertiary e5 lower.

Genus *Heterostegina* d'Orbigny 1826
NOTE: The number of operculine (or operculinoid) chambers, number of whorls, and the size of embryonic chambers are the preferred criteria for classifying species of this genus (Cole 1957; Hanzawa 1957; Matsumaru 1996). Some original desriptions of *Heterostegina* from the west Pacific region, however, are based on very small images that are difficult to interpret (Vlerk 1929; Whipple 1932).

Heterostegina saipanensis Cole 1957
Plate 23, figures 12-13

Heterostegina reticulata Rutimeyer. – VAN DER VLERK 1929, p. 16, figs. 7, 26.

Heterostegina sp. indet. – WHIPPLE 1932, p. 83, pl. 20, fig. 9.

Heterostegina saipanensis COLE 1953, p. 23-24, pl. 2, figs. 4, 6. – COLE 1957, p. 331, pl. 102, figs. 17-19. – COLE 1957, p. 760-762, pl. 234, figs. 13-24; pl. 235, figs. 1-13.

Description: Test lenticular with distal peripheral flange, and smooth except for granulations in the central boss. The spire is planispiral and evolute. Spherical to subspherical protoconch and reniform deuteroconch are followed by undivided operculine chambers and then many crescentic chambers connected by foramina or stolons, and with centrally aligned alar prolongations. Strongly curved septa are divided into chamberlets. Lateral wall is thick, calcareous and finely perforate. There is a marginal cord with marginal canals connected to intraseptal canals.

Dimensions: Diameter of test = 1.48 to 2.68 mm, thickness = 0.6 to 1.0 mm, diameter/thickness ratio = 2.47 to 2.68; diameter of protoconch = 90 × 50, 104 × 90, 104 × 104, and 112 × 102 µm in 4 specimens, deuteroconch = 118 × 56, 116 × 23, 139 × 34 and 114 × 28 µm. There are 3 to 5 operculine chambers, and

---

PLATE 24

All ×20 except 12, ×50. Figs. 1, 2, Station C7, C3, Cebu; fig. 3, Hashimoto and Matsumaru, 1981, text-fig.1; fig. 4, Station BHK4, Luzon; figs. 5, 6, Station 11468; fig. 7, Station 11477; Mindoro; fig. 10, Station 7683001, Negros; fig. 11, Station MQ10, Marinduque; figs. 12, 13, Station F31, Luzon; figs. 14, 15, Matsumaru 1971, p. 102, fig. 2 and p. 108, 109, fig. 2.

1-3 *Heterostegina borneensis* van der Vlerk. 1,tangential section. 2, 3, equatorial sections.

4 *Heterostegina suborbicularis* d'Orbigny. oblique section.

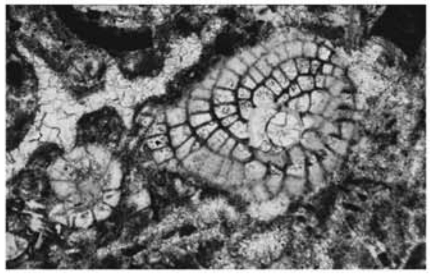
5-7 *Cycloclypeus koolhoveni* Tan. oblique sections (6, reworked).

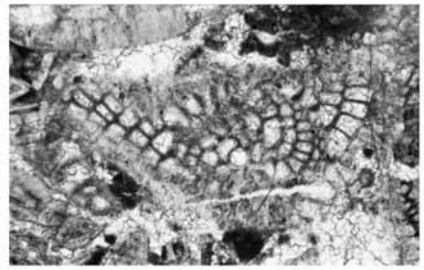
8,9 *Cycloclypeus oppenoorthi* Tan. oblique sections.

10-12 *Cycloclypeus eidae* Tan. 10, equatorial section of broken specimen. 11, 12, oblique sections. 12, ×50.

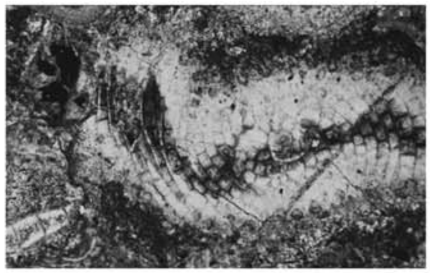
13-15 *Cycloclypeus posteidae* Tan. 13, oblique section. 14, 15. Equatorial sections.


1

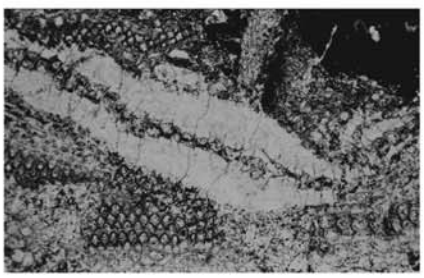

2

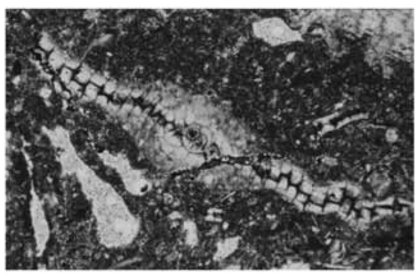

3


4

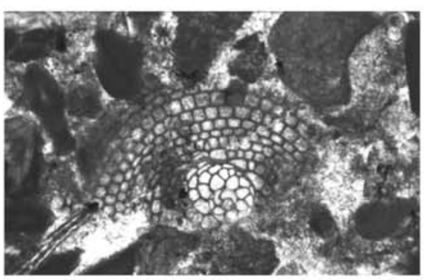

5

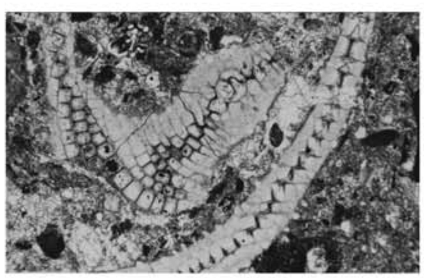

6

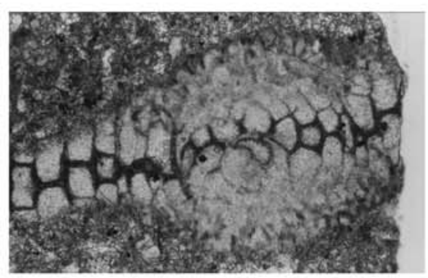

7


8

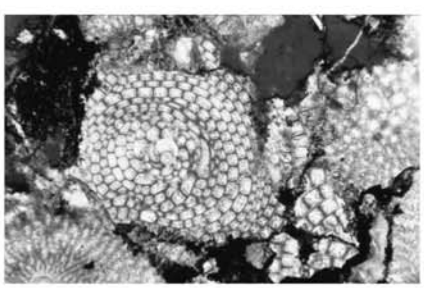

9

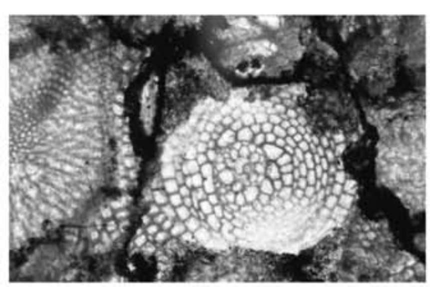

10


11


12


13


14


15

chamber number and apical distance in first half whorl, 4 to 5 and 142 to 250 µm; first whorl, 8 to 11 and 408 to 690 µm; 1½ whorl, 17 to 20 and 857 to 1011 µm; 2nd whorl, 27 to 35 and 1340 to 2000 µm; 2½ whorl, 58 and 2680 µm. Pillar diameter = 90 to 112 µm.

Remarks: Also from the upper Eocene, Tertiary b, of Saipan and Eniwetok (Cole 1957).

Upper Eocene to lower Oligocene, Tertiary b to Tertiary c.

Heterostegina aequatoria Cole 1957
Plate 23, figures 10-11

Heterostegina aequatoria COLE 1957, p. 756-757, pl. 234, figs. 1-12.

Description: Test lenticular with central boss bordered by a flat rim, smooth except for granulation on septal filaments. The planispiral spire becomes loosely evolute after the second whorl. Subspherical protoconch and reniform deuteroconch are followed by many chambers. The septa are distally curved. The lateral wall is thick, calcareous, lamellar and finely perforate.

Dimensions: Diameter of test = 1.48 to 2.68 mm, thickness = 0.5 to 0.9 mm, diameter/thickness ratio = 2.88 to 2.96; diameter of protoconch = 56 × 58 and 88 × 90 µm, deuteroconch = 50 × 24 and 72 × 45 µm. There are 15 operculine chambers; apical distance in first half whorl = 159 to 180 µm, first whorl = 409 to 468 µm, 1½ whorl = 554 to 681 µm, 2nd whorl = 886 to 1022 µm, 2½ whorl = 1250 to 1272 µm, 3rd whorl = 1522 to 1750 µm, 3½ whorl = 2568 µm and 4th whorl = 2773 µm; diameter of pillars = 52 to 100 µm.

Remarks: Heterostegina aequatoria is named from the Tertiary b limestone of Eniwetok Atoll.

Upper Eocene, Tertiary b

Heterostegina duplicamera Cole 1957
Plate 23, figures 14-15; plate 26, figure 5 left

Heterostegina duplicamera COLE 1957, p. 759-760, pl. 236, figs. 1-23. – MATSUMARU 1996, p. 98, 100, pl. 29, figs. 1-7.

Description: Test is thin to thick lenticular with a central boss, bordered by a thin peripheral flange. There are large pustules on the central boss and pillars on the septal filaments. Coiling is planispiral and evolute. Spherical to subspherical protoconch and reniform deuteroconch are followed by undivided operculine chambers, with later chambers numerous and strongly subdivided into chamberlets. Alar prolongation are oriented on the central boss. The thick wall is calcareous, lamellar and finely perforated, and a marginal cord is present.

Dimensions: Diameter of test = 1.68 to 3.44 mm, thickness = 0.43 to 1.20 mm, diameter/thickness ratio = 2.25 to 3.91; in 7 specimens, diameter of protoconch = 52 × 46 to 102 × 120 µm, deuteroconch = 72 × 48 to 110 × 54 µm. There are usually 4 but as many as 10 operculine chambers; chamber number and apical distance in first half whorl, 5 to 6 and 112 to 163 µm; 1½ whorl , 14 to 16, 432 to 875 µm; 2nd whorl, 19 to 23 and 640 to 1477 µm; 2½ whorl, 26 to 35 and 1272 to 2227 µm. Pillar diameter = 90 to 113 µm.

Remarks: Differs from *Heterostegina bantamensis* Tan Sin Hok 1932 and *Heterostegina* sp. cf. *depressa* d'Orbigny 1826, in the greater if varied number of operculine chambers and in regard to umbonal pillars. It also occurs in the Oligocene of the Ogasawara Islands (Matsumaru 1996).

Lower to upper Oligocene, Tertiary c to Tertiary e3.

Heterostegina borneensis Van der Vlerk 1929
Plate 24, figures 1-3

Heterostegina borneensis VAN DER VLERK 1929, p. 16, figs. 6a-c, 25a-b. – COLE and BRIDGE 1953, p. 23, pl. 2, figs. 1-3, 5, pl. 4, figs. 16-18. – HANZAWA 1957, p. 44-45, pl. 2, figs. 12-17; pl. 6, fig. 12. – MATSUMARU 1976, p. 199, pl. 3, figs. 17-19, 21-22. – MATSUMARU 1996, p. 94, 96, pl. 28, figs. 1-7.
Heterostegina praecursor TAN SIN HOK 1932, p. 133-135, pl. 1, figs. 1-3, 10; pl. 2, fig. 3; pl. 4, fig. 3.

PLATE 25

Figs. 1, 2, Station MQ 28, Marinduque Island; figs. 3, 4, Station PP 61, Palawan; fig. 5, Station C30, Cebu; fig. 6, Station 63636, North Luzon; figs 7, 9, Station MD 117, fig. 8, Station MD 70, and figs. 10, 11, Station TR 2-039; Mindoro; fig. 12, Station H106, Mindanao; figs. 13-15, Station A 3, Luzon.

1,2 *Katacycloclypeus transiens* Tan. 1, equatorial section. 2 right, oblique section. 2 left, axial section; both ×10.

3,4 *Cycloclypeus indopacificus* Tan. 3, tangential section. 4, axial section, ×10.

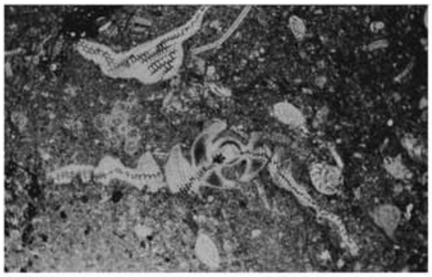
5,6 *Cycloclypeus carpenteri* Brady. 5, equatorial section of broken specimen, × 5. 6 right and left, oblique and transverse sections, ×10.

7-9 *Spiroclypeus granulosus* Boussac. 7, 8, equatorial sections. 9, axial section. 7, 9, ×20; 8, ×15.

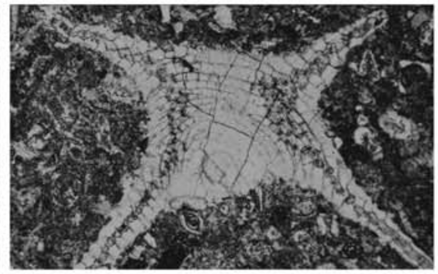
10-15 *Spiroclypeus margaritatus* (Schlumberger). 10, oblique section. 11, axial section. 12, 13, axial and transverse sections. 14, 15, equatorial sections. 10-13, 15, ×10; 14, ×20.

11 *Lepidocyclina isolepidinoides* van der Vlerk. 11 left, axial section, ×10.

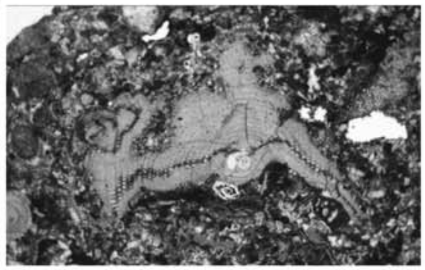
12 *Operculina balcei* Hashimoto and Matsumaru. 12 right, transverse section, ×10.


1

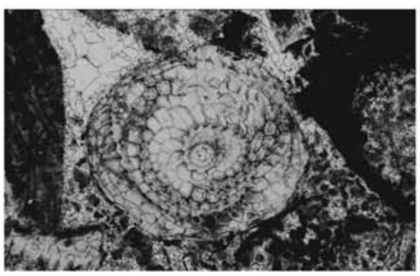

2

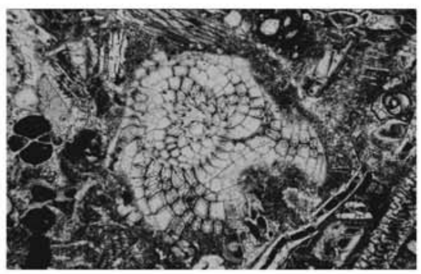

3

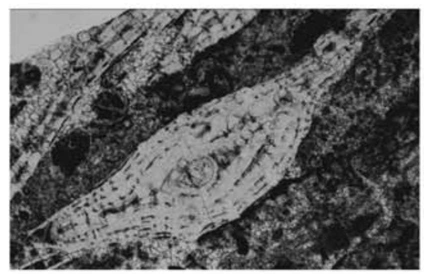

4


5

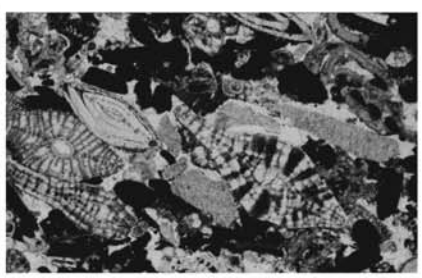

6

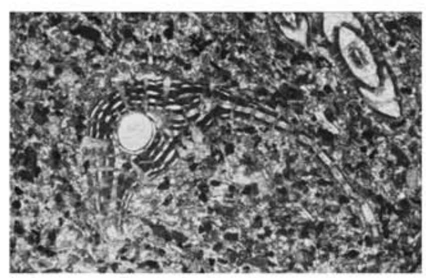

7

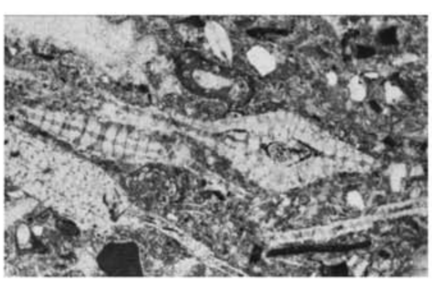

8

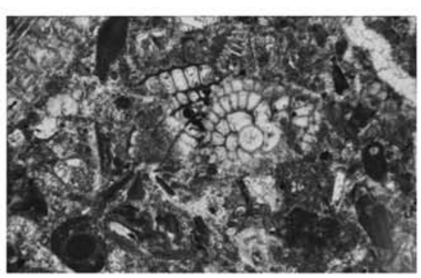

9

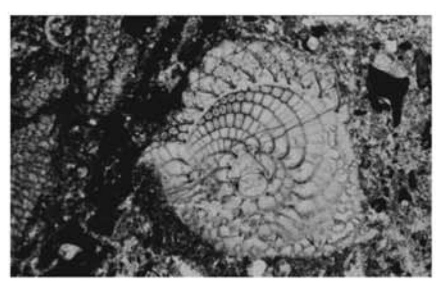

10


11


12


13


14


15

Heterostegina nigripustula COLE 1954, p. 575-576, pl. 209, figs. 1-8.
Heterostegina pusillambonata COLE 1954, p. 576, pl. 206, figs. 3-9.

Description: Test lenticular, inflated with a wide flange to thin and flat, ornamented by large pustules especially on the umbo. The planispiral coils are evolute. Spherical to subspherical protoconch and reniform deuteroconch are followed by one operculine chamber, then numerous chambers with thick lateral walls subdivided into many chamberlets. Open spaces between lateral walls resemble lateral chambers. Test wall is calcareous, lamellar and finely perforate. A marginal cord is present.

Dimensions: Diameter of test = 2.05 to 3.18 mm, thickness =0.70 to 1.16 mm, diameter/thickness ratio = 2.5 to 4.5; in 6 specimens, diameter of protoconch = 120 × 120 to 240 × 228 µm, deuteroconch = 152 × 66 to 296 × 104 µm; one operculine chamber. Chamber number and apical distance in first half whorl, 5 and 160 to 371 µm; first whorl, 9 to 10 and 582 to 1332 µm; 1½ whorl, 15 to 18 and 1061 to 1528 µm; 2nd whorl, 23 to 25 and l1550 to 1893 µm; 2½ whorl, 37 and 2020 µm. Pillar diameter = 72 to 140 µm.

Remarks: The type is from the middle Oligocene *Globigerina* Marls of NE Borneo (Van der Vlerk 1929).

Lower to upper middle Oligocene, Tertiary c to Tertiary e3.

Heterostegina suborbicularis d'Orbigny 1826
Plate 24, figure 4

Heterostegina suborbicularis D'ORBIGNY 1826, p. 305. – FORNASINI 1903, p. 395-398, pl. 14, fig. 6. – CUSHMAN 1921, p. 385. – HOFKER 1927, p. 70-71, pl. 35, figs. 1-9; pl. 36, figs. 3, 6-12. – CUSHMAN 1933, p. 58-60, pl. 17, figs. 6a, b. – COLE 1954, p. 576; pl. 205, figs. 5-8. – HOFKER 1971, p. 76-77, pl. 107, fig. 6. – MATSUMARU 1976, p. 406, pl. 1, figs. 14-16, 18-22, 24-25, 28-30.

Description: Test is biconvex, compressed or thick lenticular with broadly flaring periphery. Septal sutures are straight and raised near the central boss, recurved peripherally. Subspherical protoconch and reniform deuteroconch are followed by tightly coiled operculine cambers, then regular chambers in evolute coils, subdivided into numerous chamberlets. Alar prolongation of chambers and marginal cord are present. The wall is calcareous and lamellar, with minute pillars.

Dimensions: Diameter of test = 1.52 to 2.45 mm, thickness = 0.52 to 0.83 mm, diameter/thickness ratio = 2.61 to 2.92; diameter of protoconch = 75 × 72, 88 × 58, 122 × 113, 131 × 68, and 133 × 100 µm in 5 specimens, deuteroconch = 81 × 38, 113 × 43, 140 × 63, 100 × 38 and 133 × 76 µm, ratio of deuteroconch/ protoconch diameter = 1.08, 1.28, 1.15, 0.76 and 1.00; number of operculine chambers = 14, 9, 10, 13 and 12. Chamber number and apical distance in first half whorl, 4 to 6 and 136 to 213 µm; first whorl, 9 to 11 and 295 to 477 µm; 1½ whorl, 16 to 17 and 454 to 800 µm; 2nd whorl, 21 to 24 and 690 to 1166 µm; 2½ whorl, 30 to 33 and 1090 to 1909 µm; 3rd whorl, 38 to 44 and 1545 to 2283 µm; 3½ whorl, 48 to 49 and 1795 to 2800 µm.

Remarks: The type as defined by d'Orbigny is from Hawaii (Cushman 1921).

Upper Miocene to Recent, Tertiary f3 to Tertiary h.

Genus *Cycloclypeus* Carpenter 1856
NOTE: Tan Sin Hok (1932) divided *Cycloclypeus* into three subgenera, distinguishing *Katacycloclypeus* and *Radiocycloclypeus* from the nominate subgenus based on a statistical analysis of nepionic reduction. Later authors found this impractical (Caudri 1932; Hanzawa 1935; Cole 1945; 1963) and emended the diagnoses to be based on embryonic chambers. Loeblich and Tappan (1987) suppressed the subgenus *Katacycloclypeus,* but elevated *Radiocycloclypeus* to genus rank. In fact, it is difficult to find the cited distinctions between *Katacycloclypeus* and *Radiocycloclypeus* in the well preserved materials from the Philippines, and in elevating the taxon to genus rank *Katacycloclypeus* is regarded as the senior form.

Cycloclypeus sp.
Plate 20, figure 4 left

PLATE 26

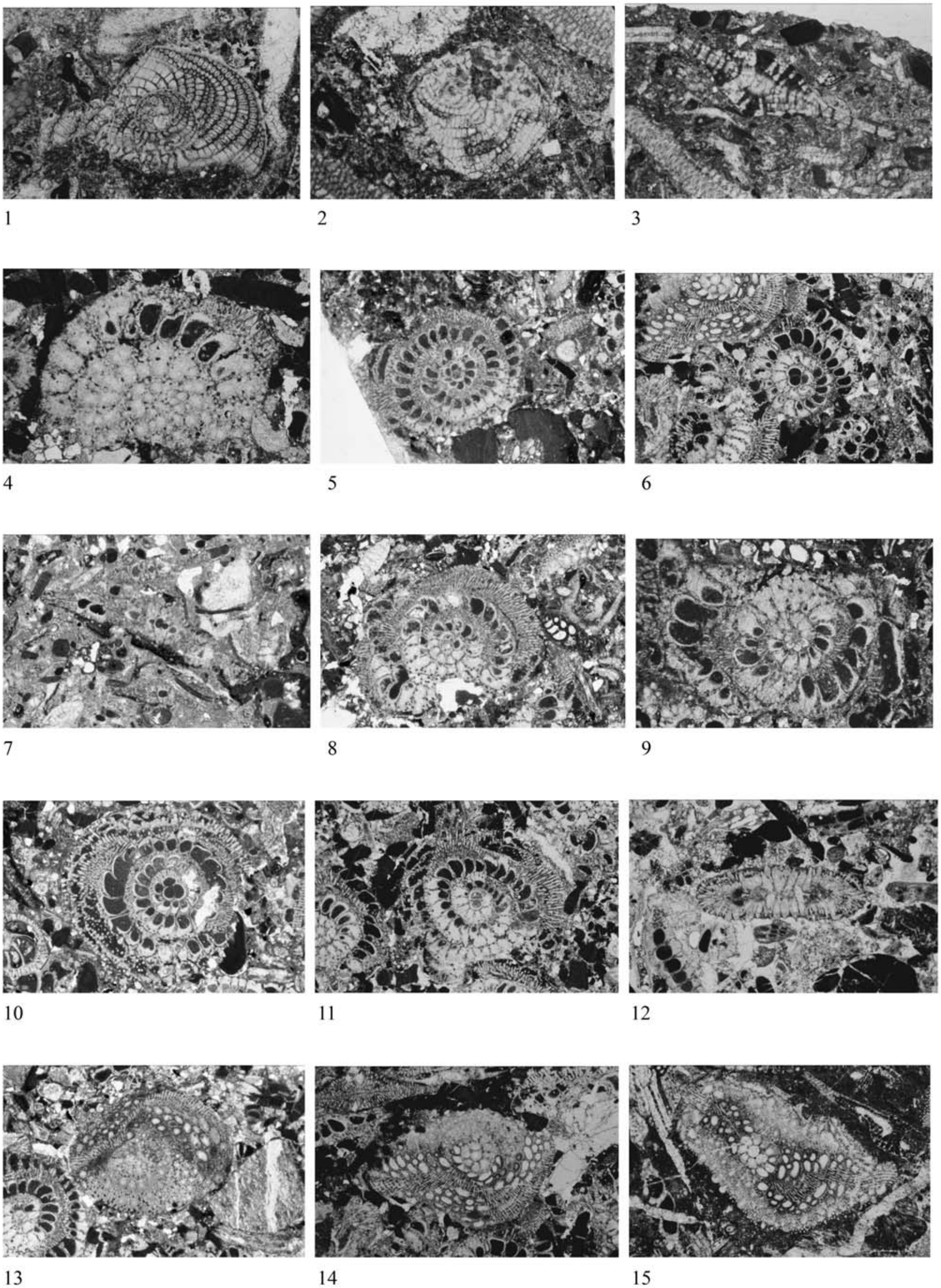
All × 10 except fig. 4, ×20. Figs. 1-3, Station A 3, NE Luzon; Figs. 4-6, 8-11, 13, 14, Station MD 83; fig. 12, Station MD 101; and fig. 15, Station MD 70; Mindoro; fig. 7, Station CT 18, Catanduanes.

1-3 *Spiroclypeus margaritatus* (Schlumberger). 1, equatorial section. 2, tangential section. 3, axial section.

4-7, 13 *Pellatispira madaraszi* (Hantken). 4, tangential section. 5, 6 center, equatorial sections. 7, axial section. 13 left, tangential section.

6, 13-15 *Biplanispira mirabilis* (Umbgrove) 6 upper, equatorial section. 13 right, 14, 15, oblique sections.

8-12 *Pellatispira provalei* Yabe. 8, 10, 11, equatorial sections. 9, tangential section. 12, axial section.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Description: Test large and lenticular, smooth except for granules on septal filaments and on the umbo.. Nepionic (= heterosteginoid) chambers make a planispiral evolute coil, enveloped by annular rings of neanic (= cycloclypenoid) chambers, subdivided into numerous chamberlets. These chamberlets gradually enlarge towards the periphery, with greater radial length than tangential length. Chamber walls have canals, and are calcareous and finely perforate.

Dimensions: Diameter of test = up to 6.6 mm; diameter of nepionic chambers = 2.6 mm; tangential × radial diameters of nepionic chamberlets = 68 × 90 to 90 × 136 µm, cycloclypenoid chamberlets = 90 × 112 to 80 × 204 µm; diameter of granules = 50 to 70 µm.

Remarks: Without examples of the embryonic and nepionic chambers, it is impossible to fully identify this form, but the existence of annular (= cycloclypenoid) chambers places it in the genus *Cycloclypeus*, extending its range into the upper Eocene of the western Pacific for the first time.

Upper Eocene, Tertiary b.

Cycloclypeus koolhoveni Tan Sin Hok 1932
Plate 24, figures 5-7

Cycloclypeus koolhoveni TAN SIN HOK 1932, p. 41-43, pl. 4, figs. 1, 5-6; pl. 5, figs. 3, 7; pl. 6, figs. 1, 3; pl. 7, figs. 1-2; pl. 8, figs. 1-2.
Cycloclypeus eidae Tan. – MATSUMARU 1996, p. 108, 110, pl. 34, figs. 4-5 (non 1-3, 6).

Description: Test lenticular, large and thin, smooth except for pillars on the central boss and spiral septal filaments. Spherical to subspherical protoconch and reniform deuteroconch are followed by four operculine, or ana-nepionic (Tan 1932), chambers, and then numerous other nepionic or heterosteginoid chambers subdivided into chamberlets, enveloped by annular rings of cycloclypenoid chamberlets. The lateral wall is calcareous and thick lamellar on either side of the equatorial layer. Pillars are present.

Dimensions: Diameter of test = 3.50 to 5.10 mm, thickness = 0.30 to 0.42 mm, diameter/thickness ratio = 9.0 to 12.7; diameter of protoconch = 68 × 68 and 80 × 66 µm in 2 specimens, deuteroconch = 80 × 50 and 90 × 45 µm; There are 4 operculine chambers. Chamber number and apical distance in first half whorl, 3 and 340 µm; first whorl = 8 and 680 µm; 1½ whorl, 15 and 909 µm; 2nd whorl, 28(?) and 1590 µm; number of nepionic chambers = over 30; diameter of pillars = 90 to 100 µm.

Remarks: Differs from *C. oppenoorthi* Tan 1932, by having a smaller embryo and larger number of nepionic chambers. Both species were earlier confused with *C. eidae* in the Ogasawara Islands (Matsumaru 1996) p. 108, 109), despite other distinct differences, because their pillars could not be distinguished as Tan Sin Hok (1932, p. 40) indicated.

Lower Oligocene, Tertiary c to Tertiary d.

Cycloclypeus oppenoorthi Tan Sin Hok 1932
Plate 24, figures 8-9

Cycloclypeus oppenoorthi TAN SIN HOK 1932, p. 43-49, pl. 5, figs. 1-2; pl. 6, fig. 2; pl. 8, figs. 3-4; pl. 9, figs. 1-2; pl. 10, figs. 1-4; pl. 11, figs. 1, 3-4; pl. 12, figs. 4-5.
Cyclolcypeus eidae Tan. – MATSUMARU 1996, p. 108, 110, pl. 34, figs. 1-3, 6 (non 4-5).

Description: Test lenticular, large and thin, smooth with central pillars and exposed septal filaments. Spherical to subspherical protoconch and reniform deuteroconch are followed by one (rarely two) operculine or ana-nepionic (Tan Sin Hok 1932) chamber(s) and whorls of heterosteginoid nepionic chambers that are subdivided into numerous chamberlets. These are enclosed by annular rings of subdivided cycloclypenoid chambers. The lateral wall is calcareous and thick lamellar on either side of equatorial layer. Pillars are present.

Dimensions: Diameter of test = 3.18 to 4.00 mm, diameter of nepionic chambers = 2.36 to 3.10 mm, thickness = 0.3 to 0.5 mm, form ratio of diameter/thickness = 8.0 to 10.3; diameter of protoconch = 80 × 76, 80 × 77, and 125 × 116 µm in 3 speci-

---

PLATE 27

Fig. 1, Station CT 20, and figs. 2-5, Station CT 19, Catanduanes; figs. 6, 11, 13-15, Station BG 8, North Luzon; figs. 7, 8, Station MD 111, fig. 9, Station WR 41, fig. 10, Station MD 117, and fig. 12, Station MD 83; Mindoro.

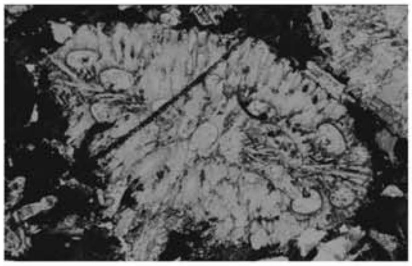
1 *Biplanispira mirabilis* (Umbgrove). axial section, ×20.

2-5 *Pellatispira orbitoidea* (Provale). 2, tangential section. 3, 4, oblique sections. 5, axial sections. 2, ×20; 3-5, ×10.

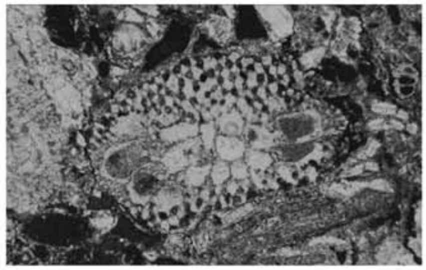
6-9 *Pellatispira crassicolumnata* Umbgrove. 6, 9, axial sections. 7, oblique section. 8, tangential section. 6, ×10. 7-9, ×20.

10-12 *Biplanispira absurda* Umbgrove. 10, axial section. 11, oblique section. 12, tangential section. 10, 12, ×10. 11, ×20.

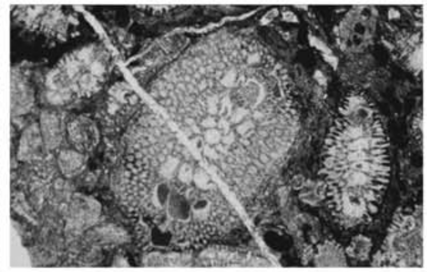
13-15 *Pellatispira inflata* (Umbgrove).13, 14, oblique sections. 15, equatorial section, all ×10.



1



2

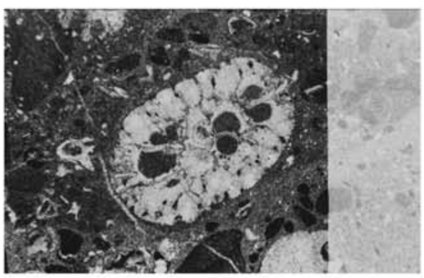


3

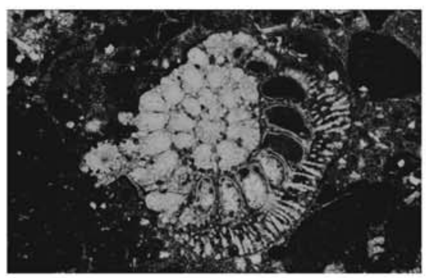
4

5

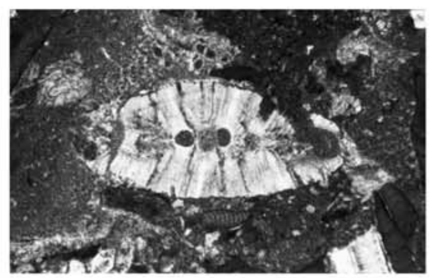
6



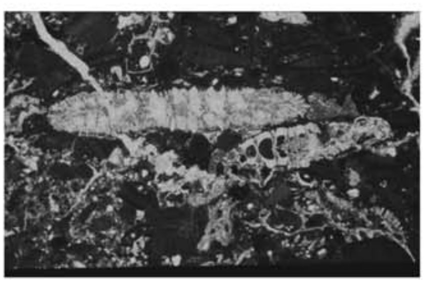
7



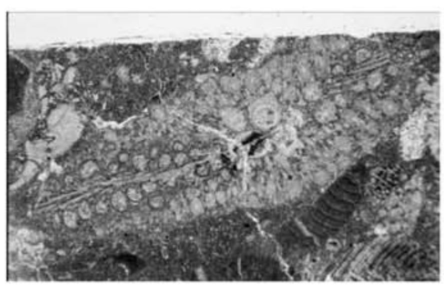
8



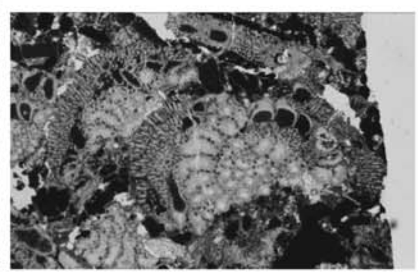
9



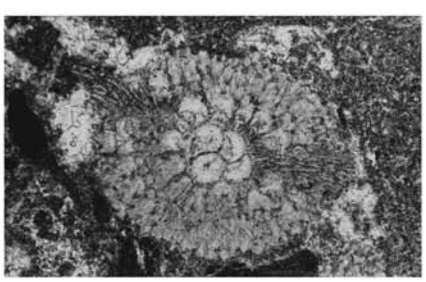
10



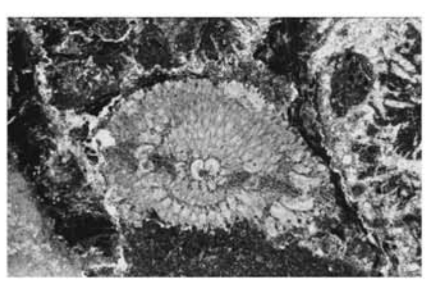
11



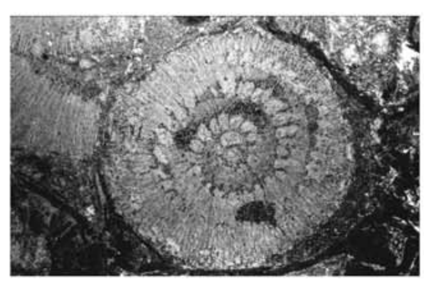
12



13



14



15

mens, deuteroconch = 94 × 60, 102 × 59, and 187 × 104 µm; one operculine chamber. The chamber number and apical distance in the first half whorl is 3 and 500 µm; in first whorl, 7 and 650 µm; in 1½ whorl, 13 and 1000 µm; 2^{nd} whorl, 25(?) and 1250 µm; number of nepionic chambers = over 18; diameter of pillars = 50 to 100 µm.

Remarks: Found with *C. koolhoveni* in assemblages 7 and 8.

Lower Oligocene, Tertiary c to Tertiary d.

Cycloclypeus eidae Tan Sin Hok 1930
Plate 24, figures 10-12

Cycloclypeus eidae TAN SIN HOK 1930, p. 3, 5. – TAN SIN HOK 1932, p. 50-59, pl. 5, fig. 6; pl. 12, figs. 2-3; pl. 13, figs. 1-2, 4-6. – MATSUMARU 1976, p. 200, pl. 5, figs. 13, 16-17.
Cycloclypeus (Cycloclypeus) eidae Tan. – COLE 1945, p. 280, pl. 14 A-D, – COLE and BRIDGE 1953, p. 27, pl. 5, figs. 13-19. – COLE 1957, p. 334, pl. 101, fig. 15.
Cycloclypeus neglectus Martin var. *eidae* Tan. – CAUDRI 1932, p.186-187, figs. 15-16. – HANZAWA 1957, p. 49-50, pl. 6, figs. 1-2.

Description: Test small to moderately large, lenticular, with central pillars and exposed septal filaments. Spherical to subspherical protoconch and reniform deuteroconch are followed by one or two operculine chambers, and then 2 to 2½ whorls of heterosteginoid nepionic chambers subdivided into chamberlets, all enclosed by annular rings of subdivided cycloclypenoid chambers. The lateral wall is calcareous, thick and lamellar on either side of the equatorial layer. Pillars are present.

Dimensions: Diameter of test = 1.70 to 3.86 mm, diameter of nepionic chambers = 0.73 to 1.45 mm, thickness = 0.45 to 0.64 mm, diameter/thickness ratio = 5.18 to 6.67; in 5 specimens, diameter of protoconch = 44 × 39 to 96 × 98 µm, deuteroconch = 44 × 31 to 160 × 68 µm; operculine chambers = 1 to 2; nepionic chambers = 17 to more than 22; pillar diameter = 110 to 180 µm.

Remarks: Most specimens are fragmentary and only a few equatorial sections were found. The number of nepionic chambers distinguishes it from *C. posteidae* Tan (Cole and Bridge; 1957).

Lower Oligocene to lower Miocene, Tertiary d to Tertiary f1.

Cycloclypeus posteidae Tan Sin Hok 1932
Plate 24, figures 13-15

Cycloclypeus posteidae TAN SIN HOK 1932, p. 59-62, pl. 13, fig. 3; pl. 14, figs. 1-6; pl. 15, figs. 1-4; pl. 18, figs. 2, 7; pl. 22, figs. 3-4, 8; – COLE 1957, p. 334-335, pl. 101, figs. 9-11. – MATSUMARU 1971, p. 176-177, pl. 26, figs. 7-8.
Cycloclypeus (*Cycloclypeus*) *posteidae* Tan. – COLE 1963, p. E18-19, pl. 6, figs. 7-12.

Description: Test small to moderately large, lenticular, with central pillars and exposed septal filaments. Subspherical protoconch and reniform deuteroconch are followed by 1 to 2 operculine chambers, then by 2 to 2½ whorls of heterosteginoid nepionic chambers subdivided into chamberlets, all enclosed by annular rings of subdivided cycloclypenoid chambers. The lateral wall is thick, calcareous, and lamellar on either side of equatorial layer. Pillars are present.

Dimensions: Diameter of test = 1.8 to 3.0 mm, diameter of nepionic chambers = 0.7 to 1.0 mm, thickness = 0.4 to 0.5 mm, diameter/thickness ratio = 4.4 to 8.0; diameter of protoconch = 88 × 96, 94 × 87, 125 × 100, and 169 × 134 µm in 4 specimens, deuteroconch = 126 × 78, 120 × 90, 200 × 90, and 294 × 70 µm; 1 to 2 operculine chambers; number of nepionic chambers = 17, 18, 14(?) and 14; diameter of pillars = 100 to 150 µm.

Remarks: Differs from *C. eidae* Tan in having a fewer nepionic chambers and larger embryonic chambers.

Middle Miocene, Tertiary f1 to Tertiary f2.

Cycloclypeus indopacificus Tan Sin Hok 1930
Plate 25, figures 3-4

PLATE 28

Figs. 1-3, Station BG 8, North Luzon (figs. 2, 3, from Hashimoto, 1975, pl. 15, figs. 8, 2, resp.); figs. 4, 6, 7, Station MD 111; figs. 5, 11, 15, Station MD 70; figs. 8-10, 12, Station MD 101, and figs. 13, 14, Station MD 83; Mindoro.

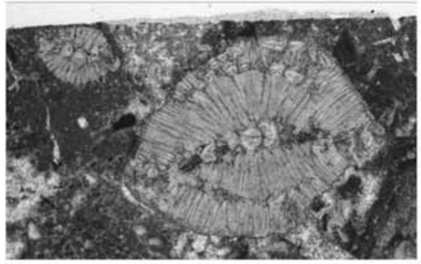
1-3 *Pellatispira inflata* (Umbgrove). 1, 2, oblique sections. 3, tangential section, all ×10.

4-7 *Eopellatispira mindoroensis* Matsumaru, n. gen., n. sp. 4 (holotype), equatorial section of microspheric specimen. 5 (paratype), equatorial section of megalospheric specimen. 6, axial section. 7, oblique section, all ×20.

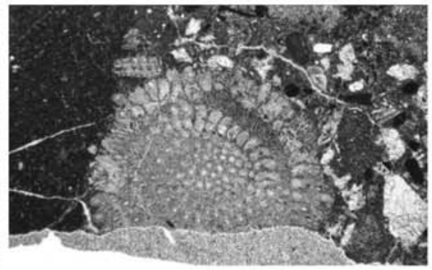
8-12 *Baculogypsinella eocenica* Matsumaru, n. gen., n. sp. 8 (holotype), equatorial section of microspheric specimen. 9 (paratype), equatorial section of megalospheric specimen. 10, tangential section. 11, axial section. 12, transverse section, all ×20.

13-15 *Mindoroella mindoroensis* Matsumaru, n. gen., n. sp. 13, tangential section. 14 (paratype), tangential section of megalospheric A2 gamont specimen. 15 (holotype), equatorial section of megalospheric A1 schizont specimen. Figs. 13,14, ×20; 15, ×50.

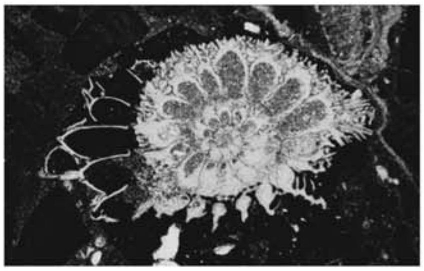
1



2

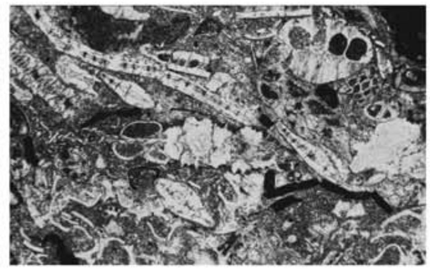


3

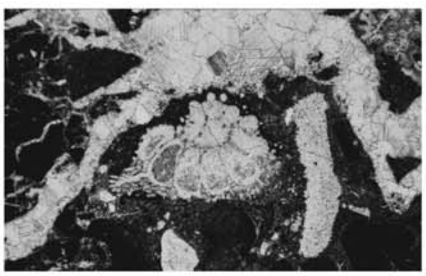


4

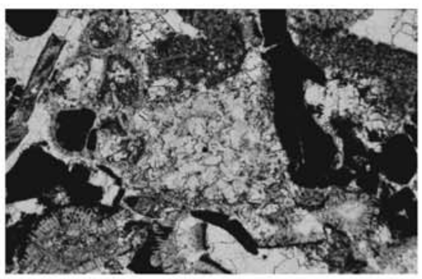
5



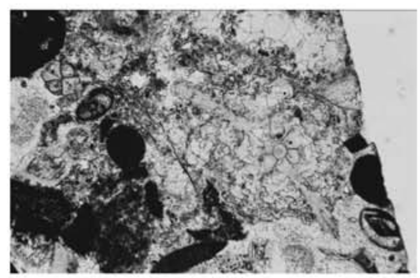
6



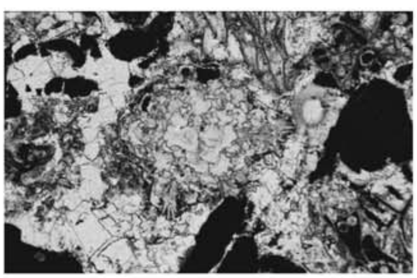
7



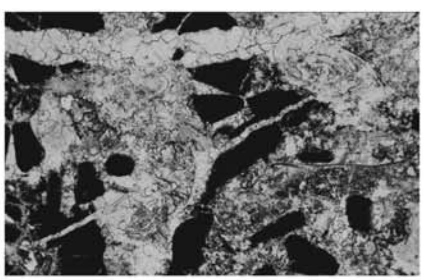
8



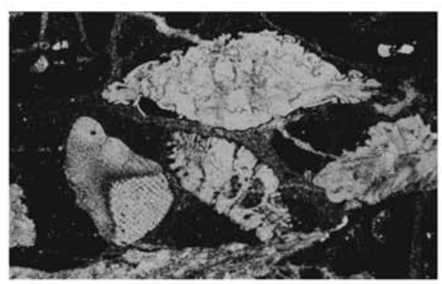
9



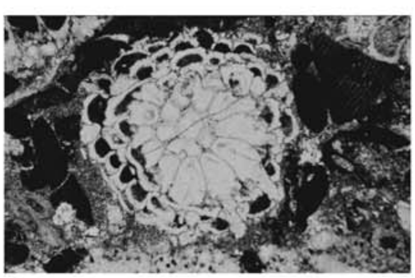
10



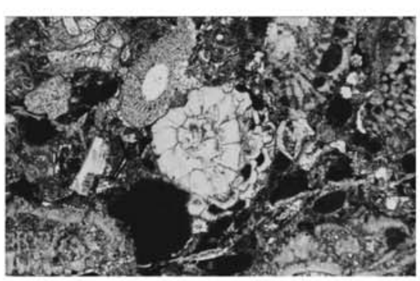
11



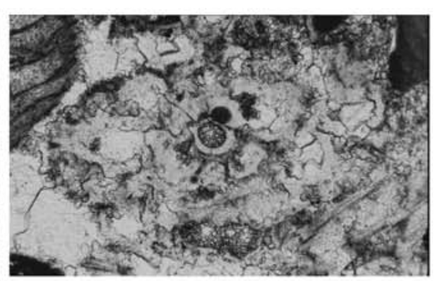
12



13



14



15

Cycloclypeus communis var. *borneesis* Rutten. – YABE and HANZAWA 1929, p. 189, pl. 19, figs. 1-2.
Cycloclypeus neglectus var. *indopacificus* TAN SIN HOK 1930, p. 5. – CAUDRI 1932, p. 186, figs. 9-13.
Cycloclypeus carpenteri Brady. – CAUDRI 1932, p. 188-189, pl. 2, figs. 18-19 (non figs. 17, 20-21).
Cycloclypeus indopacificus var. *indopacifica* TAN SIN HOK 1932, p. 66-67, pl. 18, fig. 3; pl. 19, fig. 1; pl. 22, fig. 10; pl. 23, fig. 2.
Cycloclypeus indopacificus var. *vandervlerki* TAN SIN HOK 1932, p. 67-68, pl. 17, figs. 5-6; pl. 18, figs. 5-6.
Cycloclypeus indopacificus var. *douvillei* TAN SIN HOK 1932, p. 68-71, pl. 15, fig. 8; pl. 20, figs. 3, 5-6; pl. 21, figs. 2-6.
Cycloclypeus indopacificus var. *terhaari* TAN SIN HOK 1932, p. 71-73, pl. 16, figs. 1, 3-5; pl. 17, fig. 4; pl. 18, figs. 1, 4, 9; pl. 19, figs. 2-5, 8, 11; pl. 22, figs. 5-6. – COLE 1945, p. 281, pl. 17, figs. A-K: pl. 19, figs. B-C.
Cycloclypeus (Cycloclypeus) indopacificus douvillei Tan, – COLE 1945, p. 280-281, pl. 16, figs. A-E.
Cycloclypeus indopacificus Tan. – COLE 1963, p. E17-18, pl. 7, figs. 1-6, 8-10; pl. 8, fig. 3. . – MATSUMARU 1976, p. 200-201, pl. 5, figs. 9, 14-15.

Description: Test thick, lenticular, with prominent umbo surrounded by broad thin flange. The surface is smooth except for annular wrinkles and pillars on the umbo. Spherical to subspherical protoconch and reniform deuteroconch are followed by subdivided nepionic chambers and annular rings of subdivided cycloclypenoid chambers that are longer than wide. The lateral wall is thick, calcareous and lamellar. Pillars are present.

Dimensions: Diameter of test = 3.0 to 6.1 mm, thickness = 0.45 to 0.64 mm, diameter/thickness ratio = 6.7 to 9.5; diameter of nepionic chambers = 0.61 to 0.73; in 6 specimens, diameter of protoconch = 112 × 112 to 174 × 181 µm, deuteroconch = 116 × 56 to 276 × 124 µm; number of nepionic chambers = 6 to 8; diameter of pillars = 80 to 115 µm.

Remarks: The var. *tenuitesta* has one operculine chamber, while the typical form and other variants have none. A few specimens have tests with radial ridges, which is a diagnostic feature of *Radiocycloclypeus stellatus* Tan 1932.

Upper Oligocene to lower Miocene, Tertiary e4 to Tertiary e5.

Cycloclypeus carpenteri Brady 1881
Plate 25, figures 5-6

Cycloclypeus guembeliana BRADY 1881, p. 66. – HANZAWA 1951, p. 1-4, 7-11, pl. 1, figs. 1-5; pl. 2, figs. 1-7 (Text-figs. 1-10. – HANZAWA 1957, p. 50, pl. 6, figs. 5-6.
Cycloclypeus carpenteri BRADY 1881, p. 67. – CHAPMAN 1900, p. 22, pl. 2, figs. 6-7; pl. 3, figs. 1-5. – HOFKER 1927, p. 71, pl. 24, fig. 1; pl. 37, figs. 1-10; pl. 38, figs. 1-9, 12-13. – COLE 1954, p. 581, pl. 205, figs. 9-12, 14 (non fig. 13). – MATSUMARU 1976, p. 200, pl. 5, figs. 6, 8, 10-12. – MATSUMARU 1976, p. 412, pl. 4, figs. 2, 8, 10-11, 16.
Cycloclypeus guembelianus BRADY 1884, p. 751, pl. 111, figs. 8a-b.
Cycloclypeus guembelianus-carpenteri Brady. – YABE and HANZAWA 1925, p. 55, pl. 7, fig. 19; pl. 8, figs. 1-4, 11-12; pl. 9, figs. 2-3; pl. 10, figs. 2-3.
Cycloclypeus (Cycloclypeus) carpenteri Brady. – COLE and BRIDGE 1953, p. 27, pl. 5, figs. 8-9. – COLE 1963, p. E 17, pl. 6, figs. 5-6; pl. 8, figs. 1-2.

Description: Test large, lenticular, and smooth except for evenly distributed pustules on the umbo. Relatively large spherical to subspheric protoconch and reniform deuteroconch are followed by only one and sometimes no ana-nepionic (= operculine) chamber. A few subdivided nepionic chambers are followed by regular annular rings of subdivided cycloclypenoid chambers. The wall is calcareous with thick lamellae on either side of the equatorial layer. Canals are present.

Dimensions: Diameter of test = 2.0 to 3.6 mm in fossils, but 6.5 to 9.5 mm in recent specimens, thickness = 0.6 to 0.9 mm, diameter/thickness ratio = 2.0 to 5.5; in Tertiary f2 specimen, diameter of protoconch = 478 × 354 µm, deuteroconch = 522 × 217

PLATE 29

Figs. 1-3, Station MD 83; figs. 4, 10, Station MD 115; figs. 6, 15, Station MD 117; figs. 7-9, 11-14, Station MD 70; Mindoro; fig. 5, Station 75801 (Matsumaru, MS's Koki Limestone, Sakora, Kobama-Jima (Hanzawa 1934).

1-3 *Mindoroella mindoroensis* Matsumaru, n. gen., n. sp. 1, 2, tangential sections. 3 right, oblique section, all ×20.

4-5, 8 *Discocyclina dispansa* (Sowerby). 4, axial section. 5, equatorial section. 8 left, oblique section. Fig. 4, ×20;5, 8, ×10.

6-8 *Discocyclina llarenai* Ruiz de Gaona. 6 upper, 8 right, oblique sections. 7, tangential section. Figs.6, 8, ×10; 7,, ×20.

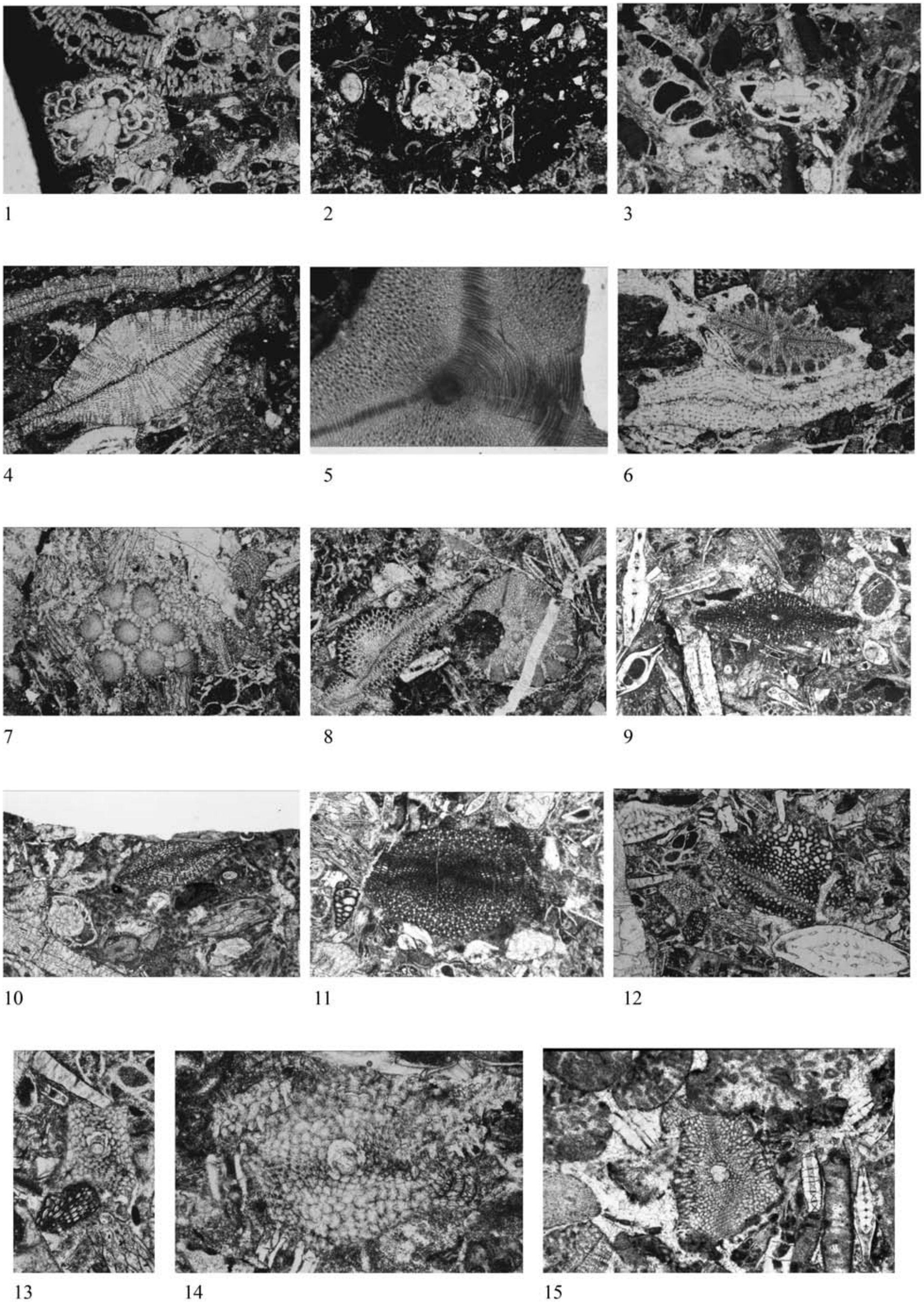
6 *Spiroclypeus granulosus* Boussac. 6 lower, axial section, ×10.

9-12 *Orbitoclypeus pygmaeus* (Henrici). 9, 10 right, axial sections. 11, 12 center, oblique sections, all ×20.

10 *Operculina schwageri* Silvestri and *Discocyclina dispansa* (Sowerby). 10 left, oblique section of broken specimen of *O. schwageri* and axial section of *D. dispansa,* ×20.

12 *Asterocyclina stellata* (d'Archiac) and *Nummulites vascus* Joly and Leymerie. 12 left, equatorial section of *A. stellate.* 12 right, transverse section of *N. vascus,* ×20.

13-15 *Asterocyclina stellata* (d'Archiac). 13, equatorial section. 14, 15, oblique sections. Figs. 13, 14,, ×50; 15, ×20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

µm, nepionic chambers = 5 with 1 ana-nepionic (= operculine) chamber. Pillar diameter = 60 to 80 µm. In two Tertiary f3 specimens, diameter of protoconch = 177 × 163 and 295 × 284 µm, deuteroconch = 254 × 63 and 454 × 189 µm, nepionic chambers = 3, one specimen with 1 operculine chamber and the other without, diameter of pillars = 40 µm. In six Tertiary h specimens, diameter of protoconch = 183 × 183 to 318 × 295 µm, deuteroconch = 330 × 161 to 568 × 227 µm, 4 specimens with 1 operculine chamber and 2 without. Diameter of pillars = 60 to 130 µm.

Middle Miocene to Recent, Tertiary f2 to Tertiary h.

Genus *Katacycloclypeus* Tan Sin Hok 1932

Katacycloclypeus transiens Tan Sin Hok 1932
Plate 25, figures 1-2

Cycloclypeus (*Katacycloclypeus*) *transiens* TAN SIN HOK 1932, tab. 2. – COLE 1945, p. 283, pl. 20D-F.

Description: Test large, lenticular. The surface is smooth with a single annular ring or wrinkle around a central inflated portion. Pillars are present in all annuli and the center of the test seen in axial section. Subspheric protoconch and reniform deuteroconch are followed by one operculine chamber and a few heterosteginoid nepionic chambers, enclosed by annular rings of cycloclypenoid chambers; all nepionic and annular chambers are subdivided into chamberlets that are longer than wide. The wall is thick, calcareous and lamellar.

Dimensions: Diameter of test = 3.2 to 4.5 mm, thickness = 0.77 mm, diameter/thickness ratio = 5.78; diameter of nepionic chambers = 1.0 to 1.2 mm; in 3 specimens, diameter of protoconch = 136 × 90, 148 × 136 and 184 × 152 µm, deuteroconch = 159 × 57, 198 × 102 and 224 × 112 µm; Number of nepionic chambers = 8; diameter of pillars = 45 to 80 µm.

Remarks: This species may have given rise to *Katacycloclypeus annulatus* (Martin 1880) due to decreasing number of nepionic septa.

Upper Oligocene to lower Miocene, Tertiary e4 to Tertiary e5.

Family DISCOCYCLINIDAE Galloway 1928
Genus *Discocyclina* Gümbel 1870

Discocyclina dispansa (Sowerby 1840)
Plate 29, figures 4-5, 8 left,10 left

Lycophris dispansa SOWERBY 1840, p. 327, pl. 24, figs. 16a-b.
Orbitolites sella D'ARCHIAC 1850, p. 405, pl. 8, figs. 16, 16a.
Orthophragmina umbilicata DEPRAT 1905, p. 497-501, pl. 16, figs. 2-11 (Text-figs A-E.
Discocyclina dispansa (Sowerby). – NUTTALL 1926, p. 145-147, pl. 7, figs. 1-3, 5. – HANZAWA 1957, p. 83-84, pl. 13, figs. 1, 3-4 (non pl. 14, figs. 2-3, 8-9). – NAGAPPA 1959, pl. 10, figs.6-8. – SAMANTA 1965, p. 422, pl. 1, figs. 9-11. – MATSUMARU 1996, p. 138-140, pl. 40, fig. 7 (non pl. 8, figs. 1-3).
Discocyclina cf. *D. dispansa* (Sowerby). – HENRICI 1934, p. 45-46, pl. 1, fig. 12.
Discocyclina (D.) omphala (Fritschi). – COLE 1957, p. 347-349, pl. 115, figs. 1-11, 12?
Discocyclina (D.) indopacifica HANZAWA 1957, p. 82-83, pl. 12, figs. 1-2, pl. 13, figs. 2, 5-6.
Discocyclina (D.) dogaensis HANZAWA 1965, p. 44-46, pl. 6, figs. 1-7 pl. 7, figs. 1-4.
Discocyclina (D.) changi HASHIMOTO and KURIHARA 1974, p. 38-40, pl. 1, figs. 3-4, 6; pl. 2, figs. 1-9; pl. 3, figs. 1-4.
Discocyclina dispansa (Sowerby) *sella* (d'Archiac). – LESS 1987, p. 161-162 (Text-fig. 27p.
Discocyclina dispansa dispansa (Sowerby). – LESS 1987, p. 163-164, pl. 13, figs. 9, 12; pl. 14, figs. 3, 6 (Text-fig. 27q.
Discocyclina dispansa (Sowerby) *umbilicata* (Deprat). – LESS 1987, p. 164-165, pl. 14, figs. 4-5, 7-8; ext-fig. 27r.
Orbitoclypeus kimurai MATSUMARU 1996, p. 118, 120, pl. 40, fig. 9 (non pl. 40, fig. 8; pl. 49, fig. 3).

Description: Test lenticular or compressed lenticular. Spherical to subspherical protoconch and reniform deuteroconch of nephrolepidine to trybliolepidine type are followed by nepionic and perinepionic chambers of *archiaci* type or *archiaci-pratti* transitional type. Equatorial chambers are rectangular, radially elongate, with *archiaci* growth pattern. Lateral chambers are moderately open to extremely shallow cavities, in regular tiers over the equatorial layer. Pillars are present throughout the test.

PLATE 30

Fig. 1, 3, Station MD 117; fig 2, Station WR 41; fig. 4, Station MD 83; figs. 5-8, Station MD 70; fig. 9, Station 11477; figs. 10, 11, 13, 15, Station 11474; figs. 12, 14, Station 11473; Mindoro.

1 *Asterocyclina stellata* (d'Archiac). axial section, ×20.

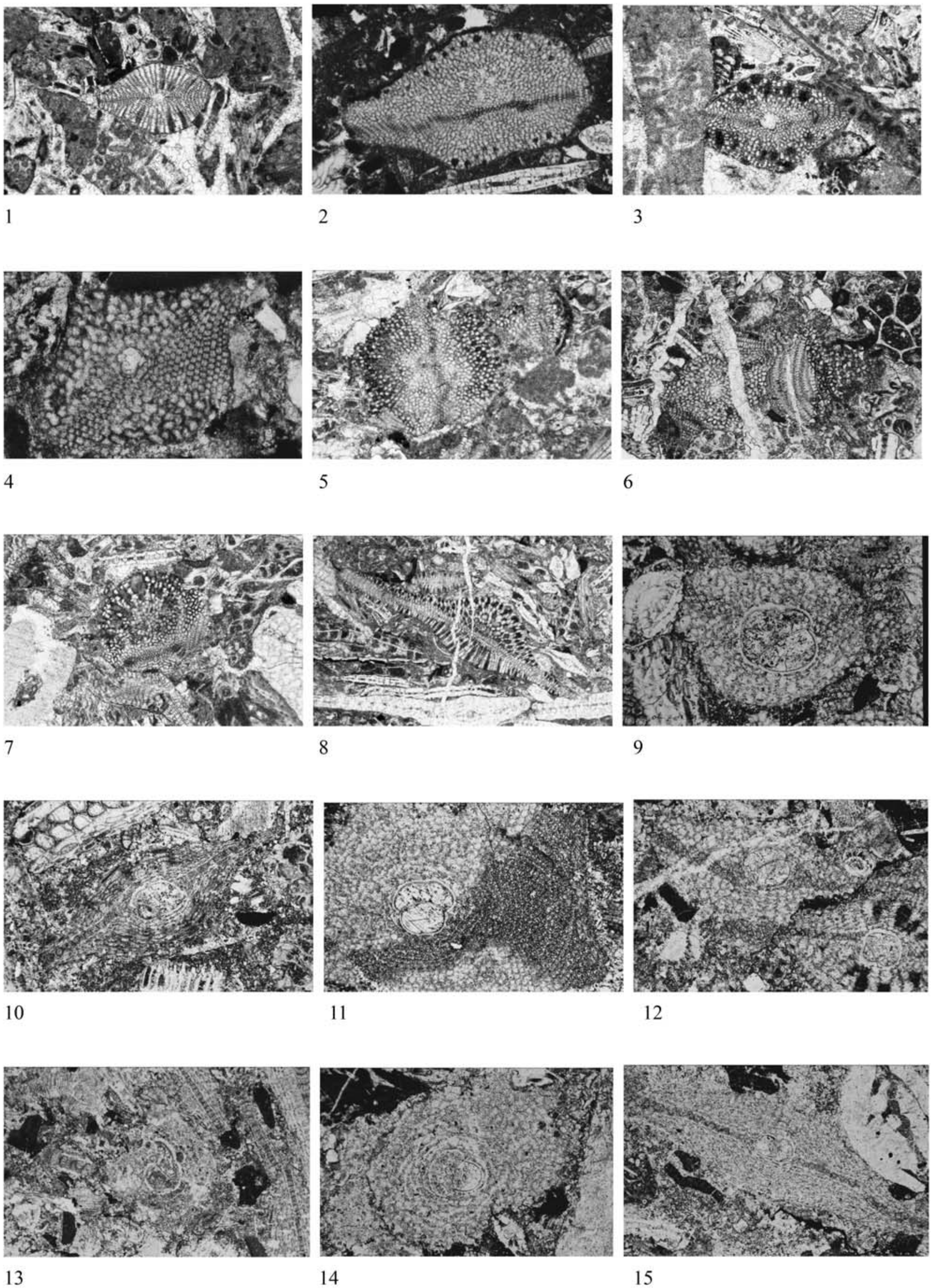
2 *Asterocyclina pentagonalis* (Deprat). oblique section, ×20.

3-8 *Asterocyclina stella* (Gümbel). 3-7, 8 upper, oblique sections. Figs.3, 5-7, ×20; 4, × 50; 8,, ×10.

8 *Spiroclypeus granulosus* Boussac. 8 lower, axial section, ×10.

9,10 *Lepidocyclina pustulosa* Douvillé. 9, oblique section. 10, axial section. Both ×20.

11-15 *Lepidocyclina boetonensis* van der Vlerk. 11, 14, tangential sections. 12, 13, 15, oblique sections, all ×20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Dimensions: Diameter of test = 2.6 to 6.5 mm, thickness = 0.84 to 1.50 mm, diameter/thickness ratio = 4.31 to 5.42; diameter of protoconch = 140 × 130 and 270 × 270 µm in two specimens, deuteroconch = 378 × 160 and 426x 180 µm, distance across protoconch and deuteroconch = 296 × 450 µm; tangential × radial diameter of nepionic chambers = 28 × 36 to 40 × 60 µm, that of equatorial chambers = 35 × 60 to 50 × 80 µm; height of equatorial layer near periphery = up to 34 µm; number of lateral chambers in tiers over embryonic chambers = 13 to 22; length × height of lateral chambers = 56 × 6 to 70 × 15 µm, diameter of pillars = 60 to 90 µm.

Remarks: Differs from *Discocyclina javana* in its nephrolepidine to trybliolepidine embryonic chambers, *archiaci*-type arrangements of nepionic chambers and presence of pillars throiughout the test. *Discocyclina changi* from the Tertiary a3 and b is a junior synonym based on these features.

Upper Eocene, Tertiary a3 to b.

Discocyclina llarenai Ruiz de Gaona 1946
Plate 29, figures 6 upper, 7, 8 right

Discocyclina roberti Douville var. *llarenai* RUIZ DE GAONA 1946, p. 204, pl. 2, fig. 28. – SCHWEIGHAUSER 1953, p. 62-63, pl. 10, figs. 4, 8; Text-figs. 19, 46.

Description: Lenticular test is thick, with 8 to 10 large pillars in a central area surrounded by tiers of 18-20 lateral chambers. Subspherical protoconch and reniform deuteroconch of trybliolepidine type are seen in oblique section. Large hexagonal or spatulate equatorial chambers form an annulusi. Lateral chambers are arranged in regular tiers over the equatorial layer with open chamber cavities. Stout pillars are present.

Dimensions: Diameter of test = 2.54 to 3.14 mm, thickness = 1.59 to 1.64 mm, diameter/thickness ratio = 1.60 to 1.97; diameter of protoconch = 150 × 114 µm, diameter of deuteroconch = 148 × 90 µm; tangential × radial diameter of equatorial chambers = 31 × 52 to 18 × 68 µm; height of equatorial layer near periphery = up to 22 µm; number of lateral chambers per tier over embryonic chambers = 18 to 20; length × height of lateral chambers = 90 × 10 to 104 × 11 µm; diameter of pillars = 272 to 348 µm.

Remarks: Type is from the Middle Lutetian of Italy.

Late Eocene, Tertiary b.

Genus *Orbitoclypeus* Silvestri 1907

Orbitoclypeus pygmaeus (Henrici 1934)
Plate 29, figures 9, 10 right, 11, 12 center

Discocyclina pygmaea HENRICI 1934, p. 47-48, pl. 3, figs. 7, 12; pl. 4, fig. 4. – SAMANTA 1965, p. 424-426, pl. 2, figs. 12-14.
Discocyclina (D.) pygmaea Henrici. – SAMANTA 1964, p. 345-346, pl. 4, figs. 1-16.
Orbitoclypeus pygmaea (Henrici). – LESS 1987, p. 224-225, text-fig. 31c.

Description: Test small, lenticular, with inflated central area bordered by thin flange. The surface is ornamented by small pustules. Subspherical protoconch and reniform deuteroconch; nephrolepidine type are followed by nepionic and perinepionic chambers of *varians* type. Annular equatorial chambers are rectangular, short spatulate to hexagonal while lateral chambers are open cavities between roofs and floors in regular tiers over the equatorial layer. Pillars are present.

Dimensions: Diameter of test = 1.0 to 2.5 mm, thickness = 0.4 to 0.8 mm, diameter/thickness ratio = 1.8 to 3.1; diameter of protoconch = 70 × 50, 73 × 40, 73 × 40, and 80 × 70 µm in 4 specimens, deuteroconch = 110 × 50, 120 × 40, 120 × 40, and 130 × 75 µm; deuteroconch/protoconch diameter ratio =1.57, 1.64, 1.64, and 1.63; distance across both protoconch and deuteroconch = 100, 90+, 120 and 145 µm. tangential × radial diameter of nepionic chambers = 31 × 35 to 34 × 38 µm, perinepionic chambers = 16 × 22 to 28 × 22 µm, equatorial chambers = 28 × 36 to 22 × 68 µm. Height of equatorial layer near periphery = up to 30 µm. There 12 lateral chambers in tiers

---

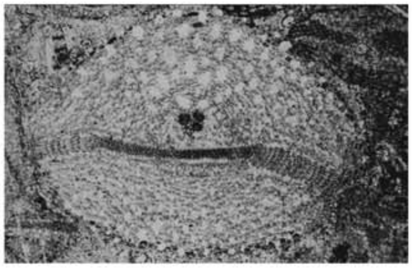
PLATE 31

Figs. 1, 2, 4, 7, 9, Station 11474; fig. 3, Station 11473;fig. 8, Station 11478; Mindoro; figs. 10-12, 14, 15, Station 7442626, Cebu; fig. 13, from Hashimoto and Matsumaru (1975, pl. 12, fig. 3), identified as *Lepidocyclina formosensis* Hanzawa.

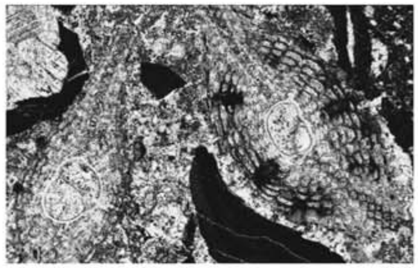
1 *Lepidocyclina boetonensis* van der Vlerk. oblique section of microspheric specimen, ×10.

2-9 *Nephrolepidina marginata* (Michelotti). 2 right, 7 upper, 8, axial sections.3-6, 9, oblique sections of megalospheric and microspheric specimens.. Figs. 2, 3, 6, 7, ×20; 8, 9, ×10.

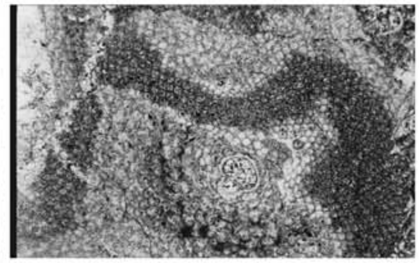
2, 7, 10-15 *Lepidocyclina isolepidinoides* van der Vlerk. 2 left, oblique section. 7 lower, transverse section. 10, tangential section. 11-13, oblique sections. 14, 15, axial sections, all ×20.



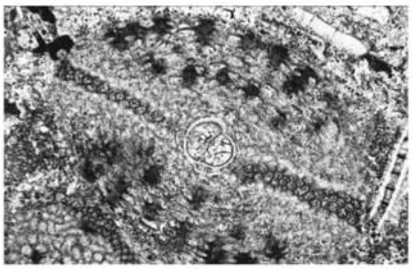
1



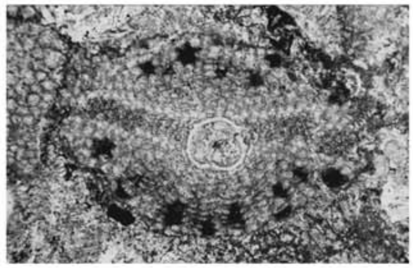
2



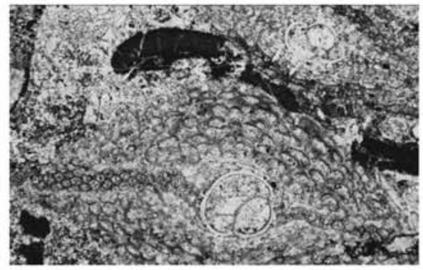
3



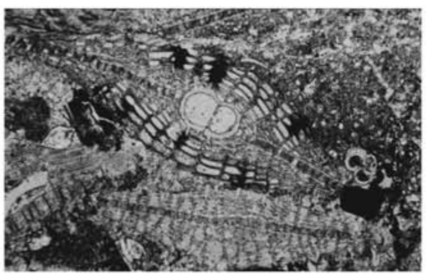
4



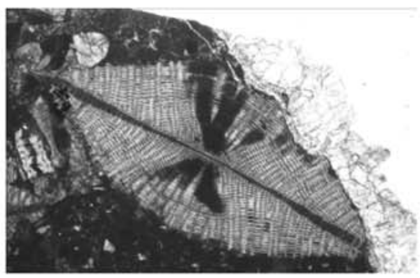
5



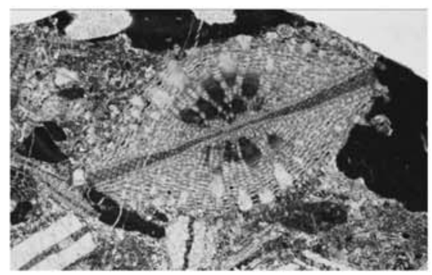
6



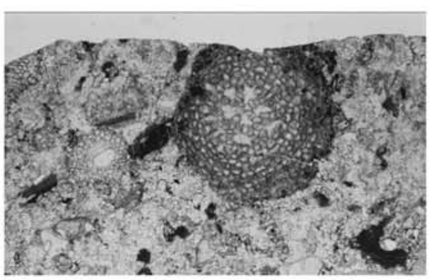
7



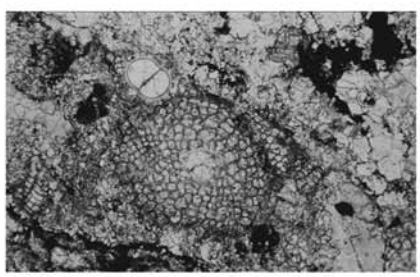
8



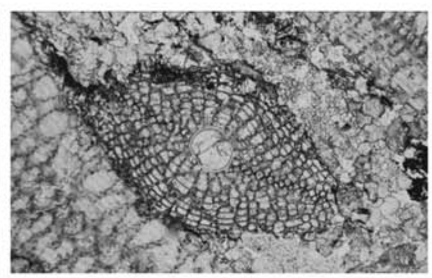
9



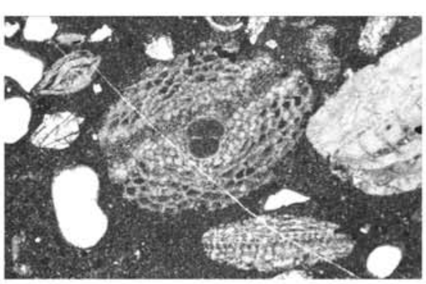
10



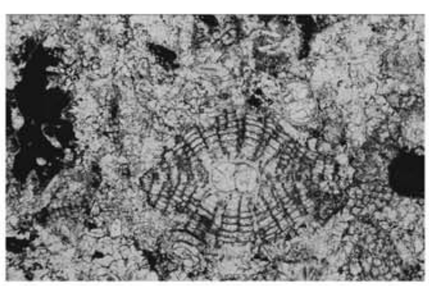
11



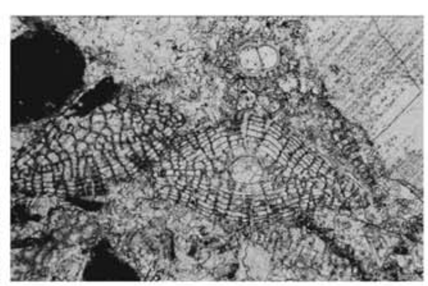
12



13



14



15

over embryonic chambers, length × height = 31 × 13 to 45 × 11 µm; diameter of pillars = 25 to 45 µm.

Remarks: Orbitoclypeus daguini may be the ancestor of *O. pygmaeus* (Less), with nepionic and perinepionic chambers closer to the *Lepidocyclina* type. *Discocyclina trabayensis* Neumann is very similar in possessing small lenticular test, nephrolepidine embryonic chambers and *varians* type nepionic chambers.

Upper Eocene, Tertiary b.

Family AMPHISTEGINIDAE Cushman 1927
Genus *Amphistegina* d'Orbigny 1826

Amphistegina radiata (Fichtel and Moll) 1803
Plate 25, figure 11 center; plate 32, fig. 4 left; plate 34, figure 12 right

Amphistegina radiata (Fichtel and Moll) – MATSUMARU 1976, p. 408, pl. 1, figs. 1-3, 5-13, 17, 23, 26-27.

Remarks: For full description of the oriental forms, see Matsumaru (1976). This is an extremely long-ranging, thus well adapted species.

Upper Eocene to Holocene, Tertiary b to Tertiary h.

Superfamily Asterigerinacea d'Orbigny 1839
Family Lepidocyclinidae Scheffen 1932
Genus *Lepidocyclina* Gümbel 1870

Lepidocyclina pustulosa Douvillé 1917
Plate 30, figures 9-10

Lepidocyclina (*Isolepidina*) *pustulos*a DOUVILLÉ 1917, p. 844, figs. 1-2, 4, 29. – DOUVILLÉ 1924, p. 41-42, pl. 1, figs. 2-3 (Text-figs. 27-32.
Lepidocyclina (*Pliolepidina*) *pustulosa* Douvillé. – COLE 1960, p. 133-136, pl. 2, fugs. 1-10; pl. 3, figs. 1-6, 9-10; pl. 4, figs. 7-9.
Lepidocyclina (*Lepidocyclina*) *pustulosa* H. Douvillé. – COLE 1963, p. 21-35, pl. 1, fig. 5; pl. 2, figs. 1-6; pl. 3, figs. 1-6; pl. 4, figs. 1-6; pl. 5, figs. 1-4; pl. 6, figs. 2, 4; pl. 10, figs. 1-4, 9-12; pl. 14, figs. 1-5. – FROST and LANGENHEIM 1974, p. 127-128, 130, pl. 32, figs. 1-14; pl. 33, figs. 1-6.
Lepidocyclina pustulosa H. Douvillé. – MATSUMARU 1996, p. 35-37, fig. 22. 3a-d.
Lepidocyclina spp. – MATSUMARU and SARMA 2010, p. 550, pl. 3, fig. 11.

Description: Test thick, lenticular, ornamented with conical pillars in the central area. Biloculine embryonic chambers of subspherical protoconch and reniform deuteroconch of isolepidine to nephrolepidine or sometimes pliolepidine (teratological) form, followed by two subequal primary auxiliary chambers and one or more accessory auxiliary chambers on deuteroconch wall. Arcuate, ogival and short spatulate equatorial chambers form intersecting curves towards the periphery. Rectangular lateral chambers, with thin roofs and floors, lie in regular tiers over the equatorial layer. Wall is calcareous and lamellar, with pillars.

Dimensions: Diameter of test = 1.8 to 2.6 mm, thickness = 0.7 to 1.0 mm, diameter/thickness ratio = 2.2 to 2.5; diameter of protoconch = 250 × 180 and 600 × 325 µm in 2 specimens; deuteroconch = 350 × 215 and 725 × 365 µm; thickness of embryonic chamber walls = 15 to 25 µm; tangential × radial diameter of auxiliary chgambers = 70 × 40, 100 × 65, 115 × 100, and 150 × 60 µm; equatorial chambers (i.e. tang. diam, xrad. diam.) = 80 × 80 to 75 × 100 µm; length × height of lateral chambers = 90 × 40 to 100 × 50 µm; diameter of pillars = 42 to 50 µm.

Remarks: The species is known from the middle to upper Eocene of the Caribbean region (Cole 1960, 1963; Frost and Langenheim 1974) and upper Eocene of NE India (Matsumaru and Sarma 2010) but is present only as reworked material in the lower Oligocene (Tertiary d) of the Philippines.

Probably upper Eocene, Tertiary b.

Lepidocyclina boetonensis Van der Vlerk 1928
Plate 30, figures 11-15; plate 31, figure 1

PLATE 32

All ×20 except figs. 9, 12, ×50. Fig. 1, Station 11480; fig. 2, Station 11467; fig. 3, Station 11468; Bugton, Mindoro; figs. 4, 9, Station MQ 10, and fig. 13, Station MQ 12, Marinduque; fig. 5, Station 7450713, Samar; fig. 6, Station CB 9, Cebu; Figs. 7, 8, Station 7682906, Negros; fig. 10, Station At 8, Atimonan, Bondoc Peninsula (Hashimoto and Matsumaru, 1975, text-fig. 3); fig. 11, Station TB 45, Tablas; fig. 12, Station MD 112, Mindoro; figs.14, 15, Station RZ 3, Binangonan, Mid-Luzon.

1-3 *Nephrolepidina borneensis* (Provale). 1, oblique section. 2, axial section. 3, transverse section. × 20.

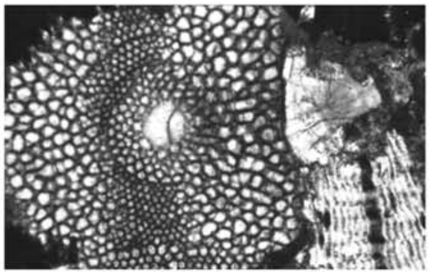
4-6 *Nephrolepidina brouweri* (Rutten). 4 right, 5, tangential sections. 6, oblique section. Specimens in Figs. 4 and 6 are reworked. × 20.

4 *Amphistegina radiata* (Fichtel and Moll). 4 left, oblique section. × 20.

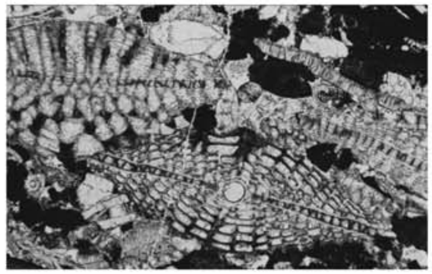
7-13 *Nephrolepidina ferreroi* (Provale). 7, 8, 11, 12, oblique sections. 9, equatorial section. 10, axial section. 13 right, tangential section. × 20.

13 *Operculina ammonoides* (Gronovius) and *Sphaerogypsina globulus* (Reuss). 13 left, oblique section of *O. ammonoides,* and tangential section of *S. globulus.* × 20.

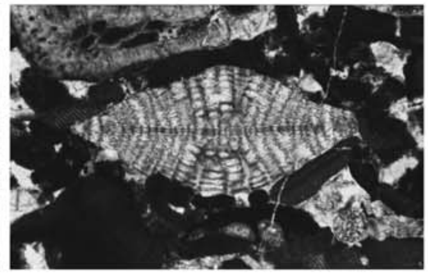
14, 15 *Nephrolepidina tournoueri* (Lemoine and Douvillé). 14, equatorial section of broken megalospheric specimen. 15, axial section. × 20.



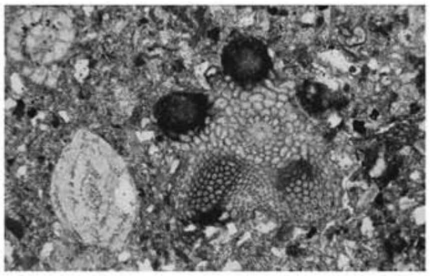
1



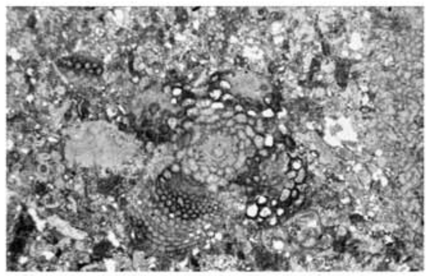
2



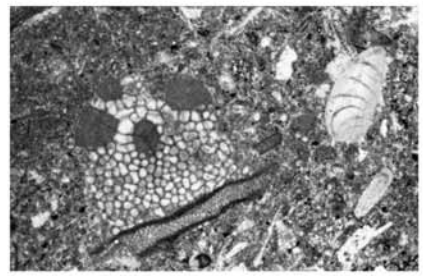
3



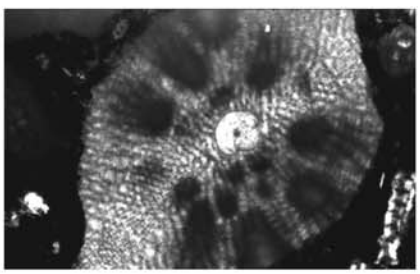
4



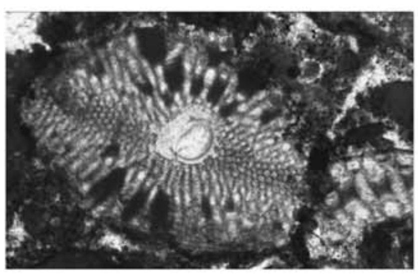
5



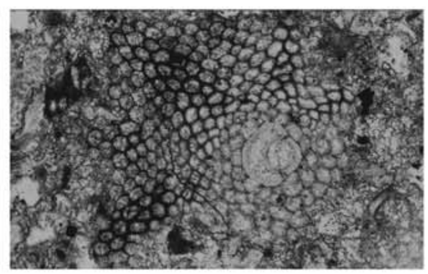
6



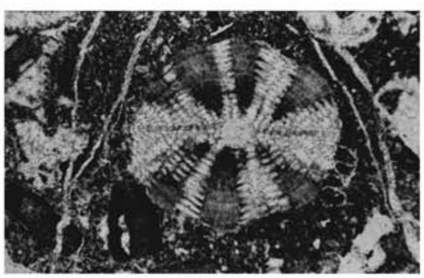
7



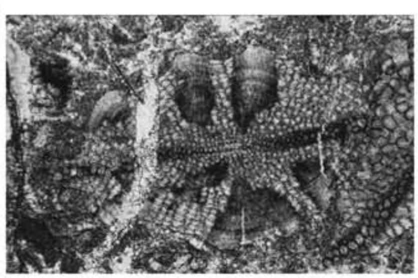
8



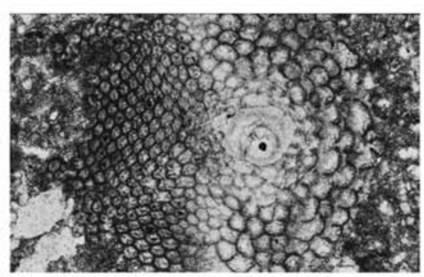
9



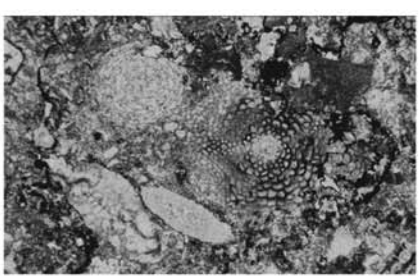
10



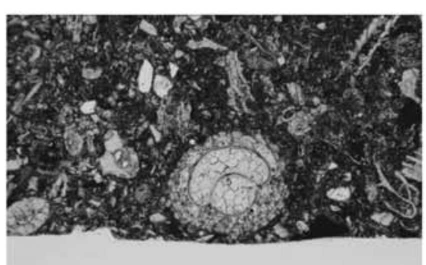
11



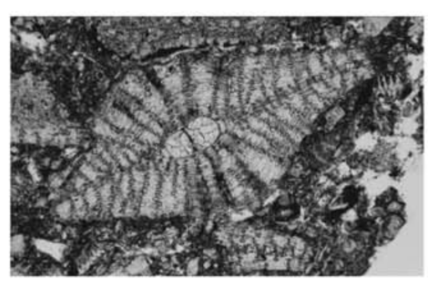
12



13



14



15

Lepidocyclina (Isolepidina) boetonensis VAN DER VLERK 1928, p. 15, 22, figs. 30 a-c; figs. 58 a-b; table 2.

Lepidocyclina (Lepidocyclina) boetonensis Van der Vlerk. – TAN SIN HOK 1935, p. 113-126, text-fig. 12. – VAUGHAN 1945, p. 64, text-fig. 10.

Lepidocyclina boetonensis van dr Vlerk. – MATSUMARU 1996, p. 37, fig. 22. 13a-b. – MATSUMARU, SALI, and OZER 2010, p. 6, pl. 6, fig. 1.

Description: Test thick, lenticuar, varying from inflated central boss with a conical pillars, to a nearly flat central area with poorly developed pillars. Subspherical protoconch and reniform deuteroconch of isolepidine to nephrolepidine type are followed by two subequal primary auxiliary chambers that originate from apertures (or stolons) in the deuteroconchal wall. One or two accessory auxiliary chambers on the deuteroconchal wall may be present. Arcuate, ogival, short hexagonal or elongate spatulate equatorial chambers form concentric rings. Lateral chambers with thin roofs and floors are rectangular, long and low, in regular or slightly overlapping tiers over the equatorial layer.

Dimensions: Diameter of test = 2.39 to 3.18 mm, thickness = 0.98 to 1.02 mm, diameter/thickness ratio = 2.34 to 3.24; in 6 specimens diameter of protoconch = 220 × 188 to 597 × 337 µm, deuteroconch = 300 × 83 to 728 × 374 µm, deuteroconch/protoconch diameter ratio = 1.31 to 1.53; distance across both protoconch and deuteroconch = 279 to 728 µm. Thickness of embryonic chambers walls = 18 to 22 µm; tangential × radial diameter of principal auxiliary chambers 102 × 68 to 159 × 45 µm, accessory auxiliary chambers = 102 × 22 to 181 × 45 µm; equatorial chambers = 56 × 79 to 84 × 113 µm; length × width of lateral chambers = 90 × 20 to 152 × 45 µm; roofs and floors = 4 to 15 µm; number of lateral chambers in tiers over embryonic chambers = 8 to 15; diameter of pillars = 45 to 113 µm.

Remarks: Resembles *L. mantelli* (Morton), type species of *Lepidocyclina*, s. str. from the Oligocene of southern USA. (Cole 1957) in its isolepidine to nephrolepidine embryonic chambers and concentrically arranged equatorial chambers, but differs in its thick lenticular form and small test (Matsumaru 1996). The close resemblance suggests migration directly from the Caribbean to the Indo-Pacific region during the early Oligocene, and then to Turkey in the upper Oligocene (Matsumaru et al. 2010). *Nephrolepidina marginata* is similar in its thick lenticular form with pillars and in other basic features, suggesting it might have evolved from *L. boetonensis* (table 18).

Lower to upper Oligocene, Tertiary d to Tertiary e4.

Lepidocyclina isolepidinoides Van der Vlerk 1929
Plate 21, figure 11 left; plate 23, figure 13 left; plate 25, figure 11 left; plate 31, figures 2 left, 7 lower, 10-15

Lepidocyclina (Nephrolepidina) isolepidinoides VAN DER VLERK 1929, p. 23-24, figs. 20, 45 a-c, 48 a-c. – TAN 1935, p. 113-126, fig. 13. – TAN 1939, p. 58, pl. 1, figs. 1 a-b.

Lepidocyclina formosensis HANZAWA 1939, p. 184-185, figs 2-4. – HASHIMOTO and MATSUMARU 1975, p. 112-114, pl. 12, figs. 1-9

Lepidocyclina isolepidinoides Van der Vlerk. – RENZ and KÜPPER 1946, p. 333, pl. 18, 4 figs. – MATSUMARU 1996, p. 36, fig. 22. 14 a-b.

Description: Lenticular test is thickened in a central boss, smooth except a few tiny conical pillars in the center. Subspherical protoconch and reniform deuteroconch of isolepidine to nephrolepidine type are followed by two nearly equal principal auxiliary chambers with one or two auxiliary chambers on the deuteroconch wall. Arcuate to ogival equatorial chambers are arranged in intersecting curves. Spaceous rectangular lateral chambers with thin roofs and floors are in regular tiers over the equatorial layer.

Dimensions: Diameter of test = 1.70 to 2.23 mm, thickness = 0.75 to 1.00 mm, diameter/thickness ratio = 1.70 to 2.51; in 6 specimens diameter of protoconch = 132 × 105 to 318 × 191 µm, deuteroconch = 176 × 104 to 308 × 137 µm, deuteroconch/protoconch diameter ratio = 0.97 to 1.50, distance across both protoconch and deuteroconch = 216 to 331 µm, thickness of embryonic chamber walls = 14 to 24 µm; tangential × radial diameter of primary auxiliary chambers = 52 × 20 to 109 × 52 µm;

PLATE 33

Fig. 1, Station F 512, and figs. 2, 8, Station C 58, East Mindanao; fig. 3, Station 7681903, Cagraray; fig. 4, Station 7450711, Samar; fig. 5, Station 120, Bontoc, North Luzon; fig. 6, Station G 16, NE Luzon; fig. 7, Station 7683003, Negros; fig. 9, Station Abuta 44 (typical letter stage tf1 with 3 species in Assemblage 14; Table 18; fig. 12, Station Abuta 5; and fig. 15, Station Abuta 52; Abuta Limestone, Japan (Matsumaru, 1967); fig.10, Station A 2; fig. 11, Station B 53; and fig. 13, Station F 31; NE Luzon; fig. 14, Station CB 30, Cebu.

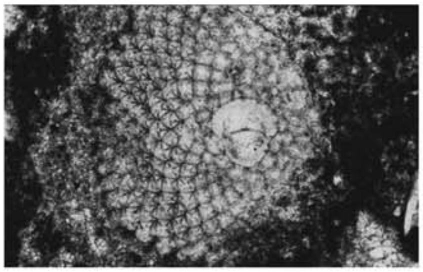
1-6,9 *Nephrolepidina sumatrensis* (Brady). 1, 9 center, equatorial sections. 2-5, oblique sections. 6, axial section. Figs. 1, 2, × 50; 3, 4, ×20; 5, 6, 9, × 10.

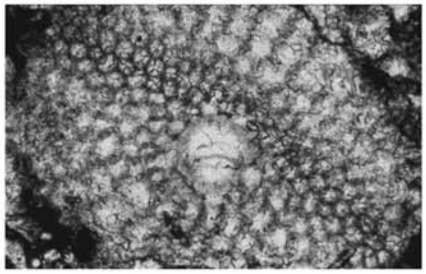
7-10 *Nephrolepidina japonica* (Yabe). 7, 8 right, oblique sections. 9 right (topotype specimen), equatorial sections. 10, axial section. 7, ×50. 8-9, ×10. 10, ×20.

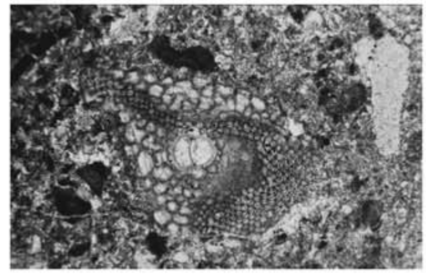
9 *Nephrolepidina rutteni* (van der Vlerk). 9 left upper, equatorial section, ×10.

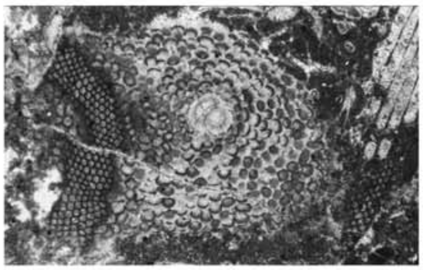
11, 12 *Nephrolepidina angulosa* (Provale). 11, axial section. 12, equatorial section.

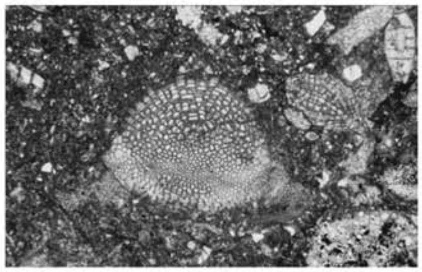
13, 15 *Nephrolepidina martini* (Schlumberger). 13, oblique section. 14, 15, equatorial sections. Figs. 13, 15, ×20; 14, ×50.

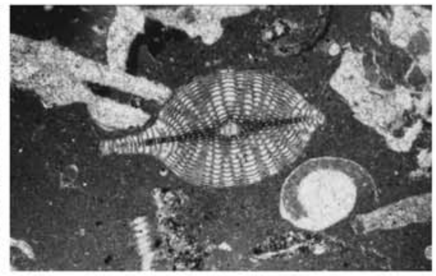

1

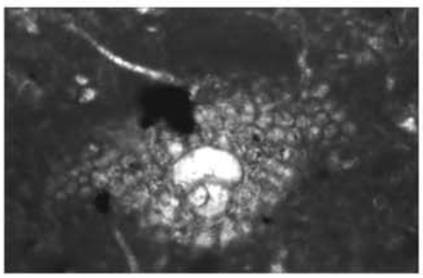

2

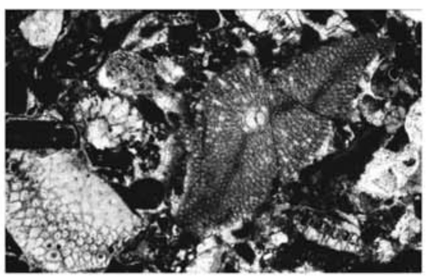

3

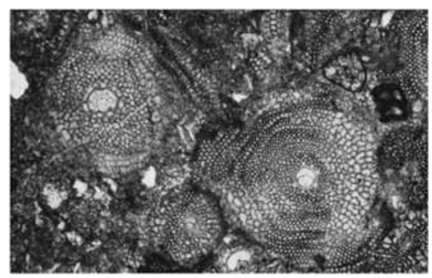

4

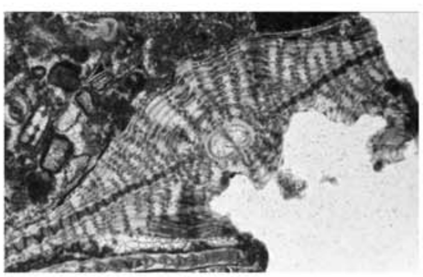

5


6

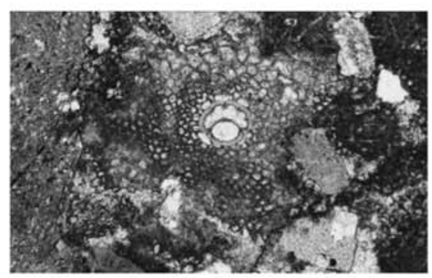

7

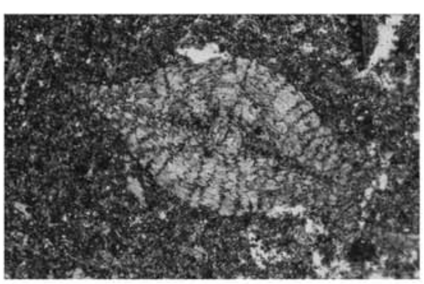

8

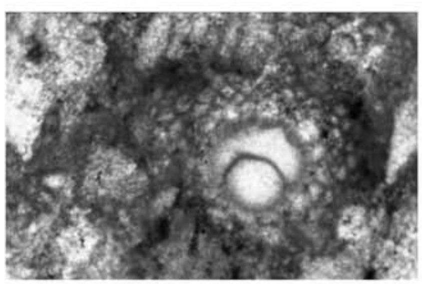

9

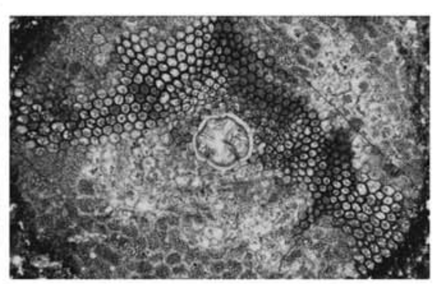

10


11


12


13


14


15

accessory auxiliary chambers = 37 × 23 to 92 × 26 µm, equatorial chambers = 61 × 52 to 70 × 75 µm; length × height of lateral chambers = 96 × 36 to 161 × 36 µm; thickness of roofs and floors = 4 to 8 µm; number of lateral chambers in tiers over equatorial layer = 8 to 9; diameter of pillars = 26 to 48 µm.

Remarks: Judging from many similarities, *Lepidocyclina yurnagunensis* Cushman 1971, probably migrated from the Caribbean during the early Oligocene to give rise to *L. isolepidinoides*.

Lower to upper Oligocene, Tertiary d to Tertiary e3.

Lepidocyclina radiata (Martin 1880)
Plate 34, figures 6-11, 12 center

Lepidocyclina (Eulepidina) radiata (Martin). – DOUVILLÉ 1916, p. 26, pl. 5, fig. 4. – WHIPPLE 1934, p. 148-149, pl. 19, figs. 3-6. – COLE 1960, p. 136-138, pl. 1, figs. 1-10; pl. 3, figs. 7, 11; pl. 4, figs. 1-3, 6, 8, 10-11. – COLE 1962, p. 29-50, pl. 4, figs. 1-3; pl. 5, fig. 3; pl. 6, figs. 1, 5; pl. 8, fig. 3. – COLE 1963, p. 157-176, pl. 42, figs. 1-4; pl. 43, figs. 1-4; pl. 44, figs. 1-6; pl. 45, figs. 1-8; pl. 46, figs. 2-5; pl. 47, figs. 5-6.
Lepidocyclina (Amphilepidina) radiata (Martin). – DOUVILLÉ 1924, p. 113.
Lepidocyclina (Multilepidina) irregularis HANZAWA 1932, p. 448, figs. 1-6.
Lepidocyclina (Nephrolepidina) radiata (Martin). – EAMES, BANNER, BLOW, CLARK and SMOUT 1962, p. 303, pl. 6, fig. 1; pl. 7, figs. 1-3.
Lepidocyclina radiata (Martin). – VAN DER VLERK 1961, p. 620-623, pl. 2, fig. 1. – ADAMS, RODDA and KITELEY 1979, p. 333-336, pl. 2, figs. 1-7.
Lepidocyclina (*Multilepidina*) *luxurians* Tobler. – HASHIMOTO and MATSUMARU 1982, p. 42-43, pl. 22, fugs. 1-5.

Description: Test large and polygonal in outline, smooth except small pillars covering the central boss. Spherical to subspherical protoconch and reniform deuteroconch of isolepidine through nephrolepidine to multilepidine types are followed by two primary auxiliary chambers together with nepionic chambers along the outer thick wall of the embryonic chambers. The equatorial chambers are arcuate, ogival, long hexagonal and spatulate, in polygonal to concentric rings. Large rectangular lateral chambers with thick roofs and floors form regular tiers over the equatorial layer.

Dimensions: Diameter of test = 2.32 to 4.55 mm, thickness = 0.80 to 1.27 mm, diameter/thickness ratio = 2.24 to 4.40; in 8 specimens, diameter of protoconch = 217 × 200 to 650 × 530 µm, deuteroconch = 217 × 145 to 950 × 250 µm, deuteroconch/protoconch diameter ratio = 1.00 to 1.86, distance across protoconch and deuteroconch = 330 to 1200 µm; thickness of embryonic chambers wall =22 to 50 µm; tangential × radial diameter of primary auxiliary chambers =122 × 45 to 163 × 56 µm, auxiliary chambers = 129 × 56 to 250 × 50 µm, equatorial chambers = 56 × 79 to 115 × 150 µm; length × height of lateral chambers = 136 × 34 to 250 × 52 µm; number of lateral chambers per tier over embryonic chambers = 9 to 15; thickness of roofs and floors = 34 to 45 µm.

Remarks: Lepidocyclina radiata has been identified as a senior synonym of several Miocene species (Cole 1963). It occurs commonly in Philippine samples.

Uppermost Oligocene to upper Miocene, Tertiary e4 to Tertiary f3.

Genus *Nephrolepidina* H. Douvillé 1911

Nephrolepidina borneensis (Provale 1909)
Plate 32, figures 1-3

PLATE 34

Figure 1, Station CB2, Cebu 2; fig. 2, Station CB30; fig. 10, Station CB 25; fig. 11, Station CB46; fig. 14, Station CB20; Cebu; fig. 3, Station PWC 5, Masbate; fig. 4, Station F 31, and fig. 6, Station A 2, NE Luzon; fig. 5, Station E 26, East Mindanao; figs. 7-9, Station QZ 10-1, Palawan; fig. 12, Station MH 5, Burias; 13, Station RZ 4, Binangonan, Mid-Luzon; fig. 15, Station 11477, Mindoro.

1 *Nephrolepidina martini* (Schlumberger). 1 left, axial section of broken megalospheric specimen; reworked with *Lepidocyclina radiata* and *Nephrolepidina rutteni*, ×20.

1 *Baculogypsinoides spinosus* Yabe and Hanzawa. 1 right, tangential section, associated with *Operculina venosa,* ×20.

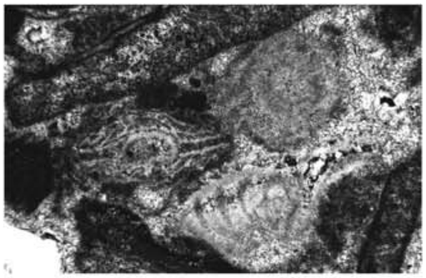
2,3 *Nephrolepidina rutteni* (Schlumberger). 2, equatorial section of broken megalospheric specimen. 3, axial section. Fig. 2, ×50; 3, ×20.

4,5 *Nephrolepidina verbeeki* (Newton and Holland). 4, oblique section. 5, axial section. Fig. 4, ×20. 5, ×10.

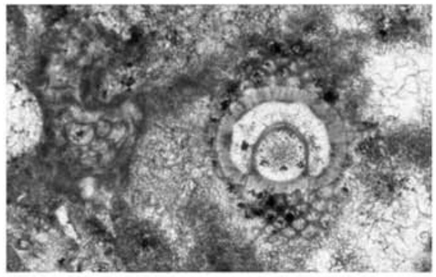
6-12 *Lepidocyclina radiata* (Martin). 6, 9, 10, axial sections. 7, 11, equatorial sections (fig, 11, reworked specimen). 8, 12 center, oblique sections. Figs. 6-10, 12, ×20.; 11, ×50.

12 *Pseudorotalia schroeteriana* (Carpenter, Parker and Jones). 12 lower, oblique section, ×20.

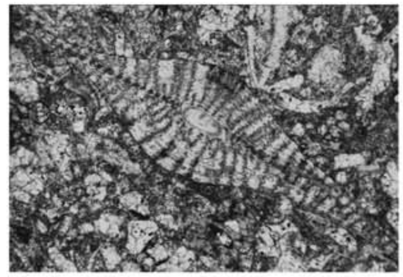
13-15 *Eulepidina dilatata* (Michelotti). 13, 14, equatorial sections. 15, oblique section. 13, 15, ×10. 14, ×5.



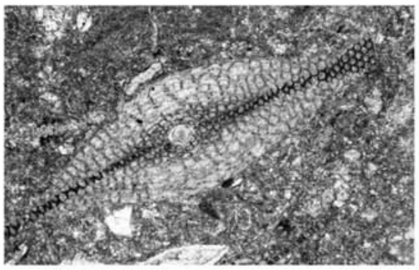
1



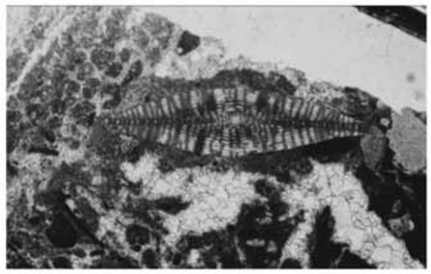
2



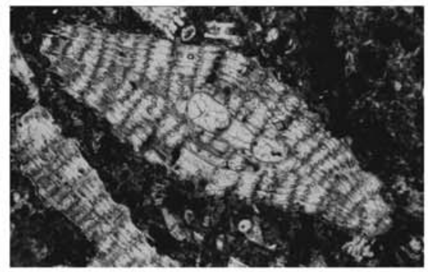
3



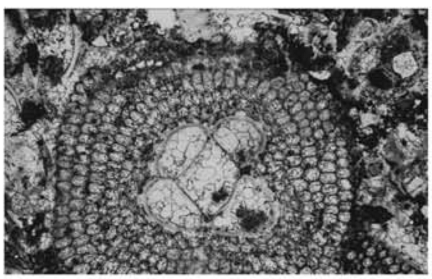
4



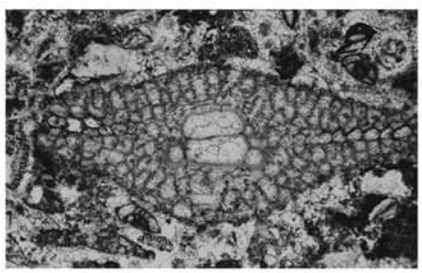
5



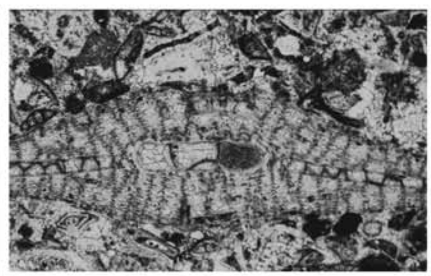
6



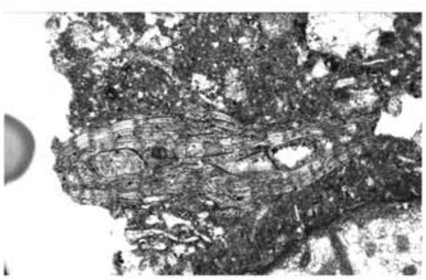
7



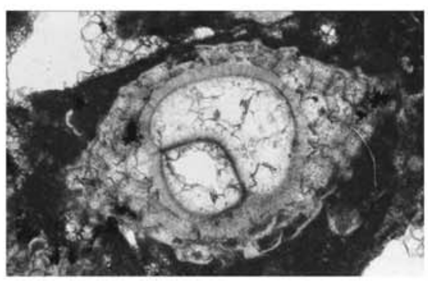
8



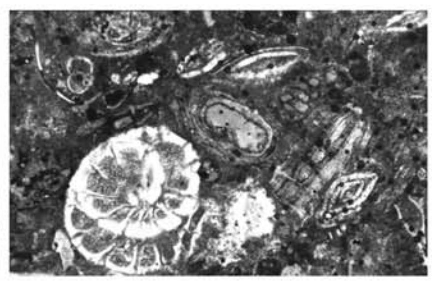
9



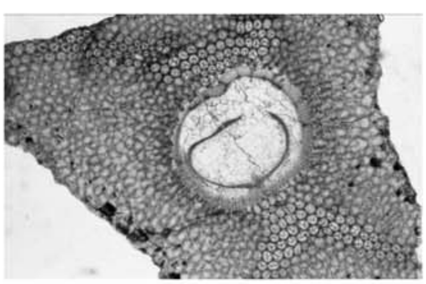
10



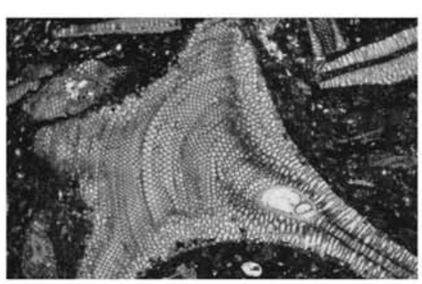
11



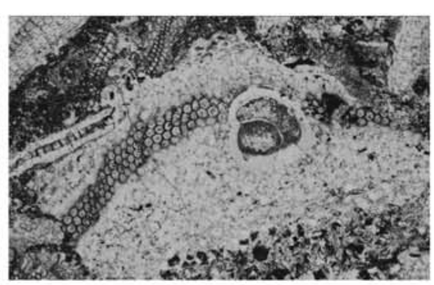
12



13



14



15

Lepidocyclina tournoueri var. *borneensis* PROVALE 1909, p. 74, pl. 2, figs. 16-19.
Lepidocyclina (Nephrolepidina) borneensis Provale. – VAN DER VLERK 1928, p. 15, 23, figs. 16a-c; table 2.
Lepidocyclina transiens UMBGROVE 1929, p. 109, figs. 1-5. – RENZ and KÜPPER 1946, p. 328, figs. 3a-t.
Lepidocyclina borneensis Provale. – CAUDRI 1934, p. 113-116, text-figs. 21s-w. – CAUDRI 1939, p. 228-231, pl. 10, figs. 77-78.

Description: Test thick, lenticular, with a globose to subglobose central boss and short peripheral flange. Subspheric protoconch and reniform deuteroconch of nephrolepidine to trybliolepidine type are followed by two primary auxiliary chambers and arcuate nepionic chambers. Concentric rings of equatorial chambers gradually increase in height towards the periphery. Lateral chambers with thin roofs and floors are swollen cavities in regular tiers over the equatorial layer. Pillars are present.

Dimensions: Diameter of test = 3.48 to 4.60 mm, thickness = 1.06 to 1.92 mm, diameter/thickness ratio = 1.81 to 4.34; diameter of protoconch = 215 × 181 and 240 × 127 µm in equatorial section, and 259 × 209 µm in vertical section, deuteroconch = 165 × 97 and 320 × 155 µm in equatorial section, and 545 × 190 µm in vertical section; ratio of deuteroconch/protoconch diameter = 1.33 to 2.10; distance across both protoconch and deuteroconch = 279 to 295 µm; thickness of embryonic chambers wall = 13 to 19 µm; length × height of lateral chambers = 190 × 54 to 250 × 79 µm; thickness of roofs and floors = 9 to 15 µm; Number of lateral chambers per tier over embryonic chambers = 12 to 16; diameter of pillars = 45 to 54 µm.

Remarks: Embryonic chambers vary widely from isolepidine through nephrolepidine to multilepidine types; differs from *Nephrolepidina marginata* in its cyclical arrangement of equatorial chambers, and from *Lepidocycla boetonensis* in its smaller embryonic chambers.

Lower Oligocene, Tertiary d to Tertiary e1-2.

Nephroepidina marginata (Michelotti 1841)
Plate 21, figure 12 lower; plate 31, figures 2 right, 3-6, 7 upper, 8-9; plate 36, figure 9 right

Nummulites marginata MICHELOTTI 1841, p. 297, pl. 3, figs. 4a-b.
Lepidocyclina marginata (Michelotti). – LEMOINE and DOUVILLÉ 1904, p. 16-17, pl. 1, fig. 7; pl. 2, figs. 7, 9, 11, 20; pl. 3, figs. 3, 8-9, 13. – GEYN and VAN DER VLERK 1935, p. 253, figs. 25-27. – SILVESTRI 1937, p. 171-172, pl. 13, fig. 4.
Lepidocyclina morgani LEMOINE and DOUVILLÉ 1904, p. 17, pl. 1, figs. 12, 15, 17; pl. 2, figs. 4, 12; pl. 3, fig. 2. – SCHEFFEN 1932, p. 97-99, pl. 1, figs. 1-3 (Text-fig. 1.
Lepidocyclina (Nephrolepidina) parva OPPENOORTH 1918, p. 255, pl. 8, figs. 11-12; pl. 9, fig. 9. – COLE 1954, p. 589-592, pl. 212, figs. 1-28; pl. 217, figs. 12-14; pl. 222, figs. 1-3.
Nephrolepidina marginata (Michelotti). – DOUVILLÉ 1925, p. 76-77, figs. 58-59; pl. 2, figs. 5-6. – LLUECA 1929, p. 348-350, pl. 32, figs. 11-21, pl. 33, fig. 28. – MATSUMARU 1992, p. 260-262, figs. 2-1-4. – MATSUMARU 1996, p. 36-37, 182, 184, 186, 188, pl. 71, figs. 1-3; pl. 72, figs. 1-6; pl. 73, figs. 1-5; fig. 22. 15 a-c.
Lepidocyclina (Amphilepidina) nipponica HANZAWA 1931, p. 151-152, pl. 25, fig. 2 (non figs. 1, 3-5; pl. 24, figs. 1-7, 11)
Lepidocyclina (Amphilepidina) scabra HANZAWA 1931, p. 165-166, pl. 27, figs. 14-15; pl. 28, figs. 2-4.
Lepidocyclina verrucosa SCHEFFEN 1932, p. 33-34, pl. 7, figs. 2-4. – COLE 1954, p. 593-594, pl. 213, figs. 1-4.
Lepidocyclina marginata (Michelotti) var. *nummulitoides* SILVESTRI 1937, p. 173, pl. 13, fig.3.
Lepidocyclina (Nephrolepidina) marginata (Michelotti). – BRÖNNIMANN 1940, p. 54-55, pl. 4, figs. 5, 7-8; pl. 5, figs. 13 19-20.
Lepidocyclina (*Nephrolepidina*) *plicomargo* HANZAWA 1940, p. 786-787, pl. 41, figs. 1-5
Lepidocyclina (Nephrolepidina) morgani Lemoine and Douvillé, – HANZAWA 1957, p. 79, pl. 19, figs. 2a-d; pl. 22, figs. 9-10.
Nephrolepidina morgani (Lemoine and Douville). – LANGE 1968, p. 63-65, 67-68; pl. 1, fig. 2. – MATSUMARU 1971, p. 172, pl. 18, figs. 1-4, 6-11 (non fig. 5); pl. 19, figs. 1-4, 7, 11-13 (non figs. 5-6, 8-10, 14-15).
Nephrolepidina japonica (Yabe). – MATSUMARU 1971, p. 166, 168, pl. 14, figs. 3-6 (non figs. 1-2); pl. 17, figs. 12-18 (non figs. 7-11, 19).
Nephrolepidina angulosa (Provale). – MATSUMARU 1971, p. 168-169, pl. 14, figs. 16-17.

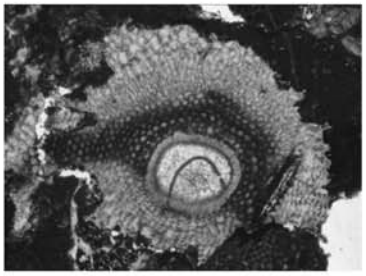
PLATE 35

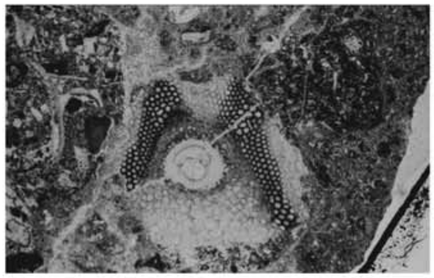
Fig. 1, Station 11480; figs. 10-13, Station TR 2-039; fig. 14, Station 11478; Mindoro; Fig. 2, Station 31058, and fig. 15, Station CLG7, Bondoc Peninsula, SE Luzon; fig. 3, Station BG 6B, Bontoc, N. Luzon; fig. 4, Station 7450713, Samar; fig. 5, Station 7442628, Cebu; figs. 6-9, Station A 3, NE Luzon.

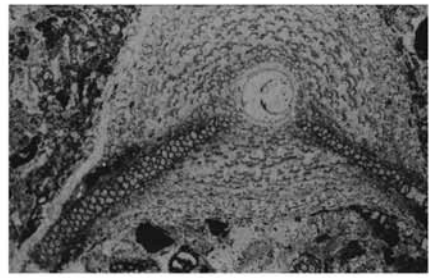
1-9 *Eulepidina ephippioides* (Jones and Chapman). 1, 3, 5-9, oblique sections. 2, 4, tangential sections. Figs 1-6, 8, 9, ×10;. 7, ×5.

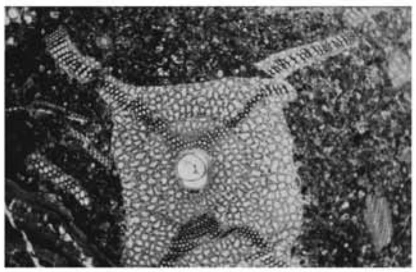
10, 11 *Pararotalia mecatepecensis* (Nuttall). 10 left and center, axial and transverse sections. 11, oblique and transverse sections. Both ×20.

10, 12-15 *Paleomiogypsina boninensis* Matsumaru. 10 right, transverse section; 12, equatorial section. 13, 14, oblique sections. 15, tangential section. Figs. 10, 12, 13, ×20; 14, 15, ×50.


1

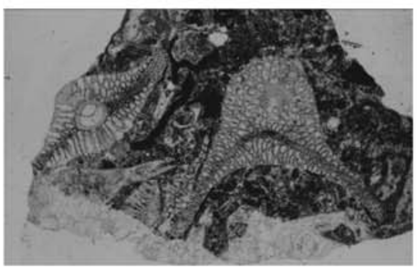

2

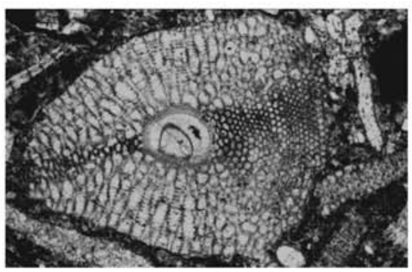

3

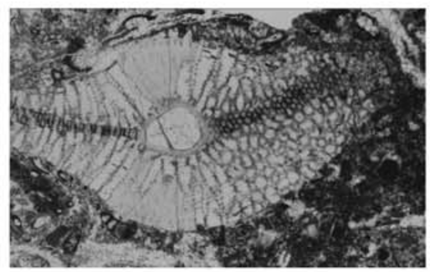

4

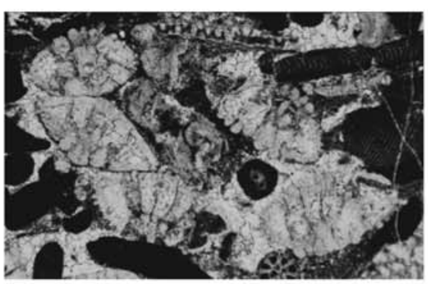

5

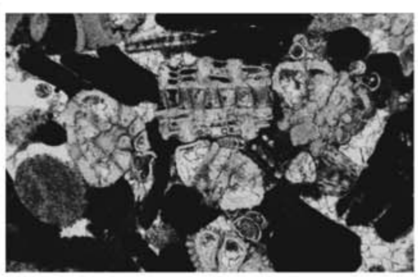

6

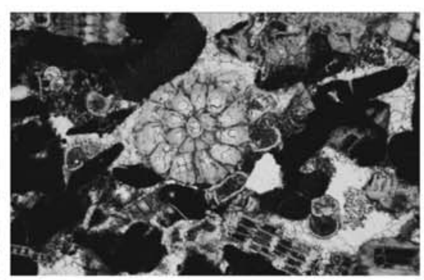

7

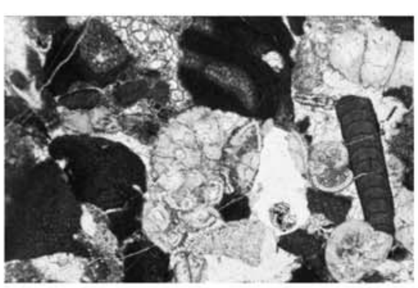

8

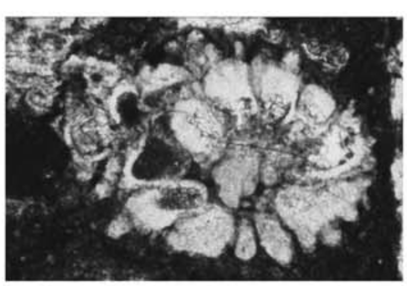

9

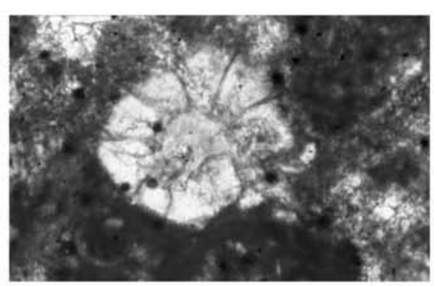

10


11


12


13


14


15

Description: Test is lenticular and polygonal to obese and rounded. Subspherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two primary auxiliary chambers and nepionic chambers. Equatorial chambers are arcuate in early stage, and ogival or rhombic in the adult stage, arranged in intersecting curves. Lateral chambers are rectangular or concavo-convex open cavities in regular tiers over the equatorial layer. Roofs and floors of lateral chambers are thin. Pillars are present in the central boss.

Dimensions: Megalospheric specimens, diameter of test = 2.14 to 3.30 mm, thickness = 0.77 to 1.02 mm, diameter/thickness ratio = 2.25 to 3.63; in 5 specimens, diameter of protoconch = 158 × 105 to 322 × 216 µm, deuteroconch = 276 × 193 to 478 × 229 µm, ratio of deuteroconch/protoconch diameter = 1.27 to 1.93; distance across both protoconch and deuteroconch= 289 to 457 µm; thickness of embryonic chambers = 16 to 20 µm; tangential × radial diameter of primary auxiliary chambers = 68 × 57 to 91 × 45 µm, accessory auxiliary chambers = 80 × 30 to 98 × 39 µm, equatorial chambers = 57 × 68 to 68 × 91 µm; height × length of lateral chambers = 114 × 30 to 172 × 43 µm; number of lateral chambers per tier over embryonic chambers = 8 to 10; thickness of roofs and floors = 6 to 15 µm; diameter of pillars = 55 to 125 µm. Microspheric specimens, diameter of test = 4.20 to 5.20 mm, thickness = 2.34 to 3.56 mm, diameter/thickness ratio = 1.46 to 1.79, length × height of lateral chjambers = 91 × 23 to 136 × 27 µm; lateral chambers in tiers over embryo = 30; thickness of roofs and floors = 9 to 27 µm; diameter of pillars = 181 to 250 µm.

Remarks: Differs from *Lepidocyclina isolepidinoides* Van der Vlerk in consistently nephrolepidine embryonic chambers and heavy pillars. *Nephrolepidina plicomargo* Hanzawa, with the same characteristics, is a junior synonym, as are numerous other species (see synonymy). *Nephrolepidina marginata* evolved into *N. tournoueri* with similar intersecting curves of equatorial chambers (Matsumaru 1996); both occur throughout the Tethys realm during the early to late Oligocene.

Lower to upper Oligocene, Tertiary d (tab. 6) to Tertiary e4 (tab. 9).

Nephrolepidina sumatrensis (Brady 1875)
Plate 33, figures 1-6, 9 center; Pl. 44, figure 3 right

Orbitoides sumatrensis BRADY 1875, p. 536, pl. 14, figs. 3 a-c.
Orbitoides (Lepidocyclina) sumatrensis Brady. – NEWTON and HOLLAND 1899, p. 259, pl. 10, figs. 7-9.
Lepidocyclina sumatrensis Brady. – DOUVILLÉ 1912, p. 271, pl. 20, figs. 7-9 (Text-figs. 2-3.
Lepidocyclina (Amphilepidina) sumatrensis Brady. – DOUVILLÉ 1925, p. 108-110, text-figs. 74-78.
Lepidocyclina (Nephrolepidina) sumatrensis Brady. – YABE and HANZAWA 1925, p. 108, pl. 25, fig. 6; pl. 26, figs. 13-14; pl. 27, fig. 16. – VAN DER VLERK 1928, p. 14, 37-38, fig. 26. – YABE and HANZAWA 1929, p. 171, pl. 23, figs. 3-5. – YABE and HANZAWA 1930, p.31, pl. 6, figs. 4, 8-9; pl. 11, fig. 13. – COLE 1953, p. 32-33, pl. 10, figs. 7-10; pl. 11, figs. 4-5. – COLE 1957, p. 773-775, pl. 239, figs. 2-4 (non fig. 1); pl. 241, figs. 9, 17-23, 26-28 (non figs. 1-8, 10-16, 24-25, 29-30); pl. 242, figs. 3-20. – MATSUMARU 1996, p. 36, fig. 22. 16a-c.
Lepidocyclina (Nephrolepidina) sumatrensis (Brady) var. *inornata* RUTTEN 1914, p. 294-295, pl. 22, figs. 6-8. – VAN DER VLERK 1928, p. 14, 38, fig. 27. – COLE 1954, p. 593, pl. 215, fig. 22.
Lepidocyclina (Nephrolepidina) sumatrensis (Brady) var. *minor* RUTTEN 1911, p. 1158. – RUTTEN 1914, p. 296-297, pl. 22, fig. 9. – VAN DER VLERK 1928, p. 14, 38-39, figs. 28 a-b, 55. – HENRICI 1934, p. 50, text-figs.23-24.
Lepidocyclina (Nephrolepidina) sondaica YABE and HANZAWA 1929, p. 172-173, pl. 20, fig. 8; pl. 21, figs. 5-6; pl. 27, fig. 5. – YABE and HANZAWA 1930, p. 29-30, pl. 6, fig. 11; pl. 9, figs. 5-7.
Lepidocyclina (Nephrolepidina) sumatrensis (Brady) forma *mirabilis* YABE and HANZAWA 1930, p. 31-32, pl. 6, figs. 1-7; pl. 7, figs. 1-11.
Lepidocyclina (Nephrolepidina) bikiniensis COLE 1957, p. 772, pl. 242, fig. 21.

PLATE 36

All ×20. Fig. 1, Station MQ 14, Marinduque; fig. 2, Station TR 2-039; fig. 4, Station 11480; fig. 6, Station 11478; Mindoro; fig. 3, Station CLG 7; figs. 7, 9, 10, Station 31058; and figs. 11, 13, 14, Station At8; Bondoc Peninsula, SE Luzon; fig. 5, Station 7682904, and figs. 8, 12, Station 7682902, Negros; fig.15, Station RZ 3, Mid-Luzon.

1 *Paleomiogypsina boninensis* Matsumaru. oblique section of a reworked specimen.

2-6 *Miogypsinella boninensis* Matsumaru. 2, 5, equatorial sections. 3, 4, 6, oblique sections.

2 *Heterostegina duplicamera* Cole and *Spiroclypeus margaritatus* (Schlumberger). 2 left and lower, transverse sections.

5 *Heterostegina duplicamera* Cole. 5 left, transverse section.

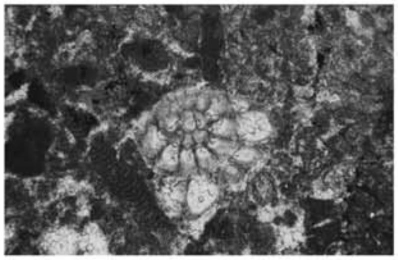
7-9 *Miogypsinella ubaghsi* (Tan). 7, tangential and transverse sections. 8, equatorial section, showing trochoidal coil of early stage of a megalospheric specimen. 9 left, transverse sections.

9 *Nephrolepidina marginata* (Michelotti). 9 right, axial section.

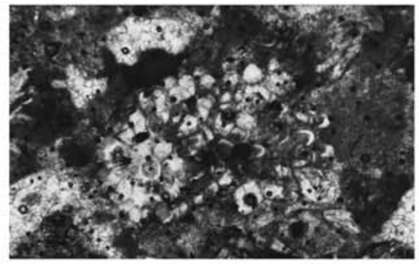
10-14 *Miogypsinella complanata* (Schlumberger). 10, axial section. 11, equatorial section. 12, 13 lower, 14, oblique sections.

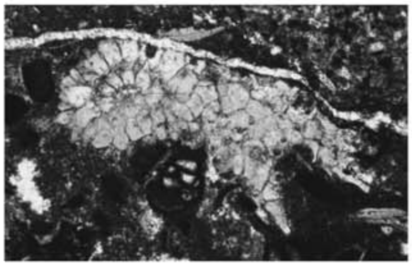
13 *Operculina* spp. 13 upper, axial section of broken specimen.

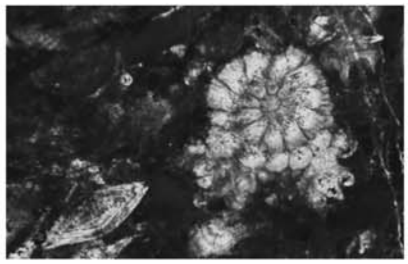
15 *Miogypsinoides formosensis* Yabe and Hanzawa. Equatorial section.

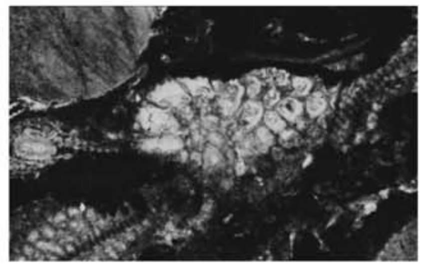

1

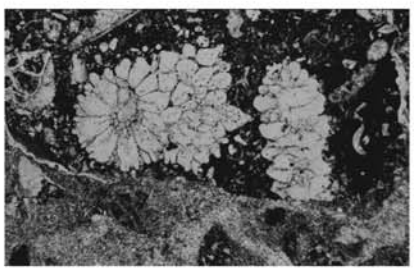

2


3

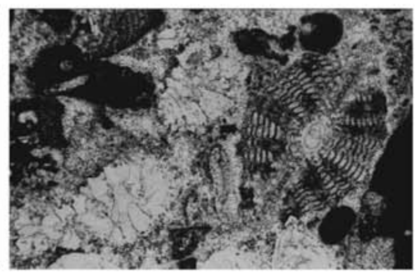

4


5

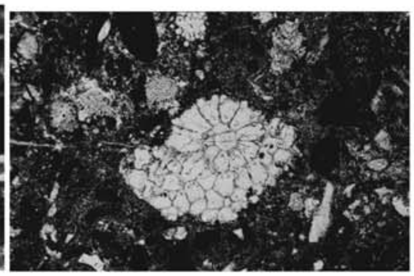

6


7

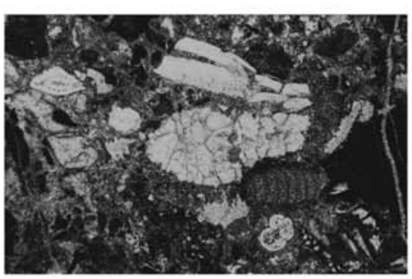

8

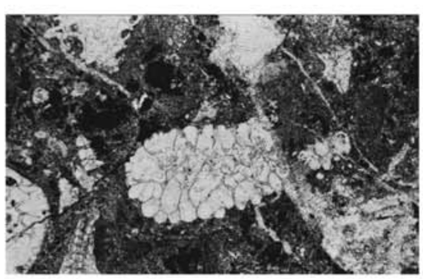

9

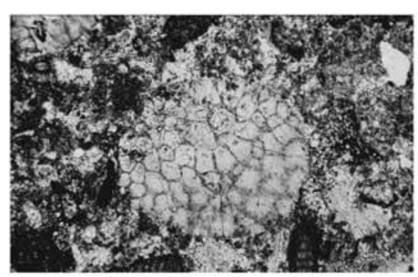

10


11


12


13


14


15

Description: Test subglobular with thin flange, polygonal outline and smooth surface. Subspherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two primary auxiliary chambers and nepionic chambers. Arcuate, ogival or rhombic equatorial chambers form intersecting curves. Spacious, concavo-convex lateral chambers with thin roofs and floors are in regular tiers over the equatorial layer. Pillars absent except occasionally in the central boss. Early stage in the microspheric form shows a symmetric biserial nepiont, type C (cf. Matsumaru 1991, p. 889) with X= 9 and 10, Y = 5, and Z = 11.

Dimensions: Megalospheric specimens, diameter of test = 1.41 to 3.82 mm, thickness = 1.2 to 1.8 mm, diameter/thickness ratio = 1.6 to 3.0; in 12 specimens, diameter of protoconch = 82 × 68 to 250 × 180 µm, deuteroconch = 125 × 51 to 350 × 150 µm, deuteroconch/protoconch diameter = 1.20 to 1.55; distance across both protoconch and deuteroconch = 116 to 330 µm; Thickness of embryonic wall = 11 to 26 µm; tangential × radial diameter of primary auxiliary chambers = 35 × 24 to 122 × 68 µm, accessory auxiliary chambers = 39 × 19 to 98 × 57 µm, equatorial chambers = 45 × 45 to 53 × 88 µm; length × height of lateral chambers100 × 33 to 118 × 40 µm; thickness of roofs and floors = 5 to 14 µm; lateral chambers per tier = 12 to 15; diameter of pillars = 22 to 48 µm. Microspheric specimens, diameter of proloculus = 14 µm, thickness of proloculus wall = 2 µm.

Remarks: Differs from *Nephrolepidina marginata* only in its smaller test and pillars, and may be a junior synonym (Matsumaru 1996, p. 186) following Lemoine and R. Douville (1904). Stout lenticular pillars and equatorial chambers arranged in intersecting curves are also found in co-existing *N. brouweri* and suggest an evolutionary relationship.

Lower Oligocene to lower Miocene, and Tertiary d to Tertiary f2.

Nephrolepidina rutteni (Van der Vlerk 1924)
Plate 33, figure 9 left upper; plate 34, figures 2-3

Lepidocyclina rutteni VAN DER VLERK 1924, p. 17-21, pl. 3, figs. 1-4. – CAUDRI 1939, p. 218-221, pl. 8, figs. 61-62, 64-65 (non fig. 63). – VAN VESSEM 1978, p. 129, pl. 9, figs. 2-3; pl. 10, fig. 13.
Lepidocyclina leytensis YABE and HANZAWA 1925, p. 107, 109, pl. 25, figs. 8-9; pl. 26, figs. 11-12; pl. 27, figs. 12-13, 15 (non fig. 14).
Lepidocyclina (Trybliolepidina) rutteni VAN DER VLERK 1928, p. 186, 202, pl. 10, figs. 12 a-c. – MATSUMARU 1981, p. 116-118, figs. 10-18.
Lepidocyclina (Amphilepidina) nipponica HANZAWA 1931, p. 151-152, pl. 24, figs. 4, 6-7, 11 (non figs. 1-3, 5; pl. 25, figs. 1-5). – HANZAWA 1931, p. 162-163, pl. 27, figs. 1-4.
Lepidocyclina (Nephrolepidina) rutteni Van der Vlerk. – COLE 1945, p. 289-290, pl. 27, figs. A-G.
Lepidocyclina (Nephrolepidina) makiyamai MORISHIMA 1949, p. 212-213, pl. 44, figs. 1-2, 4 (non fig. 3); pl. 45, fig. 2 (non figs. 1, 3-4).
Lepidocyclina (Nephrolepidina) palauensis COLE 1950, p. 25-26, pl. 5, figs. 12-13.
Nephrolepidina japonica (Yabe). – MATSUMARU 1971, p. 166, 168, pl. 23, fig. 6; pl. 24, figs. 3-6.
Nephrolepidina rutteni (Van der Vlerk). – MATSUMARU 1992, p. 260, figs. 1-8-11.

Description: Test large, thin lenticular with polygonal outline, smooth except for reticulate net of septal filaments and weak pillars. Subspherical protoconch and reniform deuteroconch; of advanced nephrolepidine to trybliolepidine types are followed by two primary auxiliary chambers and 6 to 9 accessory auxiliary chambers on the deuteroconchal wall. Equatorial chambers are arcuate in the center and ogival to hexagonal or spatulate in the adult stage, in polygonal or subcircular arrangement. Lateral chambers are large and subcircular or reniform, in regular tiers over the equatorial layer. Roofs and floors of lateral chambers are rather thin.

Dimensions: Dimeter of test = 2.45 to 7.00 mm, thickness = 1.27 to 1.80 mm, diameter/thickness ratio = 2.87 to 4.00; in 7 specimens, diameter of protoconch = 140 × 146 to 432 × 395 µm; deuteroconch = 272 × 64 to 773 × 227 µm; deuteroconch/protoconch diameter ratio = 1.63 to 2.18; distance across

---

PLATE 37

Fig. 1, Station 7682904, and figs. 3-6, 8-10, 15, Station 7682906, Negros; fig 2, Station RZ3, Mid-Luzon; fig. 7, Station E26, East Mindanao; figs. 11-13, Station BG9, Bontoc, North Luzon; fig. 14, Station C58, East Mindanao.

1 *Miogypsinella complanata* (Schlumberger). Transverse section, ×20.

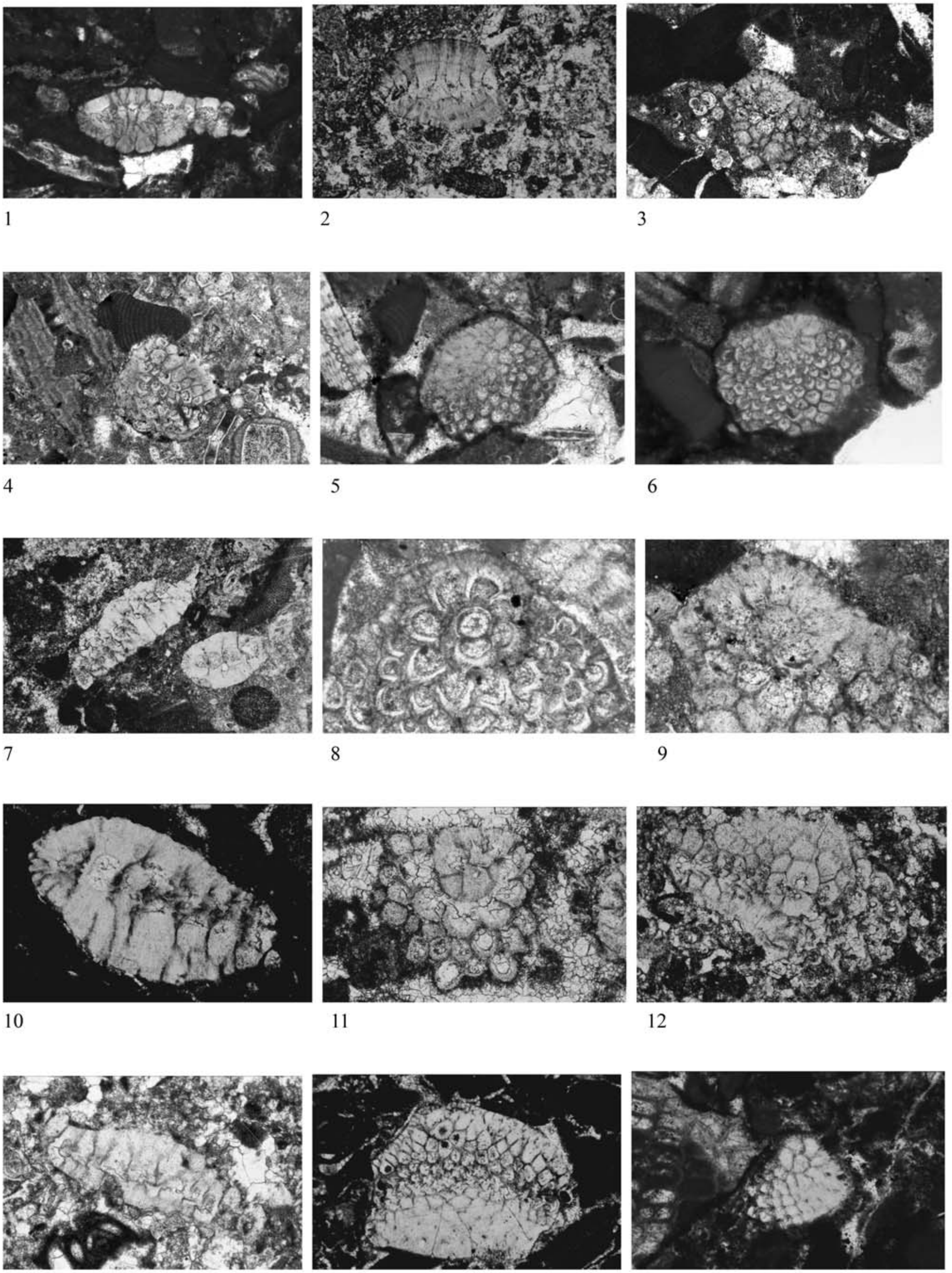
2 *Miogypsinoides formosensis* Yabe and Hanzawa. axial section, cut perpendicular for apical-frontal line of megalospheric specimen, ×20.

3-7 *Miogypsinoides bantamensis* (Tan). 3-4. Equatorial sections. 5-6. tangential sections. 7 left, oblique section. Figs. 3-6, ×20. 7, ×10.

7, 14, 15 *Miogypsinoides dehaartii* (van der Vlerk). 7 right, axial section. 14. Equatorial section. 15. tangential section. Fig. 7, ×10; 14, 15, ×20.

8-10 *Boninella negrosensis* Matsumaru, n. sp. 8 (holotype), 9, equatorial sections. 10 (paratype), axial section, both ×50.

11-13 *Luzonella trochidiformis* Matsumaru, n. gen., n. sp. 11, tangential section. 12 (holotype), equatorial section. 13 (paratype), axial section, all ×50.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

protoconch and deuteroconch = 215 to 618 µm; thickness of embryonic chambers wall = 31 to 72 µm; tangential × radial diameter of primary auxiliary chambers = 39 × 30 to 200 × 77 µm, auxiliary chambers = 38 × 38 to 195 × 105 µm, equatorial chambers = 68 × 91 to 164 × 163 µm; length × height of lateral chambers = 182 × 20 to 230 × 55 µm; thickness of roofs and floors = 11 to 27 µm; number of lateral chambers per tier = 11 to 12; diameter of pillars = 68 to 100 µm.

Remarks: Nephrolepidina rutteni (Van der Vlerk) with trybliolepidine embryonic chambers evolved from *Nephrolepidina japonica* due to embryonic acceleration (Factor A: Vlerk 1959, Matsumaru 1971).

Middle to late Miocene,Tertiary f1 to f3.

Nephrolepidina brouweri (Rutten 1923)
Plate 32, figures 4 right, 5-6

Lepidocyclina brouweri RUTTEN 1923, p. 182, figs. 22-29.
Lepidocyclina (Nephrolepidina) brouweri Rutten. – VAN DER VLERK 1928, p. 15, 23, figs. 17 a-b. – YABE and HANZAWA 1929, p. 173, pl. 18, fig. 4; pl. 25, figs. 8-9 (non pl. 20, figs. 5-6; pl. 26, fig. 8?). – YABE and HANZAWA 1930, p. 28, pl. 26, fig. 11. – COLE 1953, p. 28-29, pl. 9, fig. 1; pl. 12, figs. 5, 14 (non pl. 8, fig. 1; pl. 11, fig. 3). – COLE 1957, p. 342-343, pl. 105, figs. 1-10.
Lepidocyclina (Nephrolepidina) verrucosa Scheffen. – COLE 1957, p. 345, pl. 105, figs. 11-17; pl. 109, figs. 4-6.
Lepidocyclina (Nephrolepidina) sumatrensis (Brady). – COLE 1957, p. 773-775, pl. 239, fig. 2 (non figs. 1, 3-4); pl. 241, figs. 24-25, 29-30 (non figs. 1-23, 26-28); pl. 242, fig. 17 (non figs. 3-16, 18-20).

Description: Test inflated lenticular, with an apical crown bordered by a narrow flange and ornamented with large prominent papillae. Subspherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two primary auxiliary chambers and nepionic chambers. Equatorial chambers are arcuate, ogival or rhombic, arranged in intersecting curves. Lateral chambers are rectangular, in regular tiers over the equatorial layer. Roofs and floors of lateral chambers are thin, and large pillars are present in the central or peripheral portion of test.

Dimensions: Megalospheric specimens, diameter of test = 1.54 to 1.98 mm, thickness = 1.09 to 1.50 mm, diameter/thickness ratio = 1.26 to 1.82; diameter of protoconch = 108 × 95 and 208 × 178 µm in 2 specimens, deuteroconch = 128 × 39 and 144 × 50 µm, deuteroconch/protoconch diameter ratio =1.19 and 1.57; distance across protoconch and deuteroconch = 136 and 148 µm; thickness of embryonic chambers wall = 16 to 23 µm; tangential × radial diameter of primary auxiliary chambers = 61 × 45 to 68 × 36 µm, equatorial chambers = 39 × 57 to 68 × 70 µm; length × height of lateral chambers = 114 × 38 to 160 × 30 µm; thickness of roofs and floors = 7 to 27 µm; number of lateral chambers per tier = 12 to 14; diameter of pillars = 160 to 341 µm. Microspheric specimens, diameter of test = 2.45 mm, thickness = 1.50 mm, diameter/thickness = 1.63 to 1.83; length × height of lateral chambers = 91 × 68 to 91 × 90 µm; thickness of roofs and floors = 18 to 24 µm; number of lateral chambers per tier = 20; diameter of pillars = 250 to 409 µm.

Remarks: Synonymous with *N. sumatrensis* according to Cole (1957), but in fact it differs in the prominent papillae in the central boss which also distinguish it from its descendant *Nephrolepidina ferreroi* (Provale 1909).

Upper Oligocene, Tertiary e1-2 to Tertiary e4.

Nephrolepidina ferreroi (Provale 1909)
Plate 32, figures 7-12, 13 right; plate 43, figure 10 left

Lepidocyclina ferreroi PROVALE 1909, p. 29, pl. 2, figs. 7-13. – RUTTEN 1914, p.293-294, pl. 22, figs. 1-5. – CAUDRI 1939, p. 223-225.
Lepidocyclina (Nephrolepidina) ferreroi Provale. – VAN DER VLERK 1928, p. 15, 26-27, figs. 20 a-c. – YABE and HANZAWA 1929, p. 170-171, pl. 19, figs. 9-10; pl. 20, fig. 2; pl. 22, fig. 5. – HANZAWA 1930, p. 92-93, pl. 26, fig. 18; pl. 27, figs. 11-12. – HANZAWA 1957, p. 77-78, pl. 22, figs. 6-7. – COLEMAN 1963, p. 17, pl. 5, figs. 8-14.

PLATE 38

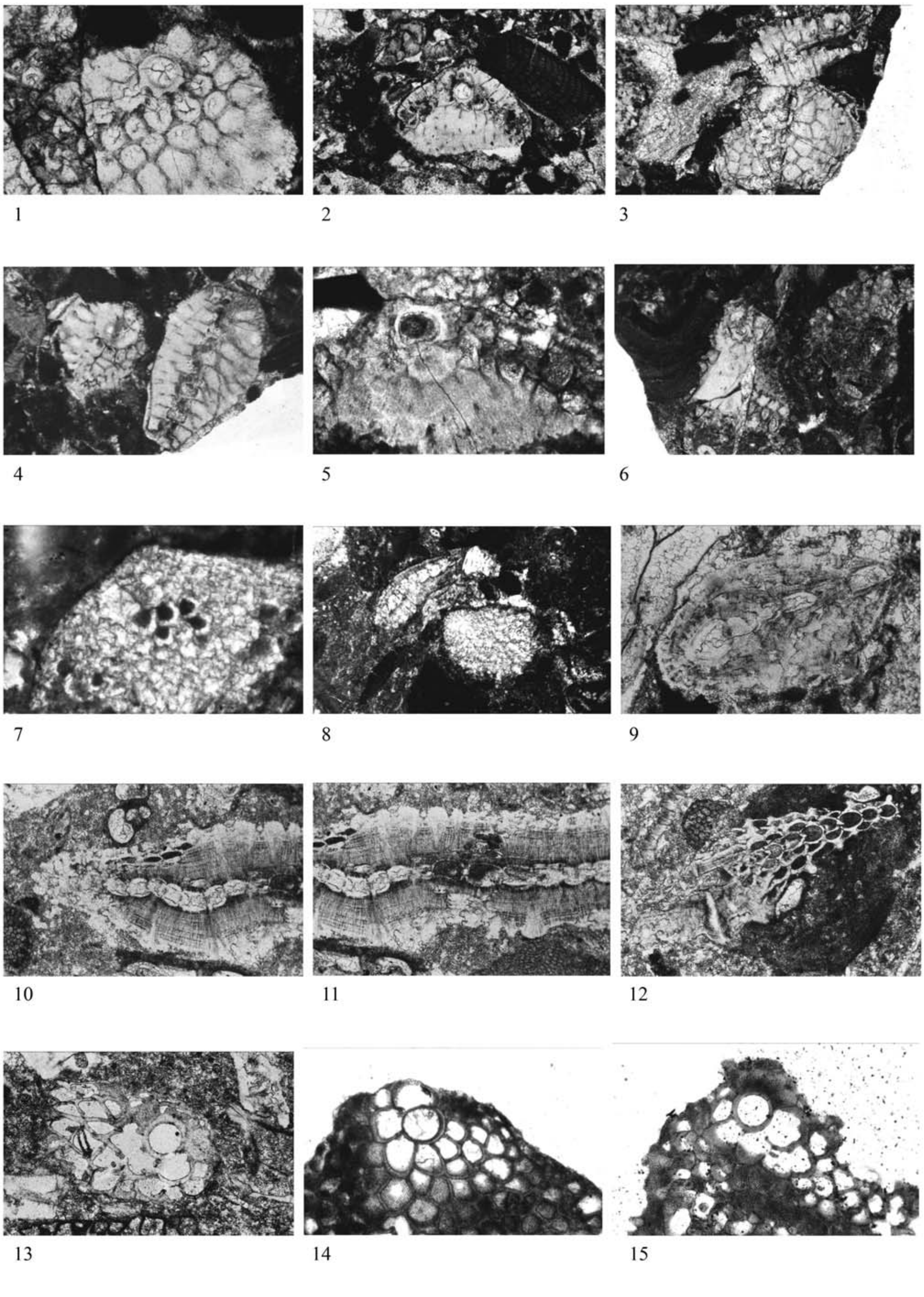
All × 20 except figs. 13-15, ×15. Figs. 1-4, Station C 58, East Mindanao; figs. 5-8, Station C 56 and nearby, NE Luzon; figs. 9, 12, Station PN 20, Panay; figs. 10, 11, Station MQ 7, and fig. 13. Station MQ 28, Marinduque; fig 14, Station 7, Hirashio, and fig. 15, Station 22, Dogo; Hirashio Formation, Japan (Matsumaru and Takahashi 2004, text-figs. 19 and 18, resp.)

1-4 *Miogypsinoides dehaartii* (van der Vlerk). 1, 3 lower, equatorial sections. 2, 4 left. tangential sections. 3 upper, 4 right, axial sections. × 20.

5-12 *Miogypsina primitiva* Tan. 5, tangential section. 6, 7. Equatorial sections. 8 left, 12, axial sections. The specimen in fig. 12 is a genetic mixture of *Mioypsinoides* without lateral chamber and *Miogypsina* with a lateral chamber layer. 5, 7, 9-12. × 50; 6, 8.x 20.

8 *Miogypsina globulina* (Michelotti). 8 right, equatorial section. ×20.

13-15 *Miogypsina borneensis* Tan. Equatorial sections. 15 has 5 nepionic chambers, × 50.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Description: Test thick, lenticular biconvex, subquadrate to asteroidal outline with 4 or 5 rays. Central boss is strongly elevated and flat-topped with a narrow to broad peripheral flange and ornamented by prominent pillars, that are also developed along the axis of rays. Subspherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two primary auxiliary chambers and nepionic chambers. Equatorial chambers are arcuate, ogival, short hexagonal or spatulate, in intersecting curves that become subquadrangular polygons or asteroidal arrangement towards the periphery. Lateral chambers are rectangular or concavo-convex open cavities in tiers over the equatorial layer. Roofs and floors of lateral chambers are thin.

Dimensions: Diameter of test = 1.60 to 2.48 mm, thickness of test = 0.42 to 1.34 mm, diameter/thickness ratio = 1.85 to 3.81; in 9 specimens, diameter of protoconch = 72 × 61 to 266 × 216 µm, deutroconch = 135 × 44 to 440 × 148 µm, deuteroconch/protoconch diameter ratio = 1.09 to 1.88; distance across both protoconch and deuteroconch = 104 to 360 µm; thickness of embryonic chambers wall = 13 to 35 µm; tangential × radial diameter of primary auxiliary chambers = 35 × 26 to 55 × 35 µm, accessory auxiliary chambers = 35 × 28 to 57 × 26 µm, equatorial chambers = 35 × 35 to 44 × 52 µm; length × height of lateral chambers = 80 × 27 to 166 × 45 µm; number of lateral chambers per tier = 6 to 8; thickness of roofs and floors = 6 to 16 µm; diameter of pillars = 88 to 210 µm.

Remarks: This species arises from *Nephrolepidina brouweri* and evolves into *N. angulosa* Provale, all with equatorial chambers arranged in intersecting curves (table 18).

Upper Oligocene to middle Miocene, Tertiary e4 to f1.

Nephrolepidina angulosa (Provale 1909)
Plate 33, figures 11-12

Orbitoides (Lepidocyclina) angularis NEWTON and HOLLAND 1902, p. 10-11, pl. 1, figs. 1, 6; pl. 3, fig. 7.
Lepidocyclina tournoueri Lemoine and Douvillé var. *angulosa* PROVALE 1909, p. 28, pl. 3, figs. 13-15.
Lepidocyclina angulosa Provale. – RUTTEN 1913, p. 291, pl. 21, figs. 1-4.
Lepidocyclina (Nephrolepidina) angulosa Provale. – OPPENOORTH 1918, p. 253, pl. 9, figs. 4-6. – YABE 1919, p. 47, pl. 7, fig. 8. – YABE and HANZAWA 1924, p. 74-76, pl. 9, figs. 1-2; pl. 10, figs. 1-2; pl. 11, figs. 1-2; pl. 12, figs. 2-6. – YABE and HANZAWA 1929, p. 170, pl. 20, fig. 3 (non fig. 7); pl. 21, fig. 1 (non figs. 2-4); pl. 25, fig. 7 (non pl. 18, fig. 3?; pl. 23, fig. 1; pl. 27, figs. 6-7). – HANZAWA 1957, p. 76-77, pl. 20, figs. 1-4, 6-7 (non figs. 5, 8-9); pl. 21, fig. 5; pl. 22, fig. 4 (non fig. 14).
Lepidocyclina (Nephrolepidina) angularis Newton and Holland. – YABE and HANZAWA 1930, p. 27-28, pl. 10, fig. 7; pl. 11, figs. 2, 4. – COLE 1957, p. 342, pl. 107, figs. 13-14.
Lepidocyclina (Amphilepidina) angulosa Provale. – HANZAWA 1931, p. 164, pl. 27, figs. 9-13.
Lepidocyclina (Amphilepidina) polygonalis HANZAWA 1931, p. 164-165, pl. 28, figs. 8-9.
Lepidocyclina dehiscens SCHEFFEN 1932, p. 23-24, pl. 2, figs. 1-2.
Lepidocyclina verrucosa SCHEFFEN 1932, p. 33-34, pl. 7, figs. 2-4. – CAUDRI 1939, p. 179-185, figs. 26-30, 42, 46.
Lepidocyclina (Nephrolepidina) verbeeki Newton and Holland. – COLE 1957, p. 344-345, pl. 106, fig. 7? (non figs. 2-3, 6-7, 9-10); pl. 107, fig. 12 (non figs. 1-11, 16); pl. 109, fig. 7? (non fig. 8).
Nephrolepidina angulosa (Provale). – MATSUMARU 1971, p. 168-169, pl. 12, figs. 1-10; pl. 13, figs. 1-11; pl. 14, figs. 7-15, 18-21 (non figs. 16-17); pl. 20, fig. 3; pl. 22, fig. 5; pl. 23, fig. 4. – MATSUMARU 1992, p. 259-260, figs. 1-6-7.
Non *Lepidocyclina angulosa* Provale. – DOUVILLÉ 1912, p. 270, pl. 21, figs. 3-5. – VAN VESSEM 1978, p. 127, pl. 10, fig. 9.

Description: Test thick, lenticular; polygonal or rarely asteroidal in outline; flat-topped central boss has a narrow peripheral flange and 7-8 large papillae. Embryonic chamber consist of subspherical protoconch and reniform deuteroconch of nephrolepidine to trybliolepidine type, followed by two primary auxiliary chambers and nepionic chambers. Equatorial chambers are arcuate, ogival or hexagonal in intersecting curves or polygonal and sometimes stellate arrangement. Lateral chambers are rectangular and spaceous in regular tiers over the equatorial layer. Conical pillars are present in the flat-topped central

---

PLATE 39

Figs. 1-2, Station MD 118, and figs. 14, 15, Station MD 112, Mindoro; fig. 3, Station MQ 10; fig.5, 6, 7, Station MQ 19-1 and nearby; fig. 8, Station MQ 5; fig. 9, Station No. 41; Marinduque; fig. 4, Station C57, NE Luzon; fig. 10, Station C57, NE Luzon; fig. 11, Station Komori 15 (CHL), Chichibu Basin, and fig. 13, Station Neishi, Takasaki Region, Japan (Matsumaru 1971, pp. 102-105); fig. 12, Station MBG 10, Masbate.

1,2 *Miogypsina borneensis* Tan. 1, equatorial section. 2, axial section, both ×20.

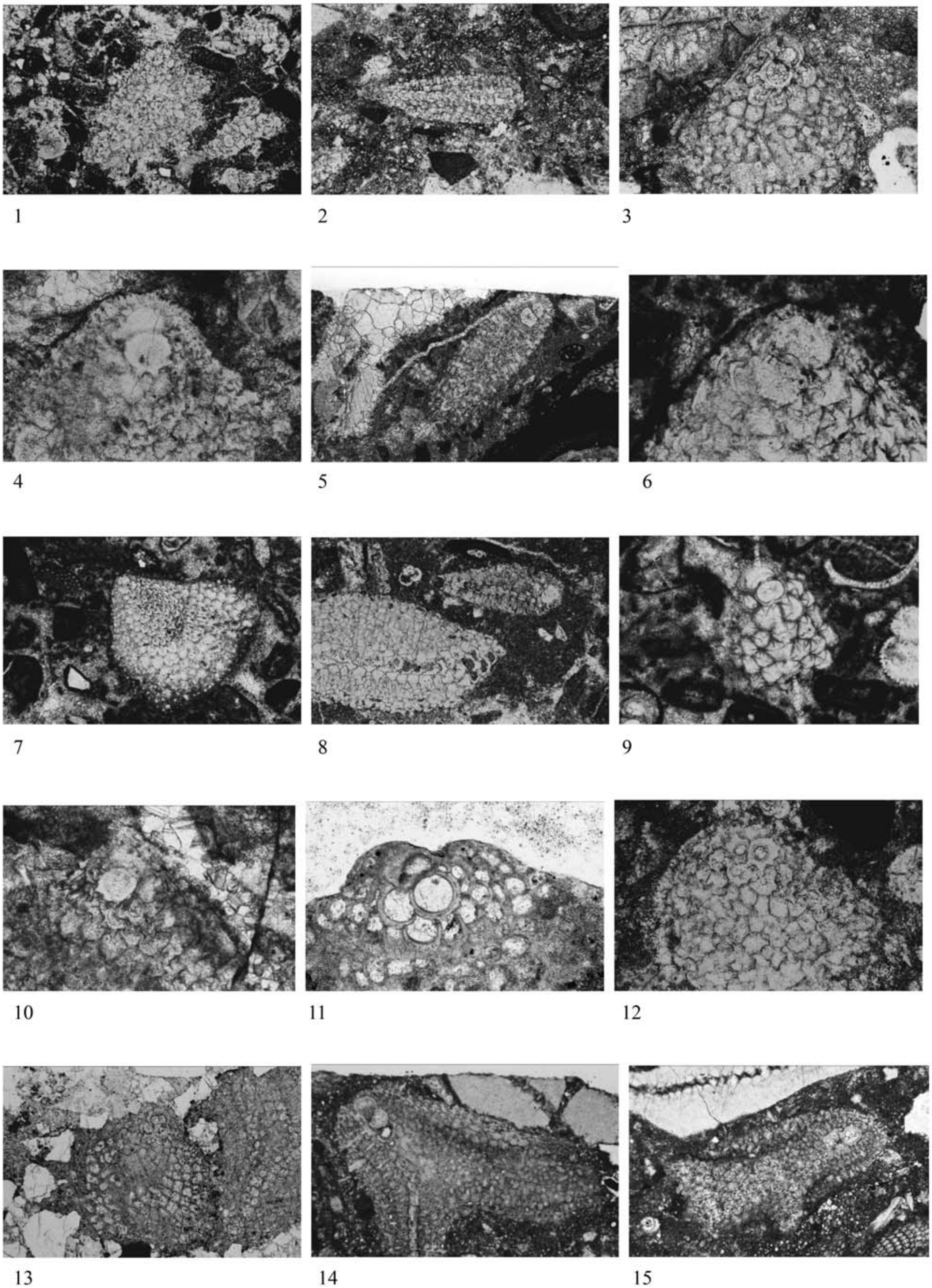
3-5 *Miogypsina globulina* (Michelotti). 3, 4, equatorial sections. 5, axial section. Figs. 3, 4, ×50. 5; ×20.

6-8 *Lepidosemicyclina thecidaeformis* Rutten. 6, 7, equatorial sections. 8 lower, oblique section. Fig. 6, ×100; 7, 8, ×20.

8-11 *Miogypsina intermedia* Drooger. 8 upper, axial section. 9-11, equatorial sections. Fig. 8, ×20.

12,13 *Miogypsina cushmani* Vaughan. 12, tangential section. 13, equatorial section. This is a comparative specimen. 12, ×50. 13, ×20.

14,15 *Lepidosemicyclina polymorpha* Rutten. Equatorial sections, ×20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

boss. Microspheric form are symmetrical nepiont, type D (Matsumaru 1991): × value = 11, Y value = 6, and Z value = 12.

Dimensions: Macrospheric specimens diameter of test = 1.77 to 3.07 mm, thickness = 0.64 to 1.39 mm, diameter/thickness ratio = 1.70 to 2.77; in 6 specimens, diameter of protoconch = 87 × 90 to 210 × 150 µm, deuteroconch = 152 × 40 to 340 × 110 µm, deuteroconch/protoconch diameter ratio = 1.56 to 1.92, distance across both protoconch and deuteroconch = 130 to 320 µm; thickness of embryonic chamber wall = 18 to 27 µm, tangential/protoconch diameter ratio = 45 × 23 to 123 × 59 µm; auxiliary chambers = 34 × 23 to 145 × 45 µm, equatorial chambers = 48 × 60 to 59 × 70 µm; length × height of lateral chambers = 102 × 11 to 182 × 35 µm; thickness of roofs and floors of lateral chambers = 14 to 25 µm; number of lateral chambers per tier = 8 to 16; diameter of pillars = 120 to 254 µm. Microspheric specimens, diameter of proloculus = 18 µm, thickness of proloculus wall = 2 µm.

Remarks: Nephrolepidina angularis (Newton and Holland 1902) from Iriomote-Jima, Japan may be a senior synonym, judging by the arrangement of equatorial chambers in the topotype specimens. *Nephrolepidina angulosa* evolved from *N. ferreroi* and evolved into *N. martini* (Schlumberger) with similar stout pillars and equatorial chamber arrangement.

Late early Miocene to middle Miocene, Tertiary f1 to Tertiary f2.

Nephrolepidina japonica (Yabe 1906)
Plate 33, figures 7, 8 right, 9 right, 10

Orbitoides (Lepidocyclina) japonica YABE 1906, p. 317-320, figs. 1-2.
Lepidocyclina (Nephrolepidina) japonica Yabe. – YABE and HANZAWA 1922, p. 47-48, pl. 6, figs. 3-4; pl. 7, figs. 2-5. – VAN DER VLERK 1928, p. 14, 32, figs. 22 a-c. – COLEMAN 1963, p. 17-18, pl. 6, figs. 1-2, 5 (non figs. 3-4, 6). – CHAPRONIERE 1984, p. 61-62, pl. 20, fig. 13.a
Lepidocyclina (Nephrolepidina) sondaica YABE and HANZAWA 1929, p. 172-173, pl. 20, fig. 3; pl. 21, figs. 5-6; pl. 27, fig. 5. – YABE and HANZAWA 1930, p. 29-30, pl. 6, fig. 11; pl. 9, figs. 5-7.
Lepidocyclina (Amphilepidina) nipponica HANZAWA 1931, p. 151-152, pl. 24, figs. 1-3, 5 (non figs. 4, 6-7, 11); pl. 25, figs. 3-4 (non figs. 1-2, 5); pl. 26, figs. 1-3, 5. – HANZAWA 1931, p. 162-163, pl. 28, fig. 10? (non fig. 11?).
Lepidocyclina (Amphilepidina) japonica Yabe. – HANZAWA 1931, p. 163-164, pl. 28, figs. 5-7.
Lepidocyclina (Nephrolepidina) nipponica (Hanzawa). – HANZAWA 1943, p. 128, pl. 7, figs. 1-7; pl. 8, figs. 1-5. – HANZAWA 1957, p. 80, pl. 19, fugs. 1 a-d, 4 a-c.
Lepidocyclina (Nephrolepidina) makiyamai MORISHIMA 1949, p. 212-213, pl. 44, fig. 3 (non figs. 1-2, 4); pl. 45, figs. 1, 3-4 (non fig. 2).
Nephrolepidina japonica (Yabe). – MATSUMARU 1967, p. 134-141, figs. 6-31, pl. 7, figs. 1-4, 6, 8-9 (non figs. 5, 7); pl. 8, figs. 1-8. – MATSUMARU 1971, p. 166, 168, pl. 9, figs. 1-12; pl. 10, figs. 1-14; pl. 11, figs. 1-8; pl. 14, figs. 1-2 (non figs. 3-6); pl. 17, figs. 7-11, 19 (non figs. 12-18); pl. 20, fig. 5; pl. 21, figs. 1, 3-4; pl. 22, figs. 1, 3-4; pl. 23, figs. 1-3, 7 (non fig. 6); pl. 24, figs. 1-21 (non figs. 3-6). – MATSUMARU 1992, p. 262-263, figs. 2-5-8.
Nephrolepidina praejaponica MATSUMARU 1989, p. 265-267, figs. 6-1-13.
Non *Lepidocyclina (Nephrolepidina) japonica* (Yabe). – COLE 1963, p. E21-22, pl. 10, figs. 1-9, 11, 13-14, 18. – CHAPRONIERE 1984, p. 61-62, pl. 20, figs. 14-16; pl. 24, figs. 16-18.

Description: Test lenticular with an inflated central boss bounded by a narrow flange and ornamented with pillars, present on the central boss. Subspherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two principal auxiliary chambers and nepionic chambers. Equatorial chambers are arcuate, ogival, short hexagonal or spatulate, in intersecting curve or polygonal pattern. Lateral chambers are rectangular open cavities. Roofs and floors of lateral chambers are thin, while pillars are thick. Microspheric specimens are symmetric biserial nepiont, type D (Matsumaru 1991, p. 889).

Dimensions: Megalospheric A2 gamont (figs. 8-9), diameter of test = 1.60 to 3.20 mm, thickness = 0.70 to 1.16 mm, diameter/thickness ratio = 2.29 to 2.98; in 10 specimens, diameter of protoconch = 128 × 104 to 227 × 155 µm, deuteroconch = 200 × 60 to 320 × 100 µm, deuteroconch/protoconch diameter ratio = 1.30 to 1.76, distance across both protoconch and deuteroconch = 190 to 282 µm, thickness of embryonic chamber wall= 18 to

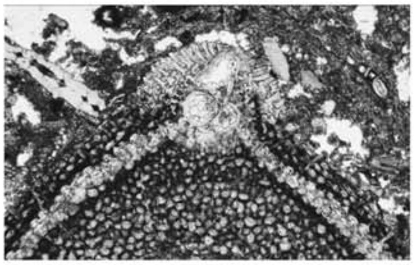
---

PLATE 40

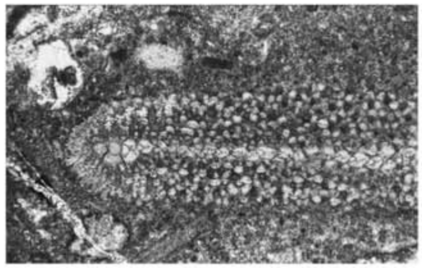
Figs. 1, 10-15, Station MD 112, Mindoro; fig. 2, Station TB 45, Tablas; fig. 3, Station PP 61, Palawan; fig. 4, Station MQ 15, and fig. 9, Station MQ 28, Marinduque; figs. 5, 6, Station PN 20, Panay; figs. 7, 8, Station BG 1 (155), Baguio, North Luzon.

1-3 *Lepidosemicyclina polymorpha* Rutten. 1, equatorial section. 2, 3, axial sections of megalospheric and microspheric specimens. Figs. 1, 2, ×20; 3, ×10.

4-15 *Lepidosemicyclina indonesiensis* (Tan). 4,5, 9, 10, equatorial sections. 6, 13,14, axial sections. 7, 8, 11, 12, oblique sections. The first reported example of **neoteny** in foraminifera is seen in the specimens in Figs. 10 to 14, with only one embryonic chamber. Figs. 4, 11, 12, ×50; 5, 6, 9, 13-15, ×20; 7, 8, 10, ×10.

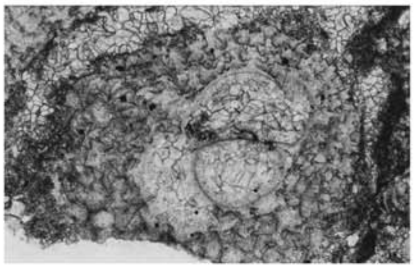


1

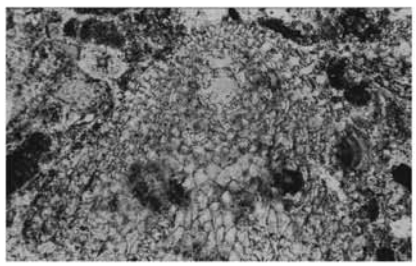


2

3

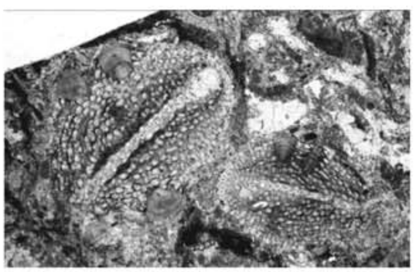


4

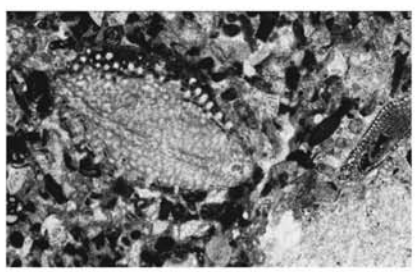


5

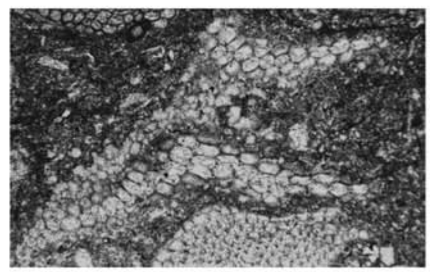
6



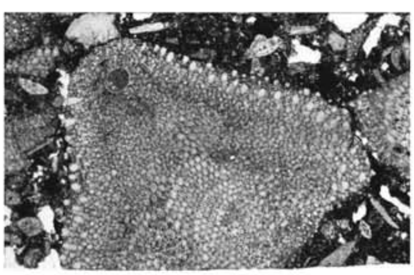
7



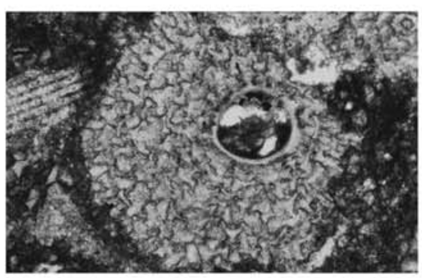
8



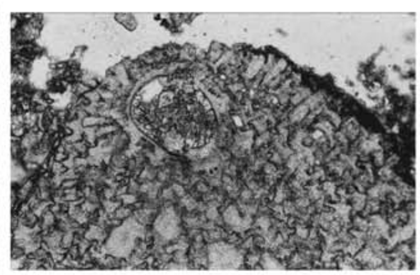
9



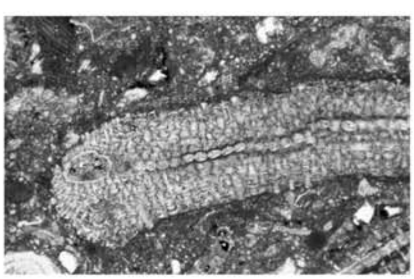
10



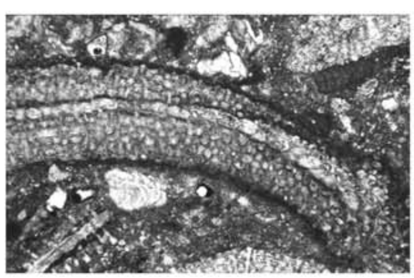
11



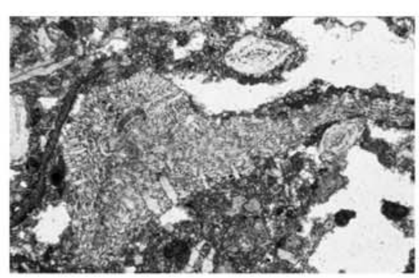
12



13



14



15

41 µm; tangential × radial diameter of primary auxiliary chambers = 44 × 26 to 82 × 45 µm, accessory auxiliary chambers = 52 × 23 to 102 × 34 µm, equatorial chambers = 37 × 53 to 70 × 91 µm; length × height of lateral chambers = 150 × 30 to 160 × 32 µm; thickness of roofs and floors = 18 to 20 µm; number of lateral chambers per tier = 10 to 14; diameter of pillars = 68 to 80 µm. Megalospheric A1 schizont (fig. 7), diameter of test = 2.16 to 3.07 mm, protoconch = 90 × 80 µm, deuteroconch = 140 × 50 µm, deuteroconch/protoconch diameter ratio = 1.55; distance across both protoconch and deuteroconch = 130 µm; thickness of embryonic chamber wall = 9 µm; tangential × radial diameter of primary auxiliary chambers = 52 × 36 µm; dimension of accessory auxiliary chambers (tang. diam, xrad. diam.) = 52 × 34 µm; dimension of equatorial chambers = 55 × 77 µm. Microspheric (agamont) specimens, diameter of test = 5.00 to 5.68 mm, diameter of proloculus = 12 µm, thickness of proloculus wall = 2 µm; Matsumaru's (1991) × value = 8, Y value = 5, and Z value = 9.

Remarks: If the arrangement of equatorial chambers of *Nephrolepidina tournoueri* (Lemoine and Douvillé 1904) is always polygonal, it is probable that this is the senior synonym of *N. japonica*. *Nephrolepidina sondaica* (Yabe and Hanzawa 1929) with equatorial chambers in concentric rings that tend to become polygonous is placed in *N. japonica.*

Late Oligocene to middle Miocene, Tertiary e3 to Tertiary f2.

Nephrolepidina tournoueri (Lemoine and Douvillé 1904)
Plate 32, figures 14-15

Lepidocyclina tournoueri LEMOINE and R. DOUVILLÉ 1904, p. 19, pl. 1, fig. 5; pl.2, figs. 2, 14; pl. 3, fig. 1. – H. DOUVILLÉ 1925, p. 78, pl. 6, figs. 8-11.
Lepidocyclina (*Nephrolepidina*) *tournoueri* Lemoine and Douvillé. – BRÖNNIMANN 1940, p. 47-50, pl. 3, figs. 6, 15; pl. 5, figs. 3, 11-12, 41. – DROOGER and SOCIN 1959, p. 417-420, pl. 1, figs. 1-4; pl. 2, figs. 1-6.
Nephrolepidina tournoueri (Lemoine and Douvillé). – LANGE 1968, p. 59-63, pl. 1, fig. 3. – MATSUMARU 1971, p. 171-172, pl. 17, figs. 1-6; pl. 20, fig. 6. – MATSUMARU 1996, p. 36.

Description: Test lenticular, more or less swollen, and smooth. Subspherical protoconch and reniform deuteroconch of nephrolepidine type are followed by two primary auxiliary chambers and nepionic chambers. Equatorial chambers are arcuate, ogival or hexagonal in intersecting curves. Lateral chambers are rectangular and narrow to wide in tiers over the equatorial layer. Pillars are present in the central boss.

Dimensions: Diameter of test = 1.85 to 4.10 mm, thickness = 1.00 to 1.25 mm, diameter/thickness ratio = 2.0 to 2.2; diameter of protoconch = 145 × 110 to 300 × 275 µm, diameter of deuteroconch = 210 × 60 to 550 × 190 µm, deuteroconch/protoconch diameter ratio = 1.60 to 1.83; distance across protoconch and deuteroconch = 170 to 470 µm; thickness of embryonic chambers wall = 12 to 15 µm; tangential × radial diameter of primary accessory chambers = 70 × 30 to 100 × 60 µm, accessory auxiliary chambers = 52 × 25 to 200 × 70 µm, equatorial chambers = 38 × 63 to 60 × 75 µm; length × height of lateral chambers = 105 × 11 to 175 × 40 µm; number of lateral chambers per tiers = 10 to 12; thickness of roofs and floors of lateral chambers = 10 to 22 µm; diameter of pillars = 60 to 80 µm.

Remarks: N. tournoueri evolved from *N. marginata* and evolved into *N. japonica,* all characterized by nephrolepidine type embryonic chambers and equatorial chambers arranged in intersecting curves. *Nephrolepidina taiwanensis* from Kwarenko District, Taiwan (Yabe and Hanzawa 1930, pl. 5, fig. 7) is closely related, but has a thicker central boss.

Late Oligocene, Tertiary e1-2.

Nephrolepidina martini (Schlumberger 1900)
Plate 33, figures 13-15; plate 34, figure 1 left

Lepidocyclina martini SCHLUMBERGER 1900, p. 131-133, pl. 6. – CAUDRI 1939, p. 212-218, pl. 8, figs. 57-60. – COLEMAN 1963, p. 14-15, pl. 3, figs. 7-14.
Lepidocyclina (Nephrolepidina) martini Schlumberger. – VAN DER VLERK 1928, p. 15, 33, figs. 23a-c. – COLE 1945, p. 288-289, pl. 25,

---

PLATE 41

Fig. 1, Station Obata 12, Japan (Matsumaru, 1967, fig. 1); fig. 2, Station 120, and fig. 12, Station BG9, Bontoc, North Luzon; figs. 3, 6, 7, 13, Station MD111; fig. 5, Station 11473; fig. 9. Station 11479; Mindoro; figs. 4, 14, 15, Station CB2, and fig. 11, Station CB7, Cebu; fig. 8, Station F28, East Mindanao; fig 10, Station QZ 10-3, Palawan.

1,2 *Lepidosemicyclina musperi* (Tan). 1, equatorial section. 2, axial section, both ×20.

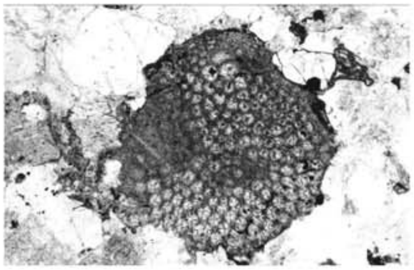
3-5 *Borelis parvulus* Hanzawa. 3, axial section;. 4, 5, oblique sections, both ×50.

6-9 *Borelis globosa* Matsumaru. 6, axial section. 7, oblique section. 8. Equatorial and tangential sections. 9. Transverse section. 6-8, ×50. 9, ×20.

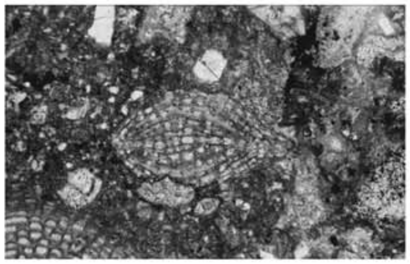
10 *Borelis melo* (Fichtel and Moll). 10 left, axial section, ×10.

10 *Alveolinella quoyii* (d'Orbigny) 10 right, oblique section, ×10.

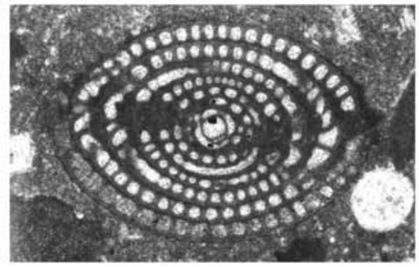
11-15 *Borelis pygmaeus* (Hanzawa). 11, 13, axial sections. 12, 15, equatorial sections. 14, transverse section. Figs. 11, 14, ×20; 12, 13, 15, ×50.



1

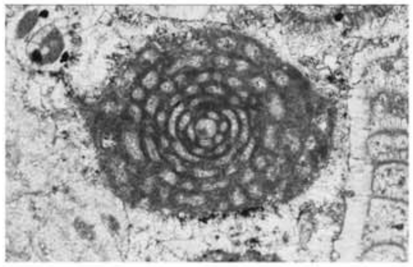


2

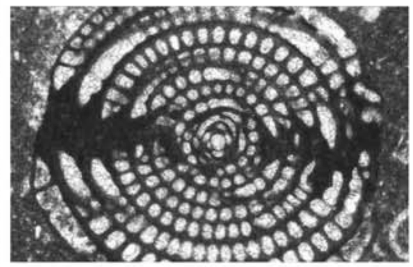


3

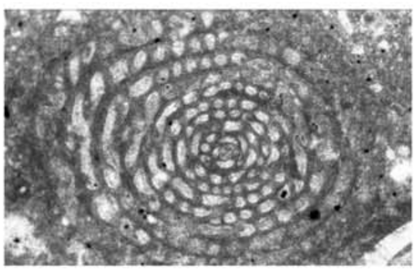
4



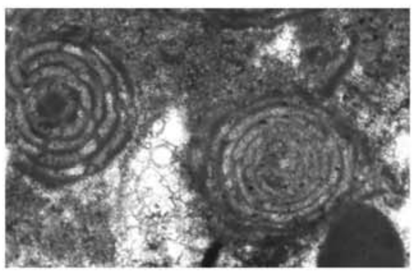
5



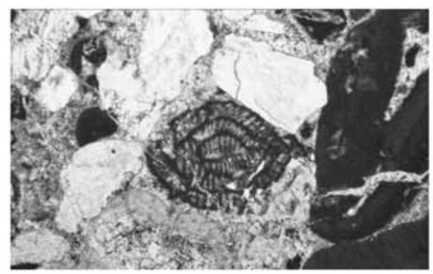
6



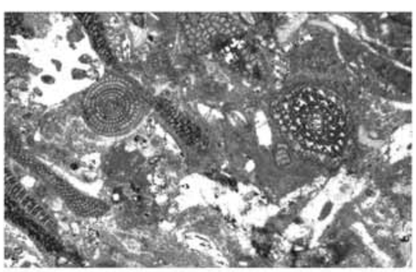
7



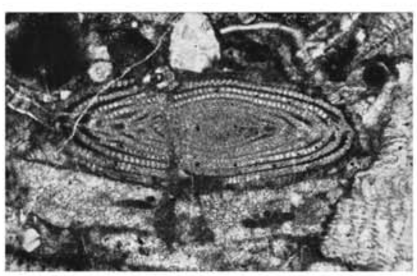
8



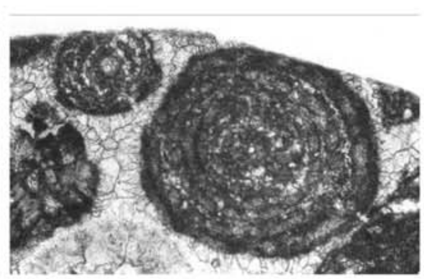
9



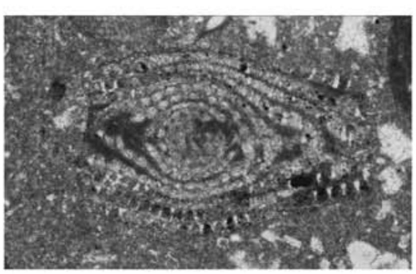
10



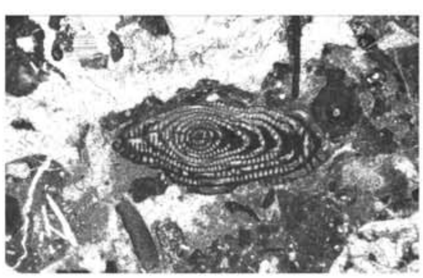
11



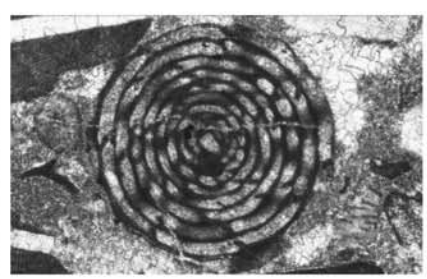
12



13



14



15

figs. A-M. – EAMES, BANNER, BLOW, CLARK and SMOUT 1962, p. 303, 316, pl. 6, figs. 2-4; pl. 8, fig. 1. – COLE 1963, p. E22-23, pl. 10, figs. 10, 12, 15-17, pl. 11, figs. 9-17.
Epidocyclina ruteni forma *globosa* SCHEFFEN 1932, p. 40-41, pl. 10, figs. 1-3.
Lepidocyclina (Eulepidina) martini Schlumberger. – COLE 1960, p. 102, pl. 12, figs. 1-3.
Lepidocyclina (*Nephrolepidina*) *japonica* Yabe. – COLE 1963, p. E21-22, pl. 10, figs. 1-9, 11, 13-14, 18.
Nephrolepidina martini (Schlumberger). – MATSUMARU 1992, p. 257-259, figs. 1-1-5.

Description: Test is compressed lenticular and stellate with 6 to 8 rays. Surface is smooth, or sometimes covered with papillae. Subspherical protoconch and reniform deuteroconch of nephrolepidine, trybliolepidine or eulepidine types are followed by two primary auxiliary chambers and nepionic chambers, and more than 4 accessory auxiliary chambers on the deuteroconchal wall. The embryonic wall is undulant. Equatorial chambers are arcuate, short spatulate or hexagonal, in intersecting curves varying to polygonal or stellate arrangement. Lateral chambers are rectangular spaceous cavities in regular tiers over the equatorial layer. Pillars are present.

Dimensions: Diameter of test =1.58 to 3.41 mm, thickness = 0.55 to 1.02 mm, diameter/thickness ratio = .84 to 287; in 6 specimens, diameter of protoconch = 110 × 100 to 616 × 500 µm, deuteroconch = 220 × 80 to 915 × 320 µm, deuteroconch /potoconch diameter ratio = 1.49 to 2.00; distance across protoconch and deuteroconch = 180 to 850 µm; thickness of embryonic chamber wall = 23 to 34 µm; tangential × radial diameter of primary auxiliary chambers = 75 × 40 to 260 × 64 µm, accessory auxiliary chambers = 70 × 33 to 253 × 70 µm, equatorial chambers = 40 × 55 to 82 × 61 µm; length × height of lateral chambers = 114 × 23 to 143 × 34 µm; thickness of roofs and floors of lateral chambers = 16 to 18 µm; number of lateral chambers per tier = 10; diameter of pillars = 45 to 68 µm.

Remarks: Differs from its ancestor *N. angulosa* in larger accessory auxiliary chambers and small pillars on the central boss. Cole (1963) considered it synonymous with *N. taiwanensis,* but the arrangement of the equatorial chambers is different.

Middle to late Miocene, Tertiary f1 to Tertiary f3.

Subfamily Eulepidinidae Matsumaru 1991
NOTE: Subfamily Eulepidininae of Family Lepidocyclinidae is characterized by the development of numerous accessory auxiliary chambers on the outer wall of the deuteroconch.

Genus *Eulepidina* H. Douvillé 1911

Eulepidina dilatata (Michelotti 1861)
Plate 34, figures 13-15

Orbitoides dilatata MICHELOTTI 1861, p. 17, pl. 1, figs. 1-2.
Orbitoides (Lepidocyclina) dilatata (Michelotti). – GÜMBEL 1870, p. 139-140, pl. 4, figs. 45 a-b, 46-47.
Lepidocyclina elephantine MUNIER-CHALMAS 1891, p. 76. – LEMOINE and DOUVILLÉ 1904, p. 13-14, pl. 2, figs. 13, 19.
Lepidocyclina dilatata (Michelotti). – LEMOINE AND DOUVILLÉ 1904, p. 12-13, fig. 13, pl. 1, fig. 2; pl. 2, figs. 8, 21; pl. 3, figs. 10, 15. – CHECCHIA-RISPOLI 1909, p. 56, 60, 99, 130; pl. 5, fig. 53; pl. 7, fig. 15. – SILVESTRI 1910, p. 139-156, figs. 19-20, 22-25; pl. 1, figs. 4-10. – CHECCHIA-RISPOLI 1911, p. 298, pl. 1, figs. 23-24. – SILVESTRI 1924, p. 7-29, pl. 1, figs. 22-25. – SILVESTRI 1937, p. 176-180, pl. 22, fig. 3.
Lepidocyclina raulini LEMOINE and DOUVILLÉ 1904, p. 11-12, pl. 1, figs. 3, 6, 9, 13, 16; pl. 2, figs. 3, 10; pl. 3, figs. 4, 14.
Lepidocyclina schlumbergeri LEMOINE and R. DOUVILLÉ 1904, p. 14, pl. 1, fig. 10; pl. 2, fig. 6.
Lepidocyclina verbeeki (Newton and Holland) var. *papuaensis* CHAPMAN 1914, p. 297, pl. 8, figs. 5-6; pl. 9, fig. 10. – VAN DER VLERK 1925, p. 30, pl. 1, fig. 4; pl. 3, figs. 25; pl. 6, fig. 55.
Lepidocyclina (Eulepidina) formosoides DOUVILLÉ 1925, p. 71, pl. 3, figs. 2-4. – LLUECA 1929, p. 339-340, p. 30, figs. 7-13, pl. 31, figs. 1-3.
Lepidocyclina (Eulepidina) dilatata (Michelotti). – DOUVILLÉ,1925, p. 71-73, 99, pl. 4,figs. 1-4; pl. 5, figs. 1-4 (Text-fig. 69. – VAN DER VERK 1928, pl. 14, 24, fig.3a-c, 38. – LLUECA 1929. p. 340-341, pl. 31, figs. 4-10. pl. 33, figs. 41-43. – WHIPPLE 1934, p. 144-148, pl. 21, fig. 2; pl. 22, fig. 1. – BRÖNNIMANN 1940, p. 44-46, fig. 11; pl. 4, figs. 4, 6, 10; pl. 5, figs. 15-17; pl. 6, figs. 6-7.
Lepidocyclina (Eulepidina) eodilatata DOUVILLÉ 1925, p. 73.

PLATE 42

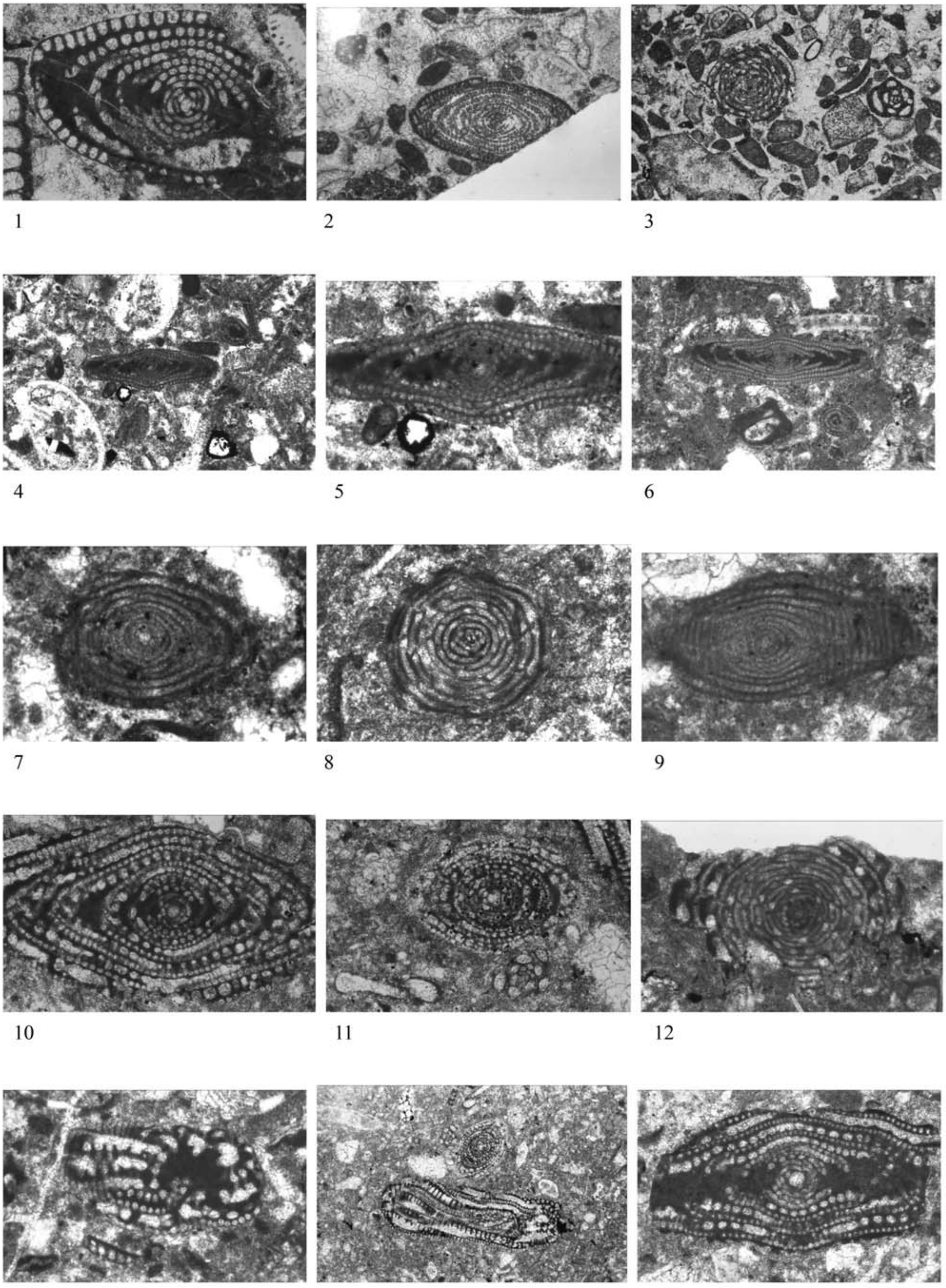
Fig. 1, Station 11475, Mindoro; figs. 2, 3, Station BG9, Bontoc, North Luzon; figs. 4-7, 9, Station F28, and fig. 8, Station F27, East Mindanao; figs. 10-12, 14, Station B102, NE Luzon; fig. 13, Station No. 19, Sibul, Mid-Luzon; fig.15, Station MQ14, Marinduque.

1-3 *Borelis philippinensis* Hanzawa. 1-2. axial sections. 3. tangential section. 1, ×50; 2, 3, ×20.

4-9 *Borelis fusiformis* Matsumaru, n. sp. 4 (holotype, megalospheric specimen), 5, 6, axial sections. 7 (paratype), equatorial section of megalospheric specimen deformed by tectonic pressure. 8, tangential section. 9, transverse section.Figs. 4, 6, ×20; 5, 7-9, ×50.

10-14 *Flosculinella bontangensis* (Rutten). 10, axial section. 11, 13, oblique sections. 12, equatorial section. 14, transverse section. Figs. 10-13, ×50; 14, ×20.

15 *Flosculinella fusiformis* Hashimoto and Matsumaru. Axial section, ×50.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Lepidocyclina (Eulepidina) roberti DOUVILLÉ 1925, p. 73, fig. 57, pl. 3, fig. 5.
Lepidocyclina dilatata (Michelotti) var. *tidoenganensis* VAN DER VLERK 1925, p. 23, figs. 5, 23, 46.
Eulepidina dilatata dilatata (Michelotti). – LANGE 1968, p. 51-55, pl. 3, fig. 1. – MATSUMARU 1971, p. 184-185, pl. 22, figs. 28-38.
Eulepidina ephippioides (Jones and Chapman). – LANGE 1968, p. 4-49, pl. , fig. 3 (non fig. 2).
Eulepidina eodilatata Douvillé. – LANGE 1968, p. 49, pl. 2, fig. 1.
Eulepidina dilatata (Michelotti). – MATSUMARU 1996, p. 34-35, 162-178, pl. 60, figs. 1-6; pl. 61, figs. 1-6; pl. 62, figs. 1-7; pl. 63, figs. 1-6; pl. 64, figs. 1-2; fig. 20. 2 and 4; figs. 30-33.

Description: Test large, thin to thick lenticular and circular or subcircular in outline, with surface papillae. Subspherical protoconch and reniform deuteroconch of eulepidine or trybliolepidine, occasionally concentric type. Thick embryonic chamber wall is pierced by many big stoloniferous foramina or stolons that lead to numerous accessory auxiliary chambers. Primary accessory chambers are of equal to subequal size. Equatorial chambers are arcuate, ogival, long spatulate or hexagonal, arranged in intersecting curves or polygons. Lateral chambers are large rectangular cavities in regular tiers over the equatorial layer. Pillars are present throughout the test.

Dimensions: Diameter of test = 4.80 to 14.6 mm, thickness = 0.98 to 2.72 mm, diameter/thickness ratio = 3.68 to 6.73; in 7 specimens, diameter of protoconch = 485 × 541 to , 600 × 553 µm, deuteroconch = 940 × 293 to 1760 × 1491 µm, deuteroconch/protoconch diameter ratio = 1.29 to 1.79, distance across both protoconch and deuteroconch = 603 to 1491 µm, embryonic chambers wall = 100 to 150 µm; tangential × radial diameter of primary auxiliary chambers) = 118 × 45 to 136 × 136 µm, accessory auxiliary chambers = 109 × 45 to 180 × 64 µm, equatorial chambers = 90 × 146 to 154 × 146 µm; length × height of lateral chambers = 159 × 36 to 227 × 45 µm; thickness of roofs and floors of lateral chambers = 9 to 23 µm; number of lateral chambers per tier = 10 to 14; diameter of pillars = 80 to 113 µm.

Remarks: Eulepidina papuaensis Chapman 1914, with large embryonic chambers and polygonally arranged equatorial chambers is a junior synonym. *E. dilatata* probably evolved from Caribbean *E. undosa* Cushman (Frost and Langenheim 1974) with similarly large embryonic chambers and subcircular to polygonally arranged equatorial chambers.

Early Oligocene to early Miocene, Tertiary d to Tertiary e5.

Eulepidina ehippioides (Jones and Chapman 1900)
Plate 35, figures 1-9

Orbitoides (Lepidocyclina) ehippioides JONES and CHAPMAN 1900, p. 251-252, 256; pl. 20, fig. 9; pl. 21, fig. 15.
Orbitoides (Lepidocyclina) murrayana JONES and CHAPMAN 1900, p. 252-253, pl. 21, fig. 10.
Orbitoides (Lepidocyclina) andrewsiana JONES and CHAPMAN 1900, p. 252-253, pl. 21, fig. 10.
Lepidocyclina (Eulepidina) formosa SCHLUMBERGER 1902, p. 251, pl. 7, figs. 1-3. – YABE 1919, p. 43-46, pl. 6, figs. 1b, 2, 4b, 6-7b, 8b; pl. 7, figs. 1b?, 4, 12b, 14b. – YABE and HANZAWA 1925, p. 105, pl. 25, figs. 1-2. – YABE and HANZAWA 1929, p. 163-164, pl. 2, fig. 4; pl. 3, figs. 1-3; pl. 5, figs. 5-6; pl. 7, fig. 6; pl. 8, fig. 3; pl. 9, fig. 4; pl. 12, fig. 9. – COLE and BRIDGE 1953, p. 34-35, pl. 7, figs. 4-5; pl. 10, figs. 1-2?, 3-6. – COLE 1954, p. 594-597, pl. 216, figs. 1-16; pl. 217, figs. 9-11; pl. 218, figs. 1, 3-4. – HANZAWA 1957, p. 72-73; pl. 16, figs. 1-2, 6; pl. 17, figs. 1?-6.
Orbitoides richthofeni SMITH 1906, p. 205, pl. 1, fig. 1.
Lepidocyclina (Eulepidina) monstrosa YABE 1919, p. 42-43, pl. 6, fig. 5a; pl. 7, figs. 11-12a, 13.
Lepidocyclina (Eulepidina) gibbosa YABE 1919, p. 46, pl. 6, figs. 3, 4c, 7c?
Lepidocyclina ephippioides Jones and Chapman. – NUTTALL 1926, p. 34-36, pl. 5, figs. 1-3, 8, 10.
Lepidocyclina (Eulepidina)? formosa Schlumberger. – NUTTALL 1926, p. 22-30.
Lepidocyclina (Eulepidina) badjirraensis CRESPIN 1952, p. 29-30, pl. 6, figs. 1-2, 5; pl. 7, figs. 1-2, 4; pl. 8, figs. 1-5. – COLE 1957, p. 345-346, pl. 108, figs. 1-3; pl. 109, figs. 9-10. – CHAPRONIERE 1984, p. 53-54, pl. 1, fig. 6; pl. 12, figs. 1-3, 5; pl. 18, figs. 11-15; pl. 25, figs. 15-16, text-figs. 19-2a-h.
Lepidocyclina (Eulepidina) abdopustula COLE 1954, p. 594, pl. 215, figs. 9-10; pl. 218, figs. 7-11.

PLATE 43

Figs. 1, 5-6, Station 4, and figs. 7, 8, Station 3, Palanan, N. Luzon; fig. 2, Station MQ 14, Marinduque; figs. 3, 4, Station B102, and fig. 9, Station C56, NE Luzon; fig. 10, Station MQ 5, Marinduque; figs. 11, 13, 15, Station QZ 10-3, Palawan; fig. 12, Station PWC16, Masbate; fig.. 14, Station PRS7, Bondoc Peninsula, SE Luzon.

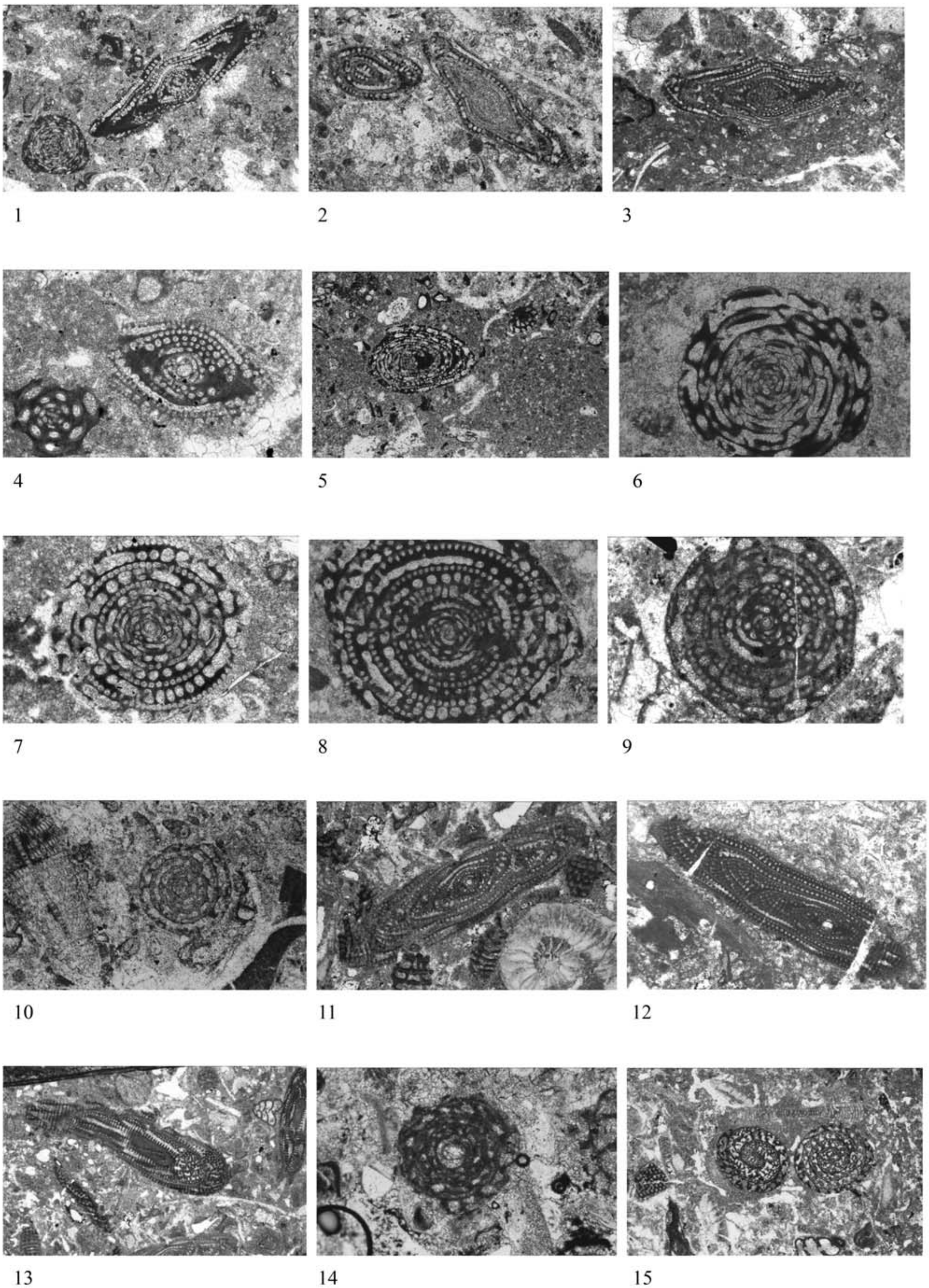
1-6 *Flosculinella fusiformis* Hashimoto and Matsumaru. 1 right, 2 right, 3, 4, axial sections. 1 left, 6, equatorial sections. 2 left, 5, oblique sections. Figs. 1-3, 5, ×20; 4, 6, ×50.

7-10 *Flosculinella globulosa* (Rutten). 7-9. axial sections. 10 right, equatorial section. Figs. 7-9, ×50; 10, ×20.

10 *Nephrolepidina ferreroi* (Provale). 10 left, transverse section, ×20.

11-15 *Alveolinella quoyii* (d'Orbigny). 11 upper, 12, axial sections. 13, transverse section. 14, equatorial section. 15, tangential section. 11-12, ×20. 13, 15, ×10. 14, ×50.

11 *Operculina complanata* (Defrance). 11 right, tangential section, ×20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Lepidocyclina (Eulepidina) ephippioides (Jones and Chapman). – COLE 1957, p. 346-347, pl. 108, figs. 4-13; pl. 109, figs. 11-15. – COLE 1957, p. 775, pl. 239, figs. 5-6. – COLEMAN 1963, p. 15-16, pl. 4, figs. 6-12; pl. 5, figs. 1-3. – ADAMS and BELFORD 1974, p. 500- 502, pl. 74, figs. 4-6, 9, 12, 14, text-fig. 12. – CHAPRONIERE 1983, p. 40-41, pl. 3, fig. 10; pl. 5, figs. 5-8; pl. 6, fig. 1, text-figs. 19-1a-j.
Lepidocyclina (Eulepidina) andrewsiana (Jones and Chapman). – ADAMS and BELFORD 1983, p. 499-500, pl. 74, figs. 7-8.
Eulepidina ephippioides (Jones and Chapman). – LANGE 1968, p. 45, 47-49, pl. 2, fig. 2 (non fig. 3). – MATSUMARU 1996, p. 34-35, 178-180, pl. 65, figs. 1-6; pl. 66, figs. 1-3; pl. 67, figs. 1-6; pl. 68, figs. 1-3; pl. 69, figs. 1-4; pl. 70, figs. 1-5; fig. 20. 5; figs. 30-33.

Description: Test large, thin lenticular to strongly inflated with a narrow flange, surface smooth except for umbonal boss with a mesh of test material and occasional papillae. In outline the test is subcircular to rounded, sometimes stellate, or in a saddle shaped or twisted thin lenticular test. Subspherical protoconch and reniform deuteroconch of trybliolepidine or eulepidine types are followed by two primary auxiliary chambers and many nepionic chambers. Equatorial chambers are arcuate, ogival, spatulate or hexagonal, in concentric or sometimes polygonal rings. Lateral chambers are large and rectangular cavities, arranged in regular tiers over the equatorial layer. Pillars are present.

Dimensions: Diameter of test = 3.64 to 17.00 mm, thickness = 1.91 to 3.67 mm, diameter/thickness ratio = 1.69 to 8.50; in 10 specimens, diameter of protoconch = 296 × 292 to 778 × 736 µm, deuteroconch = 444 × 490 to 1040 × 216 µm, deuteroconch/protoconch diameter ratio = 1.38 to 1.89, distance across protoconch and deuteroconch = 478 to 957 µm; embryonic chamber wall = 42 to 118 µm; tangential × radial diameter of primary auxiliary chambers = 45 × 64 to 167 × 133 µm, accessory auxiliary chambers = 68 × 36 to 122 × 68 µm, equatorial chambers = 91 × 77 to 167 × 142 µm; length × height of lateral chambers =136 × 55 to 205 × 45 µm; thickness of roofs and floors of lateral chambers = 12 to 36 µm; number of lateral chambers per tier = 15 to 30; diameter of pillars = 90 to 190 µm.

Remarks: The synonymy (above) includes many Western Pacific species that have been directly synonymised, or with other species that in turn have been assigned to *E. ephippioides*

Early Oligocene to early Miocene, and Tertiary d to Tertiary e5.

Superfamily PLANORBULINACEA Schwager 1877
Family PLANORBULINIDAE Schwager 1877
Genus *Neoplanorbulinella* Matsumaru 1976

Neoplanorbulinella saipanensis Matsumaru 1976
Plate 46, figures 2-4

Neoplanorbulinella saipanensis MATSUMARU 1976, p. 201-202, pl. 6, figs. 1-12. – Matsumaru 1996, p. 152-154, figs. 8-12; pl. 55, figs. 1, 4-7.

Description: Test is attached, discoidal and conical to concavo-convex, with a granulated surface. The dorsal side is covered with thickenened lamellae, and the ventral side has lateral chambers differentiated from equatorial layer. Spherical to subspherical protoconch and reniform deuteroconch are connected with a third chamber via a proximal aperture in the deuteroconchal wall. Periembryonic chambers are arcuate with slit-like peripheral stolons in a spiral arrangement surrounded by numerous equatorial chambers in more or less annular series in alternating positions. Rectangular to polygonal, irregularly overlapping lateral chambers in the ventral side are developed via pores in the lateral wall of equatorial chambers. The bilamellar wall is calcareous and coarsely perforate in the outer lamella and imperforate in the inner lamella.

PLATE 44

Fig. 1, Station 11469; fig. 7, Station MD 111; fig. 8, Station WR 202; figs. 9-10, Station WR 204; fig. 14, Station 11477; fig. 15, Station MD 100; Mindoro; figs. 2, 3, Station AG3, Angat, Mid-Luzon; figs. 4-6, Station 7682902, Negros; figs. 11, 12, Station CB51, Cebu; fig. 13, Station C57, NE Luzon.

1-3 *Linderina brugesi* Schlumberger. Reworked specimens: 1, 2, oblique sections. 3, axial section. Figs. 1, 2 ×50; 3, ×20.

3 *Nephrolepidina sumatrensis* (Brady). 3 right, transverse section, ×20.

4-6 *Peelella boninensis* Matsumaru. Axial sections; *Globigerinoides* sp, is seen in fig. 6. Figs. 4, 6, ×50; 5, ×20.

7 *Halkyardia minima* (Liebus). Axial section, ×50.

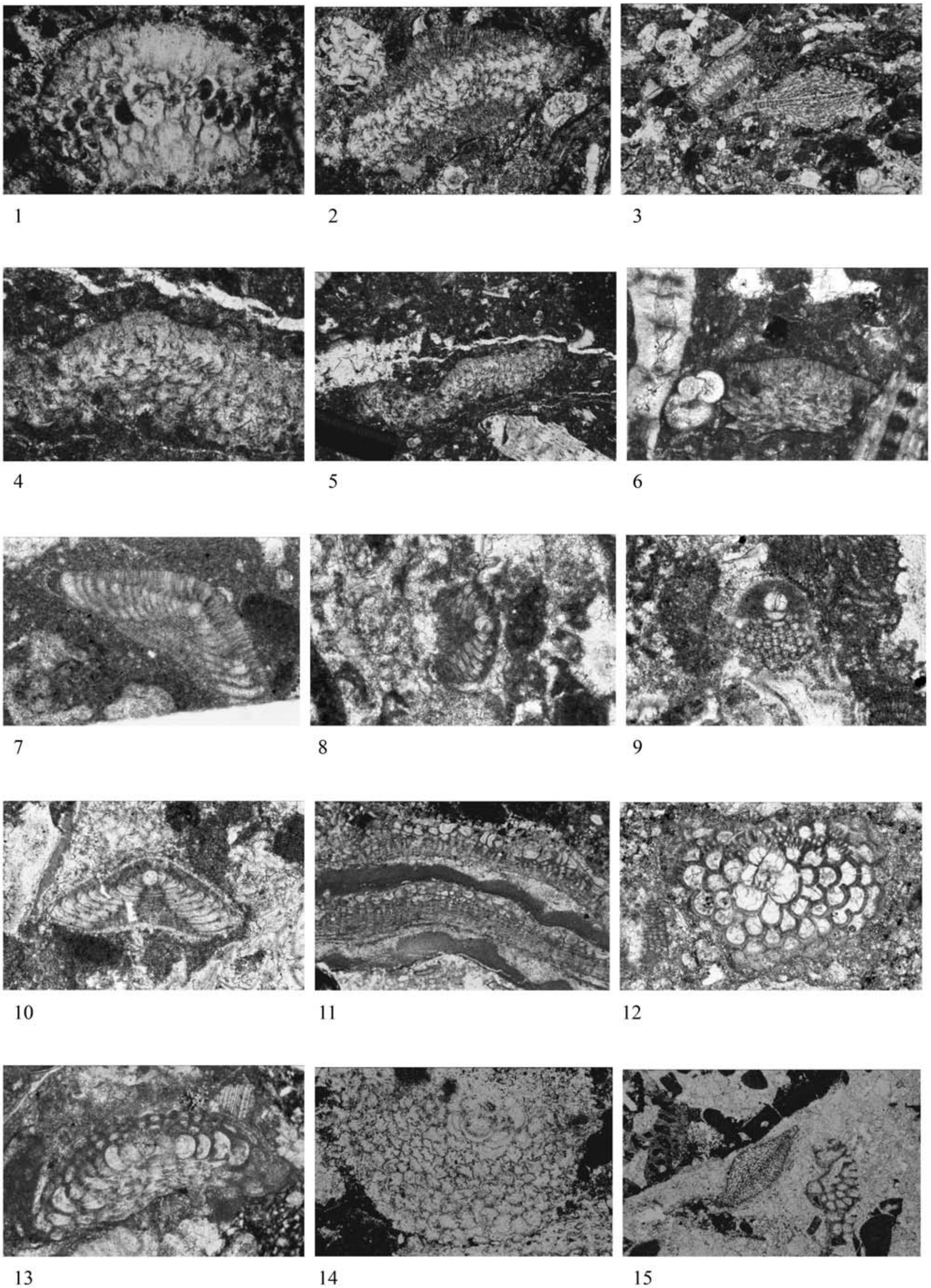
8-10 *Halkyardia bikiniensis* Cole. 8, 10, axial sections. 9, oblique section, all ×50.

11 *Borodinia septentrionalis* Hanzawa. Vertical section, ×20.

12-13 *Tayamaia marianensis* (Hanzawa). 12, oblique section. 13, axial section, both ×50.

14, 15 *Orbitogypsina vesicularis* Matsumaru. 14, equatorial section. 15, transverse section. Fig. 14, ×50; 15, ×20.

15 *Fabiania cassis* (Oppenheim). 15 right, oblique section, ×20.



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Dimensions: Diameter of test = 0.96 to 2.27 mm, thickness = 0.25 to 0.38 mm, diameter/thickness ratio = 3.78 to 9.08; diameter of protoconch = 112 × 97 µm, deuteroconch = 97 × 58 µm, third chamber = 80 × 53 µm; thickness of embryonic chamber wall = 18 µm; tangential × radial diameter of primary auxiliary chamber in equatorial section = 60 × 58 µm, nepionic chambers = 60 × 35 to 80 × 60 µm, equatorial chambers = 52 × 35 to 61 × 48 µm, lateral chambers = 50 × 40 to 200 × 110 µm, or length × height in axial section = 68 × 30 to 90 × 40 µm; thickness of dorsal layer = 26 to 44 µm; thickness of ventral layer = 18 to 29 µm.

Remarks: Neoplanorbulinella saipanensis is named from the Tagpochou Limestone, Saipan (Matsumaru 1976), and also occurs in limestones of Chichi-Jima and Haha-Jima, Japan (Matsumaru 1996).

Early Oligocene to middle Miocene, Tertiary d to Tertiary f1.

Genus *Peelella* Matsumaru 1996

Peelella boninensis Matsumaru 1996
Plate 44, figures 4-6

Peelella boninensis MATSUMARU 1996, p. 156-158, pl. 56, figs. 1-8; pl. 57, figs. 1-10.

Description: Test is attached, discoidal and flat to concavo-convex, with thick, coarsely perforate dorsal lamellar and lateral chambers differentiated from the equatorial layer. In the early stage of the microspheric generation, spherical to subspherical proloculus is followed by arcuate nepionic chambers in a low trochoid spire, surrounded by alternating annuli of many equatorial chambers. Irregularly overlapping, rectangular lateral chambers on the ventral side are developed through pores in the lateral walls of equatorial chambers. The bilamellar wall is calcareous, coarsely perforate in outer lamella and imperforate in inner lamella. Roofs and floors of lateral chambers are thin and finely perforated, and septa are thick, elevated and imperforate.

Dimensions: Diameter of test = 2.16 to 2.30 mm, thickness = 0.28 to 0.48 mm, diameter/thickness ratio = 4.79; diameter of proloculus = 20 × 24 µm; tangential × radial diameter of nepionic chambers = 30 × 20 to 30 × 26 µm; number of nepionic chambers in first whorl = 7; tangential × radial diameter of equatorial chambers = 39 × 38 to 44 × 30 µm; length and height of lateral chambers = 30 × 8 to 44 × 10 µm; thickness of roofs and floors = 18 to 24 µm.

Remarks: Peelella boninensis is named from the Oligocene Minamizaki Limestone, Chichi-Jima and Minami-Jima, Ogasawara Islands (Matsumaru 1996).

Late Oligocene, Tertiary e3.

Genus *Planorbulinella* Cushman 1927

Planorbulinella larvata (Parker and Jones 1865)
Plate 45, figures 13 left, 14-15; plate 46, figure 1

Planorbulina vulgaris d'Orbigny var. *larvata* PARKER and JONES 1865, p. 380, pl. 19, figs. 3 a-b.
Planorbulina larvata Parker and Jones. – BRADY 1884, p. 568, pl. 92, figs. 5-6. – CUSHMAN 1921, p. 310. – HOFKER 1927, p. 6-8, pl. 1, figs. 1-5; pl. 2, figs. 1-10.
Planorbulinella larvata (Parker and Jones). – CUSHMAN 1927, p. 96, pl. 20, fig. 9. – YABE and HANZAWA 1929, p. 177, pl. 15, fig. 5; pl. 16, fig. 6; pl. 20, fig. 6; pl. 23, fig. 8. – HANZAWA 1957, p. 69, pl. 38, fig. 2. – MATSUMARU 1996, p. 158,-160, pl. 58, figs. 1-10.

Description: Test is attached, discoidal and planoconvex or slightly concavo-convex, with both sides covered by thickened lamella with pillars. Subspherical protoconch and reniform deuteroconch are succeeded by a third chamber connected by a proximal aperture to the deuteroconch. Primary and secondary nepionic spirals meet at a symmetrical chamber on the opposite side from the third chamber. Numerous equatorial chambers form alternating annular series. The bilamellar wall is calcareous, with the outer lamella coarsely perforate and the inner lamella imperforate.

PLATE 45

Figs. 1, 2, 5, 6, Station MD 111; fig. 7, Station MD 77; fig. 10, Station MD 112; Mindoro; figs. 3, 4, Station CB51, Cebu; figs. 8, 15, Station 7450814, Samar; fig. 9, Station h2155, Bontoc, North Luzon; fig. 11, Station PN20, Panay; fig. 13, Station 7682906, Negros; fig. 14, Station BHK 4, Bondoc Peninsula, SE Luzon.

1-3 *Orbitogypsina vesicularis* Matsumaru. Axial sections, ×50.

4, 13 *Tayamaia marianensis* (Hanzawa). 4, oblique section; 13, axial section. 4, ×50; 13, ×20.

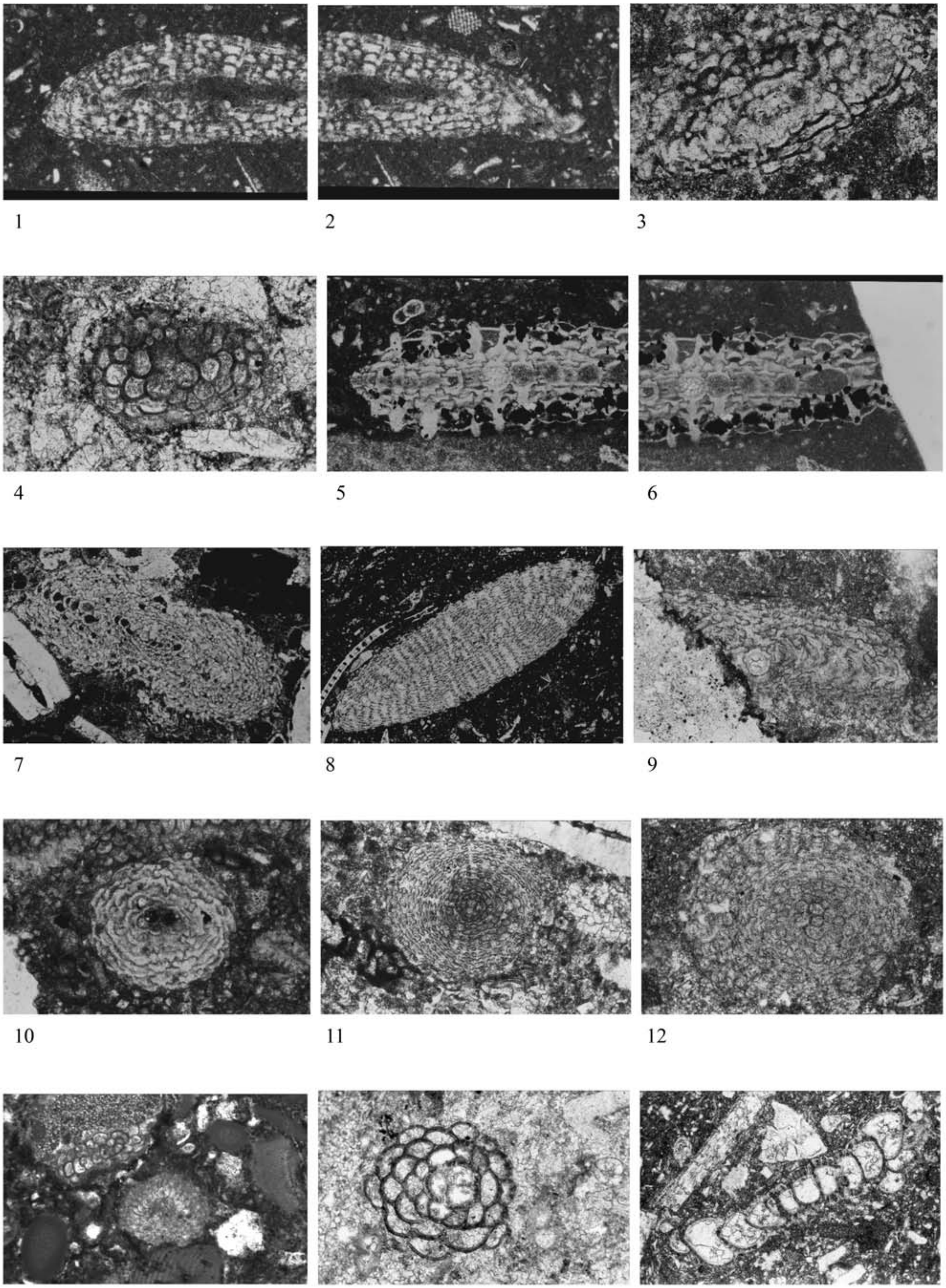
5, 6 *Orbitogypsina mindoroensis* Matsumaru, n. sp. Holotype, axial sections, ×50.

7-9 *Discogypsina vesicularis* (Parker and Jones). 7, oblique section. 8, 9, axial sections. Figs. 7, 8, ×20; 9, ×50.

10 *Orbitogypsina globulus* Matsumaru. Equatorial section, ×50.

11, 12 *Sphaerogypsina globulus* (Reuss). Equatorial sections, ×50.

13-15 *Planorbulinella larvata* (Parker and Jones). 13 left, oblique section. 14, equatorial section. 15, axial section. Fig. 13, ×20; 14, 15, ×50,


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Dimensions: Diameter of test = 1.08 to 1.30 mm, thickness = 0.21 to 0.31 mm, diameter/thickness ratio = 4.19 to 5.20; protoconch = 96 × 70 µm, deuteroconch = 104 × 65 µm, third chamber = 96 × 57 µm; thickness of embryonic chamber wall = 26 µm; tangential × radial diameter of nepionic chambers = 61 × 39 to 92 × 48 µm, symmetrical chamber = 122 × 57 µm, equatorial chambers = 96 × 61 to 158 × 66 µm; thickness of outer lamella = 26 to 30 µm, inner lamella = 3 to 5 µm; diameter of pillars = 18 to 26 µm.

Remarks: There is no significant difference between fossil material and Recent *Planorbulinella larvata* (Parker and Jones), apart from slight variations in lamellar thickness and test shape.

Early Oligocene to Pleistocene-Holocene, Tertiary c to Tertiary h; also known from Tertiary b in the Ogasawara Islands (Matsumaru 1996).

Genus *Tayamaia* Hanzawa 1967

Tayamaia marianensis (Hanzawa 1957)
Plate 44, figures 12-13; plate 45, figures 4, 13 right

Gypasina marianensis HANZAWA 1957, p. 66-67; pl. 21, fig. 8; pl. 27, figs. 1-8. – Cole 1957, p. 337, pl. 103, figs. 1-4.
Tayamaia marianensis (Hanzawa) – HANZAWA 1967, p. 22-23, text-fig. 3.

Description: Test thick, discoidal, planoconvex or concavo-convex, in three layers of different shaped and sized chambers. Equatorial layer is made of proloculus surrounded by five nepionic chambers of "raspberry" type, enclosed in annular arcuate or spatuliform chambers with two to four stolons, alternating in position. Dorsal layer consists of several tiers of small, depressed, polygonal to spatuliform chambers that evenly cover the equatorial layer. Ventral layer consists of several tiers of chambers that are smaller than equatorial chambers, but larger than dorsal chambers, also depressed and and polygonal to spatuliform. The vertical walls are calcareous, solid and imperforate while roofs and floors of lateral chambers are perforate.

Dimensions: Diameter of test = 0.80 to 1.32 mm, thickness = 0.22 to 0.46 mm, diameter/thickness ratio = 2.87 to 4.77; diameter of proloculus = 60 × 60 to 80 × 80 µm, diameter of raspberry structure of embryonic and nepionic chambers = 246 × 237 µm; tangential × radial diameter of equatorial chambers = 66 × 48 to 96 × 66 µm; length and height of equatorial chambers = 57 × 96 to 60 × 114 µm; dorsal chambers tangential × radial diameter = 40 × 26 to 70 × 44 µm, length × height = 44 × 5 to 53 × 22 µm; number of chambers in tiers over embryonic chambers = 4 to 6; ventral chambers tangential × radial diameter = 44 × 60 to 70 × 80 µm, length × height = 57 × 13 to 88 × 35 µm; number of lateral chambers in tiers under embryonic chambers = 6 to 8; thickness of roofs and floors = 8 to 18 µm.

Remarks: Differs from *Gypsina vesicularis* (Parker and Jones) in having regularly superposed dorsal and ventral chambers in tiers, with roofs and floors clearly differentiated from vertical walls.

Late Eocene to middle Miocene, Tertiary b to Tertiary f1.

Suborder MILIOLINA Delage and Herouard 1896
Superfamily ALVEOLINACEA Ehrenberg 1839
Family ALVEOLINIDAE Ehrenberg 1839
Genus *Borelis* de Montfort 1808
NOTE: Cole (1969) suggested that *Borelis* species from the Pacific region, such as *Borelis pygmaeus* Hanzawa 1930, *B. philippinensis* Hanzawa 1947, *B. primitivus* Cole 1957 and *B. parvulus* Hanzawa 1957, are all synonyms of *Borelis melo* (Fichtel and Moll, 1798), with environmentally caused differences. While examples of *Borelis* in the Philippines are relatively few and poorly preserved, the visible features such as test shape, size of proloculus, coiling of early stage, diameter/height ratio in the whorls, number of whorls and number and dimension of chamberlets in the last chamber establish a level of variation that make its possible to reliably identify at least six

PLATE 46

Figs. 1-3, Station PN 20; fig. 13, Station PN 21; fig. 15, Station PN23; Panay; fig. 4, Station C57, NE Luzon; fig. 5, Station MQ 16, Marinduque ; figs. 6-11, Station HR206, Mindoro; fig. 12, Station QZ10-3, Palawan; fig. 14, Station TB17, Tablas.

1 *Planorbulinella larvata* (Parker and Jones). Axial section, ×20.

2-4 *Neoplanorbulinella saipanensis* Matsumaru. 2, oblique section. 3, axial section. 4, transverse section, all ×50.

5 *Kanakaia marianensis* Hanzawa. Horizontal section, ×20.

6 *Operculina venosa* (Fichtel and Moll). 6 right, axial section, ×20.

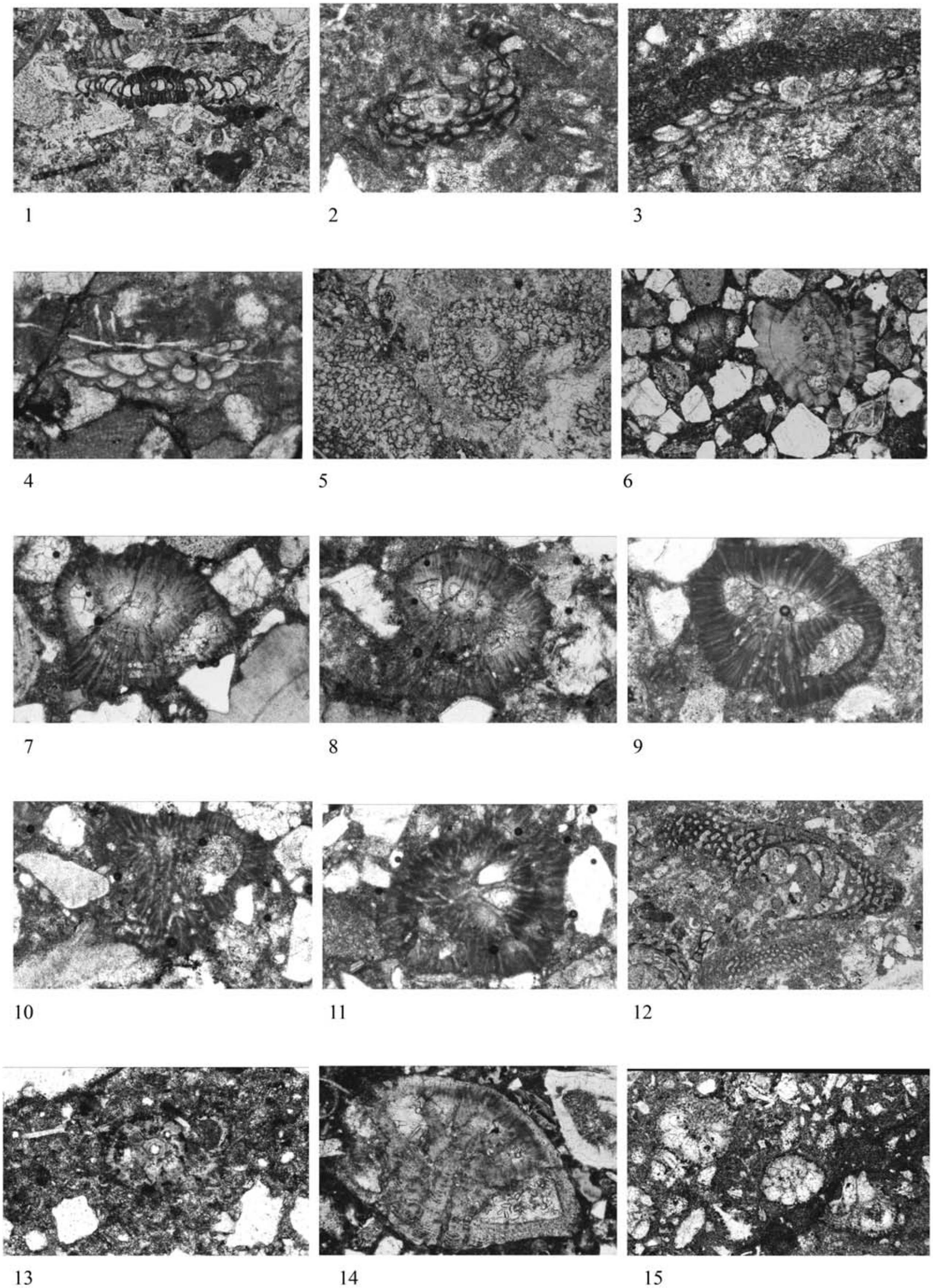
6-11 *Quasibaculogypsinoides primitive* Matsumaru, n. gen., n. sp. 6 left and 7 (holotype), 8-10, axial sections. 11, oblique section. Fig. 6, ×20; 7-11, ×50.

12 *Amphisorus hemprichi* Ehrenberg. Oblique section, ×20.

13 *Baculogypsinoides spinosus* Yabe and Hanzawa. Oblique section, ×50.

14 *Calcarina spengleri* (Gmelin). Axial section, ×50.

15 *Calcarina delicata* Todd and Post. Oblique section, ×20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Borelis species in the Philippines, including *B. melo* distinct from others.

Borelis globosa Matsumaru 1974
Plate 41, figures 6-9

Borelis globosa MATSUMARU 1974, p. 113, pl. 19, figs. 2-4, 7.
Borelis boninensis MATSUMARU 1996, p. 208, 210, pl. 83, figs. 1-2; pl. 85, fig. 5.

Description: Test globular to slightly subglobular, with an early stage consisting of spherical to subspherical proloculus followed by irregular, streptospiral whorls beginning with 3 miliolid coils and then 7 or 8 planispiral coils. The septa are aligned alternately, radial or parallel from chamber to chamber, with preseptal passages.

Dimensions: axial diameter of test = 0.67 to 1.16 mm, height = 0.58 to 1.09 mm, ratio of axial diameter/height = 0.95 to 1.13; diameter of proloculus = 35 × 35, 40 × 40, 40 × 42, and 42 × 40 µm in 4 specimens; ratio of axial diameter/ height in 4th whorl = 1.13 for 0.27 to 0.24 mm, in 5th whorl = 1.06 for 0.34 to 0.32 mm, in 6th whorl = 1.05 for 0.43 to 0.41 mm, in 7th whorl = 1.00 for 0.55 to 0.55 mm, in 8th whorl = 1.06 for 0.70 to 0.16 mm, in 9th whorl = 0.98 for 0.84 to 0.86 mm, and in 10th whorl = 0.97 for .0.95 to 0.98 mm; number of whorls = 11; tangential diameter × height of chamberlets in last chamber = 45 × 68 to 50 × 80 µm, and number of chamberlets in last chamber = 26 to 30.

Remarks: Differs from similar *Borelis parvulus* Hanzawa 1957 from Saipan, *B. primitivus* Cole 1957 from Eniwetok, and *Neoalveolina inflata* Adams 1965 from Borneo, in its small proloculus and many whorls.

Late Eocene to early Oligocene, Tertiary b to Tertiary e3.

Borelis parvulus Hanzawa 1957
Plate 41, figures 3-5

Borelis parvulus HANZAWA 1957, p. 56, pl. 23, figs. 3a-c.
Borelis primitivus COLE 1957, p. 766-769, pl. 240, figs. 3-10.
Borelis pygmaeus Hanzawa. – ADAMS and BELFORD 1974, p. 438-490, pl. 71, fig. 10 (non figs. 9, 11-14).

Description: Test subglobular, with subspherical proloculus followed by streptospiral whorls beginning with 2 miliolid coils and then 6 or 7 or 8 planispiral coils. Septa are aligned alternately, radial or parallel from chamber to chamber, with preseptal passages.

Dimensions: axial diameter of test = 0.94 mm, height = 0.71 mm, ratio of axial diameter/height = 1.19 to 1.47; diameter of proloculus = 65 × 60 µm; diameter/height ratio in 3rd whorl = 1.29 for 0.18 to 0.14 mm, in 4th whorl = 1.14 for 0.24 to 0.21 mm, in 5th whorl = 1.19 for 0.32 to 0.27 mm, in 6th whorl = 1.35 for 0.46 to 0.34 mm, in 7th whorl = 1.28 for 0.55 to 0.43 mm, and in 8th whorl = 1.47 for 0.78 to 0.53 mm; number of whorls = 8; tangential length × height of chamberlets in last chamber = 24 × 39 to 35 × 40 µm, and number of chamberlets= 22 to 23.

Remarks: Borelis parvulus Hanzawa 1957 from Saipan is essentially the same as *B. primitivus* named by Cole in the same year from Eniwetok. It is considered senior because *B. primitivus* cannot be examined except in core samples. It differs from *Neoalveolina inflata* from Borneo in having fewer whorls.

Late Eocene to early Oligocene, Tertiary b to Tertiary d.

Borelis philippinensis Hanzawa 1949
Plate 42, figures 1-3

Borelis sp. indet. YABE and HANZAWA 1929, p. 181, pl. 23, fig. 7 (non pl. 15, figs. 12-13).
Borelis philippinensis HANZAWA 1949, p. 156-157, pl. 4, figs. 1-7.

Description: Test subglobular to subcylindrical, with subspherical proloculus and streptospiral early whorls of 2 or 3 miliolid coils followed by 8 planispiral whorls. The septa are aligned alternately, radial or parallel from chamber to chamber, with preseptal passages.

PLATE 47

Figs. 1, 2, Station TR2-005, and fig. 11, Station MD117, Mindoro; fig. 3 Station h2144, Bontoc, North Luzon; fig. 4, Station 7682902, Negros; figs. 5-10, Station B130, NE Luzon; fig. 12, Station 31058, Bondoc Peninsula, SE Luzon; figs. 13, 14, Station 7681905, Cagraray; fig. 15, Station QZ4, Palawan.

1 *Globigerinatheka* cf. *G. index tropicalis* (Blow and Banner). Axial section, ×100.

2 *Globigerina* ex gr. *G. ampliapertura* Bolli. Axial section, ×50.

3 *Globigerinatheka* cf. *G. index index* (Finlay). Axial section, ×50.

4, 10, 14 *Globigerina* cf. *G. tripartita* Koch. Axial section, 4. × 100; 10, 14. ×50.

5, 6 *Paragloborotalia* ex gr. *P. opima nana* (Bolli). Axial sections, ×50 and ×100.

7-9 *Globigerina* ex gr. *sellii* (Borsetti). Axial sections, ×50.

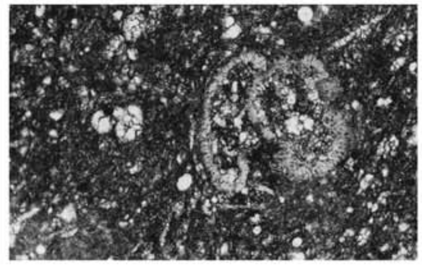
11, 12 *Catapsydrax* cf. *C. dissimilis* (Cushman and Bermudez). Axial sections, ×50.

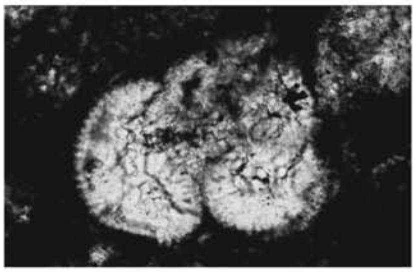
13 *Globigerina* ex gr. *G. ciperoensis ciperoensis* Bolli. Axial section, ×50.

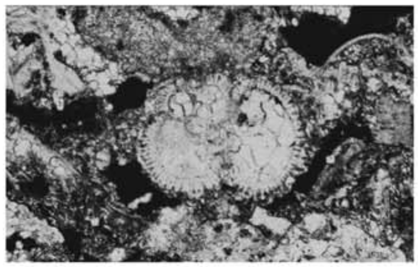
15 *Paragloborotalia* ex gr. *P. opima opima* (Bolli). Axial section, ×50.

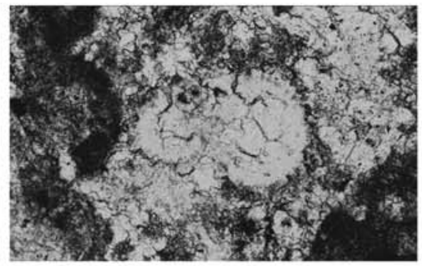

1

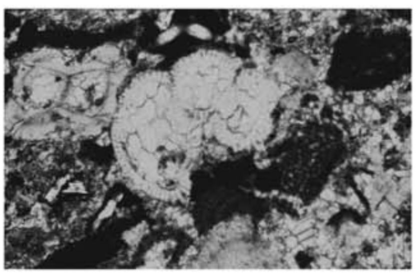

2

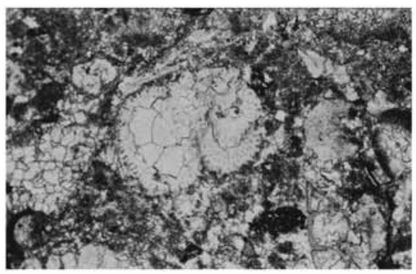

3

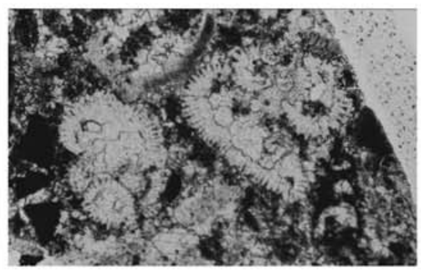

4

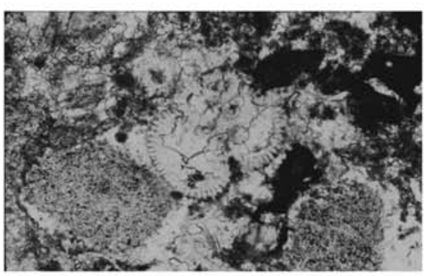

5

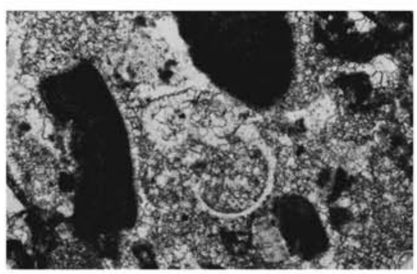

6


7

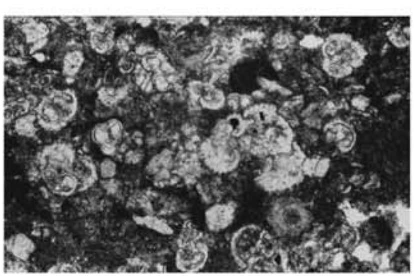

8

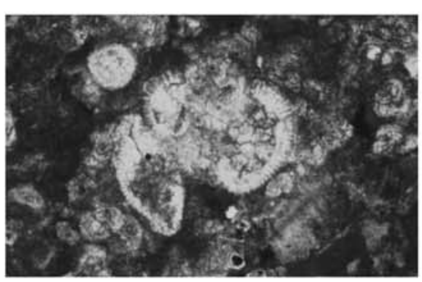

9

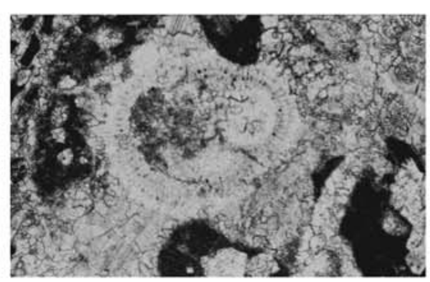

10


11


12


13


14


15

Dimensions: axial diameter of test = 1.07 to 1.25 mm, height = 0.60 to 0.82 mm, diameter/height ratio = 1.52 to 1.76; diameter of proloculus = 42 × 50 and 45 × 45 µm in 2 specimens; diameter/height ratio of test in 4th whorl = 1.05 for 0.21 to 0.20 mm, in 5th whorl = 1.04 for 0.26 to 0.25 mm, in 6th whorl = 1.27 for 0.38 to 0.30 mm, in 7th whorl = 1.39 for 0.53 to 0.38 mm, in 8th whorl = 1.39 for 0.61 to 0.44 mm, 9th whorl = 1.61 for 0.82 to 0. 51 mm, in 10th whorl = 1.78 for 1.07 to 0.60 mm, and 11th whorl = 1.70 for 1.17 to 0.69 mm; number of whorls = 11; tangential length × height chamberlets in last chamber = 42 × 54 to 54 × 48 µm, and number of chamberlets = 38 to 40.

Remarks: The illustrated specimens from Sagada Limestone sample BG9, Bontoc (table 3; text-fig. 2) may be from the same locality as the type of this species.

Early to late Oligocene,Tertiary d to Tertiary e3.

Borelis pygmaeus (Hanzawa 1930)
Plate 41, figures 11-15

Borelis sp. indet. YABE and HANZAWA 1929, p. 181, pl. 15, figs. 12-13 (non pl. 23, fig. 7).
Borelis (Fasciolites) pygmaeus HANZAWA 1930, p. 94-95, pl. 26, figs. 14-15.
Neoalveolina pygmaea Hanzawa. – BAKX 1932, p. 237-239, pl. 3, figs. 18-20.
Fasciolites pygmaea Hanzawa. – HENRICI 1934, p. 44, pl. 2, fig. 18; pl. 3, figs. 1, 5.
Borelis pygmaeus (Hanzawa). – HANZAWA 1947, p. 9-11, pl. 5, figs. 1-4. – COLE and BRIDGE 1953, p. 27, pl. 12, fig. 16; pl. 13, figs. 4-7. – HANZAWA 1957, p. 55-56, pl. 34, figs. 8-9. – COLE 1957, p. 336, pl. 102, fig. 1; pl. 110, figs. 5-7. – COLE 1957, p. 767, pl. 240, figs. 11-13. – ADAMS and BELFORD 1974, p. 488-490, pl. 71, figs. 9-14. – CHAPRONIERE 1984, p. 31, pl. 14, figs. 16?, 17. – MATSUMARU 1996, p. 210-212, pl. 83, figs. 3-4.

Description: Test fusiform, with spherical proloculus and streptospiral early whorls of 2 or 3 miliolid coils followed by 9 or 10 planispiral whorls. The septa are aligned alternately, radial or parallel from chamber to chamber, with preseptal passages.

Dimensions: axial diameter of test = 1.58 to 2.45 mm, height = 0.59 to 0.84 mm, diameter/height ratio = 2.44 to 2.92; diameter of proloculus = 35 × 35, 56 × 56, and 58 × 58 µm in 3 specimens; ratio of diameter/height of test in 4th whorl = 1.27 for 0.33 to 0.26 mm, in 5th whorl = 1.63 for 0.52 to 0.32 mm, in 6th whorl = 1.94 for 0.70 to 0.36 mm, in 7th whorl = 2.27 for 0.93 to 0.41 mm, in 8th whorl = 2.46 for 1,23 to 0.50 mm, in 9th whorl = 2.61 for 1.49 to 0.57 mm, in 10th whorl = 2.44 for 1.61 to 0.66 mm, in 11th whorl = 3.57 for 2.00 to 0.56 mm, in 12th whorl = 2.92 for 2.45 to 0.84 mm; number of whorls = 12; tangential length × height of chamberlets in last chamber = 27 × 60 to 34 × 60 µm, and number of chamberlets = up to 60.

Remarks: Although this species has a fusiform test and form ratio from 2.0 to 3.3, Cole (1969) assigned it to *Borelis melo*.

Late Eocene to late Oligocene, Tertiary b to Tertiary e4.

Borelis fusiformis Matsumaru, **n. sp**.
Plate 42, figures 4-9

Etymology: Refers to the test shape.

Type locality: Sample locality, F 28, East Mindanao (text-fig. 22).

Holotype (fig. 4), Saitama Univ. Coll. no. 8923; paratype (fig. 4), no. 8924.

Description: Test large elongate fusiform, with spherical to subspherical proloculus and early stretospiral whorls in 2 or 3 miliolid coils followed by 8 to 9 planispiral whorls. Septa are

PLATE 48

Fig. 1, Station MQ20, Marinduque; fig. 2, 3 Station PN20, Panay; figs. 4-8, Station TR127, Mindoro; fig. 9, Station PTG9, Bondoc Peninsula, SE Luzon; fig. 10, Station 7682904, Negros; fig. 11, Station Abuta 28, Tertiary f1 of Japan (Matsumaru 1967, fig. 4); fig. 12, Station MH5, Burias; fig. 13, Station QZ10-1, Palawan; fig. 14 Station CB30, and fig. 15 Station CB29, Cebu.

1 *Globorotalia* cf. *G. kugleri* Bolli. Axial section, ×100.

2,6,7 *Paragloborotalia* cf. *P. mayeri* (Cushman and Ellisor). Axial section, 2, 7.x100; 6. × 50.

3 *Globigerina* cf. *G, venezuelana* Hedberg. Axial section, ×100.

4,5 *Globigerina* cf. *G. tripartita* Koch. Axial sections, ×50.

8 *Globigerina* cf. *G. praebulloides* Blow. Axial section, ×50.

9 *Globigerinoides* cf. *G. primordius* Blow and Banner. Axial section, ×50.

10 *Globigerina* cf. *G. binaiensis* Koch. Transverse section, ×100.

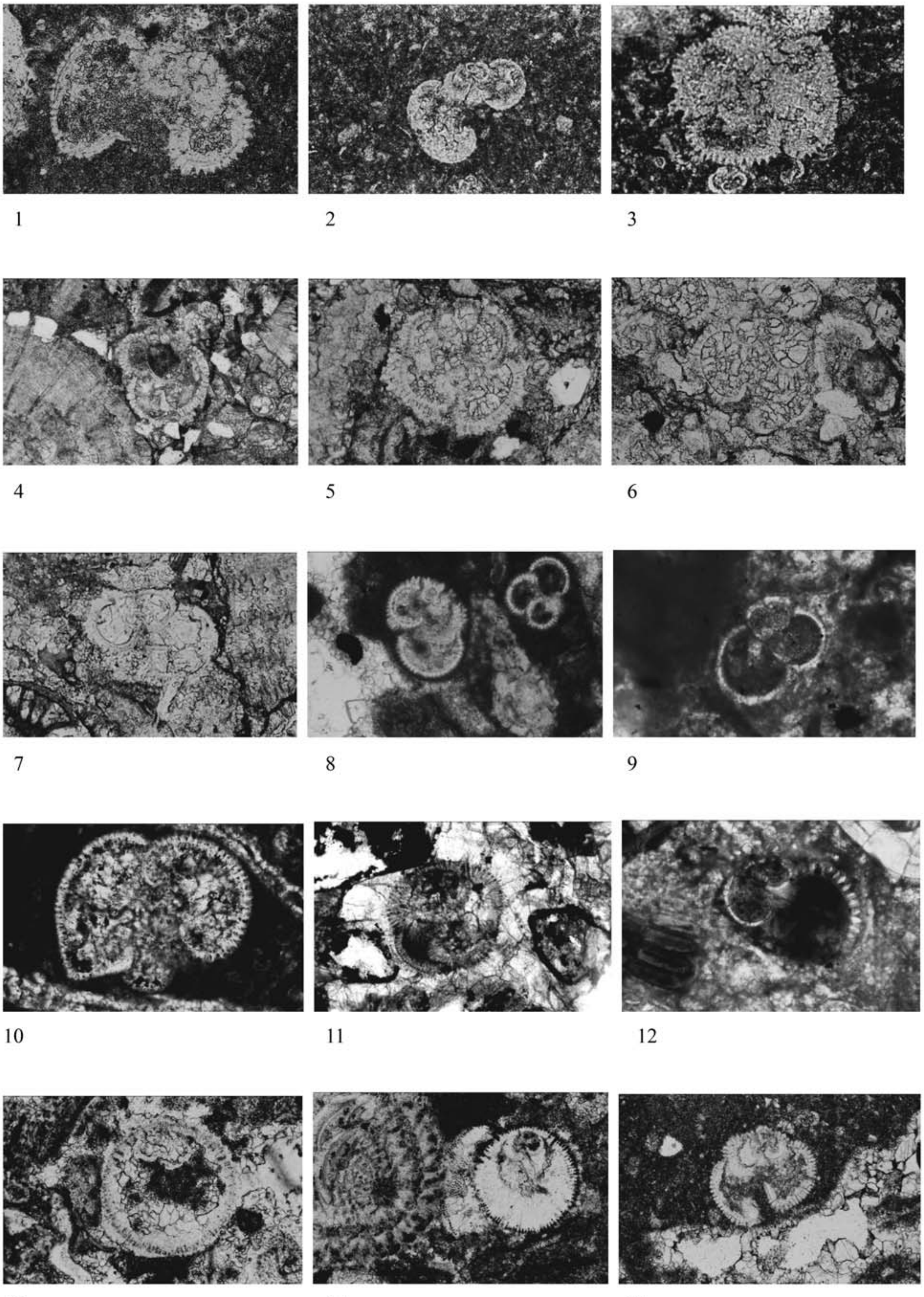
11 *Globigerinatella insueta* Cushman and Stainforth. Axial section, ×50.

12 *Praeorbulina sicana* (de Stefani). Axial section, ×100.

13 *Praeorbulina glomerosa* (Blow). Axial section, ×50.

14 *Orbulina universa* d'Orbigny. Axial section, ×50.

15 *Dentoglobigerina* cf. *D. altispira* (Cushman and Jarvis). Axial section, ×50.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

aligned alternately, radial or parallel from chamber to chamber, with preseptal passages.

Dimensions: axial diameter of test = 1.31 to 2.61 mm, height = 0.40 to 0.55 mm, diameter/height ratio = 2.53 to 5.44; diameter of proloculus = 32 × 32, 33 × 44, 35 × 35, 44 × 44, and 44 × 44 µm in 5 specimens; diamter/height ration in 4th whorl = 3.27 for 0.36 to 0.11 mm, in 5th whorl = 2.53 for 0.43 to 0.17 mm, in 6th whorl = 3.00 for 0.66 to 0.22 mm, in 7th whorl = 3.19 for 0.86 to0.27 mm, in 8th whorl = 3.57 for 1.25 to 0.35 mm, in 9th whorl = 4.03 for 1.57 to 0.39 mm, in 10th whorl = 3.83 for 1.84 to 0.48 mm, and in 11th whorl = 3.76 for 2.07 to 0.55 mm; number of whorls = 11; tangential length × height ratio of chamberlets in last chamber = 22 × 34 to 31 × 38 µm, and number of chamberlets = 64 to 66.

Remarks: Differs from its ancestor *Borelis pygmaeus* in its larger large axial diameter and larger number of chamberlets in the last whorl.

Early to late Oligocene, Tertiary d to Tertiary e3.

Borelis melo (Fichtel and Moll 1798)
Plate 41, figure 10 left

Nautilus melo var. á FICHTEL and MOLL 1798, p. 118, pl. 24, figs. a-f.
Alveolina melo (Fichtel and Moll). – D'ORBIGNY 1846, p. 147, pl. 7, figs. 15-16.
Neoalveolina melo (Fichtel and Moll). – REICHEL 1937, p. 105-108, pl. 10, figs. 8-9. text-fig. 22.
Borelis melo (Fichtel and Moll). – COLE 1969, p. 5-7, pl. 4, figs. 19-20, 23 (non pl. 4, figs. 8-18, 21-22, 25)

Description: Test globular, with spherical to subspherical proloculus and 3 to 4 streptospiral miliolid coils followed by 7 planispiral coils. Septa are aligned alternately, radial or parallel from chamber to chamber, with preseptal passages. Wall is porcellaneous and imperforate.

Dimensions: axial diameter of test = 0.95 to 1.10 mm, height = 0.92 to 1.09 mm, ratio of axial diameter/height = 1.01 to 1.03; diameter of proloculus = 35 and 36 µm in 2 specimens; ratio of axial diameter/height in 4th whorl = 1.24, in 5th whorl = 1.17, in 6th whorl = 1.13, in 7th whorl = 0.97, in 8th whorl = 1.00, in 9th whorl = 1.03, in 10th whorl = 1.03 and in 11th whorl = 1.03; tangential diameter × height of chamberlets in last chamber = 28 × 50 to 34 × 68 µm, and number of chamberlets = 32(?).

Remarks: The peculiar globular test and many chamberlets identifies *Borelis melo*, which is rare in the Philippines.

Pliocene to Holocene (acc. Cole 1969), Tertiary g to Tertiary h.

Genus *Flosculinella* Schubert 1910

Flosculinella bontangensis (Rutten 1913)
Plate 42, figures 10-14

PLATE 49

Figs. 1, 2, Station BHY2, and fig. 4, Station BHY6, Leyte; fig. 3, Station MBG1, and fig. 14, Station MBG2, Masbate; fig. 5, Station A9, and fig. 6, Station BYG2, Bondoc Peninsula, SE Luzon; fig.7, Station MH5, Burias; figs. 8-10, Station TB17, Tablas; figs. 11-13, Station CB46, Cebu; fig. 15, Station W9 (Hashimoto 1939, p. 400; BMG 1981, p. 31, tab. II-7, upper Miocene), Bontoc, North Luzon.

1 *Globigerinoides* cf. *G. ruber* (d'Orbigny). Axial section, ×50.

2 *Sphaeroidinellopsis* cf. *S. subdehiscens* (Blow). 2 right, axial section, ×50.

2 *Pulleniatina* cf. *P. primalis* Banner and Blow. 2 left, transverse section, ×50.

3 *Globigerinoides* cf. *G. obliquus* Bolli. Axial section, ×50.

4 *Orbulina suturalis* Brönnimann. Axial section, ×20.

5 *Paragloborotalia* cf. *P. mayeri* (Cushman and Ellisor). Axial section, ×100.

6 *Pulleniatina* sp. Axial section, ×100.

7 *Globigerina* ex gr. *G. praebulloides* Blow. Axial section, ×100.

8 *Globorotalia* cf. *G. crassaformis* (Galloway and Wissler). Axial section, ×100.

9 *Globorotalia* ex gr. *G. pseudomiocenica* Bolli and Bermudez. Transverse section, ×100.

10 *Globigerinoides* cf. *G. immaturus* Leroy. Axial section, ×100.

11 *Globorotalia* ex gr. *G. miocenica* Palmer. 11 right, axial section, ×50.

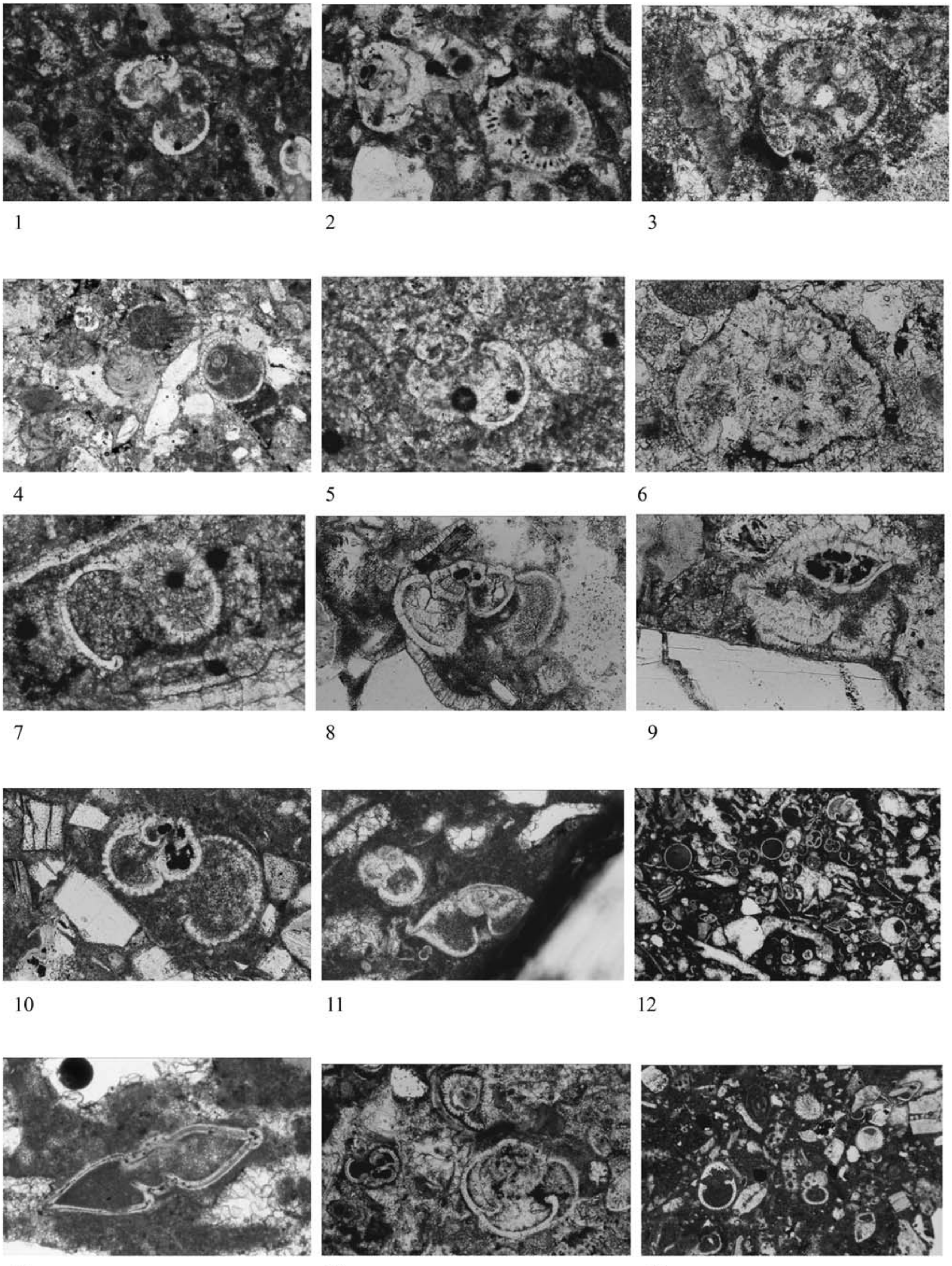
11 *Globigerinoides* sp. 11 left, axial section, ×50.

12 *Globorotalia* ex gr. *G. miocenica* Palmer. 12 center, transverse section, umbilical side strongly convex and dorsal side curved, ×10.

13 *Globorotalia* ex gr. *G. menardii* (d'Orbigny). Transverse section, very low trochospiral and compressed, ×50.

14 *Candeina* cf. *C. nitida* d'Orbigny. Oblique section, with axial periphery broadly rounded, ×50.

15 *Sphaeroidinella dehiscens* (Parker and Jones). Transverse section, with axial periphery rounded and last whorl rapidly increased, ×20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Alveolina bontangensis RUTTEN 1913, p. 221-224; pl. 14, figs. 1-2. – DOUVILLÉ 1916, p. 32-33, pl. 4, fig. 10. – VAN DER VLERK 1929, p. 14-15, figs. 1-5.
Flosculinella bontangensis (Rutten). – REICHEL 1937, p. 1, 113-115, pl. 11, fig. 7 (Text-figs. 23-24. – COLE 1963, p. E20, pl. 9,figs. 1-3 – ADAMS and BELFORD 1974, p. 490, pl. 74, fig. 3.
Flosculinella bontangensis bontangensis (Rutten). – CHAPRONIERE 1984, p. 32, pl. 14, figs. 18-19, 22.

Description: Test fusiform to cylindrical. Spherical to subspherical proloculus is followed by 3 streptospiral miliolid coils and then 5 planispiral whorls. Subdivision of whorls begins with the fourth whorl, with tangential septa dividing whorls into low outer and high inner zones of 2 tiers, all divided by meridinal septa into chambers of the same tangential length, further subdivided by secondary septula into chamberlets in alternating alignment. Chamberlets of the outer zone are always narrower and less high than those of inner zone. Large preseptal passage and intercameral foramen are present.

Dimensions: axial diameter of test = 1.62 to 1.89 mm, height = 0.56 to 0.75 mm; ratio of diameter/height = 1.53 to 2.68; diameter of proloculus = 40 × 36, 48 × 48, and 52 × 48 µm in 3 specimens; number of whorls = 8 to 10; length × height of chamberlets in outer zone = 17 × 21 to 21 × 22 µm, and inner zone = 33 × 38 to 42 × 43 µm.

Early to middle Miocene, Tertiary e5 to Tertiary f1.

Flosculinella globulosa (Rutten 1917)
Plate 43, figures 7-9, 10 right

Alveolinella (Flosculinella) globulosa RUTTEN 1917, p. 277, pl. 5, figs 140-141. – VAN DER VLERK 1922, p. 395, pl. 2, figs. 12, 12a.
Flosculinella globulosa Rutten. – REICHEL 1937, p. 113. – COLE 1954, p. 584, pl. 209, fig. 9. – HANZAWA 1957, p. 56-57, pl. 23, figs. 1a-d. – COLE 1957, p. 336, pl. 110, figs. 1-4. – COLE 1969, p. C7, pl. 4, figs. 24, 26. – HASHIMOTO and MATSUMARU 1975, p. 122-123, pl. 14, figs. 1-6.
Flosculinella reicheli MOHLER 1949, p. 521-527 (Text-figs. 1-3. – MATSUMARU 1996, p. 212, 214. pl. 84, figs. 1-2.
Flosculinella bontangensis globulosa (Rutten). – CHAPRONIERE 1984, p. 32-33, pl. 3, figs. 2a-b; pl. 14, fig. 22.

Description: Test globular, with spherical to subspherical proloculus followed by 3 to 4 streptospiral miliolid coils and then 5 or 6 plainspiral whorls. Each whorl is divided by tangential septa into low outer and high inner zones, divided by meridional septa into chambers of the same tangential length and further subdivided by secondary septula into chamberlets in alternating alignment. Chamberlets of the outer zone are always narrower and less high than those of inner zone. Preseptal passage and intercameral foramen are present.

Dimensions: axial diameter of test = 0.55 to 1.36 mm, height = 0.73 to 1.10 mm, ratio of diameter/height = 0.96 to 1.26; diameter of proloculus = 33 × 33, 41 × 43, 43x 39, and 43 × 43 µm in 3 specimens; number of whorls = 8 to 10; length × width of chamberlets in outer zone = 13 × 15 to 21 × 21 µm, and inner zone = 26 × 56 to 65 × 45 µm.

Remarks: According to Cole (1954, 1957, 1969) has a long range from the lower *Heterostegina borneensis* beds to *Spiroclypeus margaritatus* beds in Bikini, Eniwetok and Midway drill holes.

Upper Oligocene to lower Miocene, Tertiary e4 to Tertiary f1.

Flosculinella fusiformis Hashimoto and Matsumaru 1975
Plate 42, figure 15; plate 43, figures 1-6

Flosculinella fusiformis HASHIMOTO and MATSUMARU 1975, p. 123- 124, pl. 14, fig. 8.

Description: Test large, fusiform, with spherical to subspherical proloculus followed by 3 streptospiral miliolid coils and then 7 planispiral whorls. Each whorl is tightly coiled and divided by tangential septa into low outer and high inner zones, divided into chambers by meridional septa of the same tangential length. The chambers are further subdivided by secondary septula into chamberlets in alternating alignment, those of outer zone narrower and lower in height than those of inner zone. Preseptal passage and intercameral foramen are present.

Dimensions: axial diameter of test = 2.16 to 2.73 mm, height = 0.66 to 0.93 mm; ratio of diameter/height = 2.57 to 3.64; diameter of proloculus = 32 × 32, 34 × 36, 36 × 36, 40 × 37, 56 × 56, and 56 × 57 µm in 6 specimens; number of whorls = 10; length × height of chamberlets in outer zone = 15 × 17 to 22 × 22 µm, and inner zone = 21 × 28 to 26 × 31 µm.

Remarks: Differs from *Flosculinella bontangensis* (Rutten) in its elogated fusiform test and tightly coiled whorls.

Early Miocene, Tertiary e5 to Tertiary f1.

Genus *Alveolinella* H. Douvillé 1907

Alveolinella quoyii (d'Orbigny 1826)
Plate 41, figure 10 left; plate 43, figures 11 upper, 12-15

Alveolina quoyii D'ORBIGNY 1826, p. 307, pl. 17, figs. 11-13.
Alveolina boscii Defrance. – VAN DER VLERK 1929, p. 16, fig. 24.
Alveolinella quoyii (d'Orbigny). – CUSHMAN 1933, p. 68, pl. 19, fig. 10. – TODD and POST 1954, p. 558, pl. 202, figs. 5, 8. – COLE 1957, p. 767, pl. 240, figs. 16-25. – MATSUMARU 1976, p. 403, 406, pl. 5, figs. 1-10, 15; tabs. 1-2.

Description: Test large elongated fusiform, with spherical to subspherical proloculus followed by 1 or 2 irregular miliolid coil(s) and then planispiral whorls. Each whorl is subdivided by tangential septa into 2 or more layers of low outer zones and one high inner zone. Both inner and outer zones are divided by meridional septa into chambers of the same tangential length, further subdivided by equatorial septula into chamberlets in alternaing alignment. The outer chamberlets are always smaller than the inner ones. Preseptal passages are present in chamber floors and smaller secondary preseptal passages are also present. Multiple apertures are in longitudinal rows along the apertural face.

Dimensions: axial diameter of test = 3.41 to 4.50 mm, height of test = 0.74 to 1.36 mm, ratio of diameter/height = 3.31 to 5.40; diameter of proloculus = 50 × 50, 56 × 56, 61 × 78, and 104 × 54 µm in 4 specimens; Number of whorls = up to 8; length × width of chamberlets in outer zone = 9 × 12 to 13 × 18 µm; and inner zone = 20 × 45 to 37 × 50 µm.

Remarks: Occurs widely in the latest Cenozoic of the equatorial Pacific and Indian oceans, but is missing from Recent faunas in the Pacific region (Matsumaru 1976).

Middle Miocene to Holocene, Tertiary f1 to Tertiary h.

CONCLUSION

Taking the data from Part 1 and Part 2 together, the 192 species of larger foraminifera from shallow-water carbonates and sediments of latest Cretaceous to Quaternary age in the Philippine Archipelago, as documented in table 16 and assigned to 19 assemblage zones, can be closely correlation to the complete range of Vlerk letter stages as newly defined from Tertiary a0 to Tertiary h, as well as to Maastrichtian ms1 if not to any other Late Cretaceous units. Because of the wide geographic range of larger foraminiferal species across the Tethyan realm, the Philippine assemblages are also well correlated to other assemblage sequences in Japan (Matsumaru 1996), India (Matsumaru and Sarma 2010) and Turkey (Matsumaru et al. 2010; Matsumaru 2016), as shown in table 17. The age ranges of 130 taxa, shown in table 18 (following Matsumaru 2011, fig. 3) provide a basis for dating and correlation of shallow marine deposits across the Tethys realm, in terms of the redefined and amplified letter stage system.

This study includes the recognition of 18 new species, of which eight are the types of new genera. In addition, the study describes the first documented example of neoteny (reduction to a single embryonic chamber) in larger foraminifera, in a specimen of *Lepidocyclina indonesiensis* (pl. 40, figs. 10-14).

ACKNOWLEDGMENTS

The author wishes to honor his late colleagues Dr. Wataru Hashimoto, Department of Geology and Mineralogy, Tokyo University of Education (now Tsukuba University) and Dr. Alphonse Blondeau, Université Pierre et Marie Curie, Paris 6. Thanks are also due to Dr. Izver Öngen (Tansel), Deapartment of Geology, Faculty of Engineering, Istanbul University; Dr. Bernardo M. Barcelona and Mr. Pancrasio M. Alcantala, former staff at the Bureau of Mines and Geosciences, Philippines; Dr. Hiro'o Natori (ret.), Geological Survey of Japan; Mr. Tomohisa Nishizuka of Idemitsu Oil & Gas Co. Ltd. and Mr. Tsukei Sugawara (ret.), Sumitomo Petroleum and Development Co. Ltd., Tokyo, for their valuable comments, and gifts of samples. The generosity of Mr. Hiroshi Fuchimoto and his research group at the former Metal Mining Agency and to JAICA agency of Japan in granting permission to use geological information is deeply appreciated. Saitama University made this work possible by providing facilities and partial financial support, and Dr. John A. Van Couvering, Editor-In-Chief (ret.), Micropaleontology Press, New York, is gratefully acknowledged for his hard work in preparing the manuscript for publication.

REFERENCES

ADAMS, C. G., 1965. The foraminifera and stratigraphy of the Melinau Limestone, Sarawak, and its importance in Tertiary correlation. *Quarterly Journal of Geological Society of London,* 121: 283–338.

———, 1987. On the classification of the Lepidocyclinidae (Foraminiferida) with redescriptions of the unrelated Paleocene genera *Actinosiphon* and *Orbitosiphon. Micropaleontology*, 33: 289–317.

———, 1983. Speciation, phylogenesis, tectonism, climate and eustacy: Factors in the evolution of Cenozoic larger foraminiferal bioprovinces. In: Sims, R. W., Price, J. H. and Whatley, P. E. S., Eds., *Evolution,time and space: The emergence of the biosphere,* 255–289. London: Systematics Association. Special Volume 23.

———, 1985. The letter classification and Neogene. In: Snelling, N. J., Ed., *The chronology of the geological record,* 141–195. Boulder: Geological Society of America. Memoir 10.

ADAMS, C. G.. and BELFORD, D. J., 1974. Foraminiferal biostratigraphy of the Oligocene – Miocene limestones of Cristmas Island (Indian Ocean). *Palaeontology,* 17: 475–506.

ADAMS, C. G., RODDA, P. and KITELEY, R. J., 1979. The extinction of the foraminiferal genus *Lepidocyclina* and the Miocene/Pliocene boundary problem in Fiji. *Marine Micropaleontology,* 4: 319–339.

ALCANTARA, P. M., 1980. Tertiary larger foraminifera from the Argao – Dalaguete region, southern Cebu Island, Philippines. In: Igo, H. and Noda, H., Eds., *Professor Sabro Kanno Memorial Volume, Ibaraki,* 221–232.

ANTHONISSEN, D. E. and OGG, J. G., 2012. Cenozoic and Cretaceous biochronology of planktonic foraminifera and calcareous nannofossils. In: Gradstein, F. M., Ogg, J. G., Schmitz, M. D. and Ogg, G. M., Eds., *The Geological Time Scale 2012, vol. 2*. Amsterdam: Elsevier.

ARCHIAC, E. J. d'. 1846. Decription des fossils recueillis par M. Thorent dans les couches à *Nummulites* des environs de Bayonne. *Mémoires de la Societé Géologique de France,* 2: 190–217.

———, 1850. Déscription des fossiles du groupe nummulitique recuillis par Ms.. P. Pratt et M. J. Delbos aux environs de Bayonne et de Dax. *Mémoires de la Société Géologique de France,* 3: 397–456.

ARCHIAC, E. J. d' and HAIME, J., 1853. Decription des animaux fossils du groupe nummulitique de l'Inde. *Monographie des Nummulites,* 373 pp..

BAKX, L. A. J., 1932. De genera *Fasciolites* en *Neoalveolina* in het Indo-Pacifische gebied. *Verhandelingen van het Geolologische Mijnbouwkundig Genootschap voor Nederland en Kolonien, Geol. Ser.,* 9: 205–266.

BARKER, R. W., 1960. *Taxonomic notes on the species fig.d by H. B. Brady in his report on the foraminifera dredged by H. M. S. Challenger during 1873–1876*. Tulsa: Society of Economic Paleontologists and Mineralogists Special Publication No. 9, 238 pp.

BASSIOUNI, M. A., ALLAM, A., BOUKHARY, M. and ZALAT, A., 1988. On the occurrence of *Nummulites ptukhiani* Kacharava at the base of Maadi Formation (Bartonian), Gebel Mokattam, east of Cairo, Egypt. *Revue de Paléobiologie, Vol. Spec.* 2: 615–620.

BECKMAN, J. P., 1976. Shallow-water foraminifers and associated microfossils from Site 315, 316 and 318, DSDP Leg 33. In: Schlanger, S. O., Jackson, E. D., et al., *Initial Reports of the Deep Sea Drilling Project, 33*, 467–489. Washington, DC: U. S. Government Printing Office.

BERGGREN, W. A. and VAN COUVERING, J. A., 1974. The late Neogene: biostratigraphy, geochronology and paleoclimatology of the last 15 million years in marine and continental sequences. *Paleogeography, Paleoclimatology, Paleoecology,* 16: 1–215.

BERGGREN,W. A., KENT, D. V., SWISHER C. C. III and AUBRY, M.-P., 1995. A revised Cenozoic geochronology and chronostratigraphy. In: Berggren, W. A., Kent, D. V., Aubry, M.-P. and Hardenbol, J., Eds., *Geochronology, time scales and global stratigraphic correlation,* 129–212. Tulsa: Society for Sedimentary Petrology (SEPM), Special Publication 54.

BIEDA, F., 1950. Sur quelques foraminifèrs nouveaux ou peu connus du flysch des Karpates Polonaises. *Rocznik Polskiego Towarzystwa Geologicznego,* 18: 167–179.

———, 1963. Duże otwornice eocenu Tatrzanskiego. *Instytut Geologiczny, Prace,* 37: 157–215.

BIGNOT, G. and NEUMANN, M., 1991. Les "Grandes" foraminifères du Crétacé terminal et du Paléogène du Nord-ouest Européen. Recensement et extensions chronologiques. *Bulletin Inférieur Géologique du Bassin de Paris,* 28: 13–29.

BISCHOFF, B., 1968. "Die Geologie von Nord-Ithaka (Griechenland)." Unpubl. Diploma-Arbeit. Univ. München, Institut der Paläontolgie u. Historisches Geologie, 92 pp.

BLAINVILLE, H. M. DUCRATAY de, 1827. *Manuel de malacologie et de conchyliologie* (1825). Paris: F. G. Levrault, 664 pp.

BLONDEAU, A., 1972. *Les Nummulites.* Paris: Vuibert, 254 pp.

BLOW, W. H., 1969. Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. In: Brönnimann, P. and Renz, H. H., Eds., *Proceedings of the First International Conference on Planktonic Microfossils,* 199–422. Leiden: E. J. Brill.

———, 1979. *The Cainozoic Globigerinida, vols. 1–3*. Leiden; E. J. Brill, 1413 pp.

BMG (Bureau of Mines and Geosciences), 1981. *Geology and mineral resources of the Philippines.* Manila: Bureau of Mines and Geosciences, 406 pp.

BUREAU OF MINES, 1963. *Geological map of the Philippines (1:1,000,000)*. Manila: Bureau of Mines and Geosciences.

BOLLI, H. M. and SAUNDERS, J. B., 1985. Oligocene to Holocene low latitude planktonic foraminifera. In: Bolli, H. M, Saunders, J. B. and Perch-Nielsen, K,. Eds., *Planktonic stratigraphy,* 155–264. Cambridge: Cambridge University Press.

BOUBÉE, N., 1832. Présentation de deux nouvelles espèces de Nummulites*. Bulletin de la Société Géologique de France,* 2: 444–445.

BOUDAGHER-FADEL, M. K., LORD, A. R. and BANNER, F. T., 2000. Some Miogypsinidae (foraminifera) in the Miocene of Borneo and nearby countries. *Revue de Palébiologie,* 19: 137–156.

BOUKHARY, M., BLONDEAU, A. and AMBROISE, D., 1982. Étude sur les Nummulites de la région de Minia-Samalut, vallée du Nil, Égypte. *Cahiers de Micropaléontologie,* 1: 65–78.

BOURCART, J. and DAVID, E., 1933. Étude stratigrafique et paléontologique des Grès à foraminifères d'Ouezzan au Maroc (Olig. et Mioc. Inférieur). *Mémoires de la Société Naturelles, Maroc,* 37.

BOUSSAC, J., 1906. Dévelopment et morphologiques de les foraminifères de Priabona. *Bulletin de la Société Géologique de France,* 6: 88–100.

———, 1911. *Études stratigraphiques et paléontologiques sur le Nummulitique de Biarritz*. Paris:, Laboratoire de Géologie, Annales de Stratigraphique et Paléontologies*,* 99 pp..

BRADY, H. B., 1875. Fossil foraminifera of Sumatra. *Geological Magazine, London,* 2: 532–539.

———, 1881. Notes on some of the reticularian Rhizopoda of the Challenger Expedition. Part III. *Quaterly Journal of Micropaleontological Science, new ser.,* 21: 31–71.

———, 1884. Report on the Foraminifera dredged by HMS Challenger, during the years 1873–1876. *Report on the Sientific Results of the Voyage of the H. M. S. Challenger during the years 1873–1876, Zoology,* 9: 814 pp.

BRONN, H. G. and ROEMER, F., 1853. *Vieste Periode; Kreide-Gebirge*. Stuttgart: E. Schweizerbart. Lethaea Geognostica, Aufl. 3, Bd. 2, Theil 5 (1851–1852)

BRÖNNIMANN, P., 1940. Über die tertiären Orbitoididen und die Miogypsiniden von Nordwest-Marokko. *Abhandlungen der Schweizerschen Palaontologischen Gesellschaft,* 63: 1–113.

———, 1945. Zur Frage der verwandschaftlichen Bezichungen zwischen *Discocyclina* und *Asterocyclina*. *Eclogae Geologicae Helvetiae*, 38: 579–615.

———, 1951. A model of the internal structure of *Discocyclina* s. s. *Journal of Paleontology,* 25: 208–211.

———, 1954. Upper Cretaceous orbitoidal Foraminifera from Cuba. Part 1. *Sulcorbitoides*, n. gen*. Contributions of the Cushman Foundation for Foraminiferal Research,* 5: 55–61.

BRUGUIÈRE, J. G., 1792. Histoire naturelle des Vers. *Encyclopedie methodique-Paris,* 345–757.

BURSH, J. G., 1947. Mikropaläontologisache Untersuchungen des Tertiärs von Gross Kei (Molukken). *Schweizerische Paläontologische Abhandlung,* 65:1–69.

BUTTERLIN, J., 1987. Origine et Évolution des Lepidocyclines de la region des Caribes. Comparisons et relations avec les Lepidocyclines des autres regions du monde. *Revue de Paléontologie,* 29: 203–219.

———, 1991. Réflexions sur l'origine et l'evolution des Lépidocyclines du Basin Méditerraneen. *Revue de Micropaléontologie,* 34: 175–183.

CAAGUSAN, N. L., 1980. Stratigraphy and evolution of the Cagayan Valley basin, Luzon, Philippines. *Geology and Palaeontology of Southeast Asia,* 21: 163–182.

CAHUZAC, B. and POIGNANT, A., 1991. Morphologie des Especes de *Pararotalia* et de *Miogypsinoides* (Foraminiferida) dans l'Oligocene d'Aquitaine Meridionale. *Geobios, 1991* M.S. 13: 69–78.

CARON, M., 1985. Cretaceous planktic foraminifera. In: Bolli, H. M., Saunders J. B. and Perch-Nielsen, K., Eds., *Plankton stratigraphy,* 17–86. Cambridge: Cambridge University Press. Earth Science Series.

CARPENTER, W. B., 1856. Researches on the foraminifera. Monography of the genus *Orbitolites. Philosophical Transactions of the Royal Society of London,* 146: 181–224.

———, 1856. Researchs on the foraminifera. Pt. 2. On the genera *Orbicula, Alveolina, Cycloclypeus* and *Heterostegina. Philosophical Transactions of the Royal Society of London,* 146: 547–569.

———, 1859. Research on the foraminifera. *Philosophical Transactions of the Royal Society of London,* 149: 32–35.

CARPENTER, W. B., PARKER, W. K. and JONES, T. R., 1862. *Introduction to the study of the foraminifera.* London: Royal Society, 319 pp.

CARTER, H. J., 1877. On a Melobesian form of foraminifera (*Gypsina melobesioides,* mihi); and further observations on *Carpenteria monticularis. Annals and Magazine of Natural History, London,* 20: 172–176.

CAUDRI, C. M. B., 1932. De foraminiferenfauna van eeinige *Cycloclypeus* houdende gesteen van Java. *Verhandelingen van het Geologisch Mijnbouwkundig Genootschap voor Nederlandsch en Kolonien, Geol. Ser.* 9: 171–204.

———, 1934. *Tertiary deposits of Soemba*. Amsterdam-MCMXXXIV. 223 pp.

———, 1939. *Lepidocyclina* van Java. *Verhandelingen van het Geologisch Mijnbouwkundig Genootschap voor Nederlandschen Kolonien Geologisch Servissen.* 2: 135–257.

CAUDRI, C. M. B., 1944. The larger foraminifera from San Juan de los Morros, State of Guarico, Venezuela. *Bulletins of American Paleontology,* 28: 351–404.

CAUS, E., HOTTINGER, L. and TAMBAREAU, Y., 1980. Plissement du "septal flap" et système de canaux chez Daviesina, foraminifère paléocenes. *Eclogae Geologicae Helvetiae,* 73: 1045–1060.

CHANG LI-SHO, 1966. Tertiary biostratigraphy of Taiwan and its correlation. In: Hatai, K., Ed., *Tertiary correlations and climatic changes in the Pacific,* 57–65. Sendai: Sasaki Printing and Publishing Co. Ltd.

———, 1967. A biostratigraphic study of the Tertiary in the coastal range, eastern Taiwan, based on smaller foraminifera (I: Southern part). *Proceedings of the Geological Society of China,* 10:64–76.

———, 1968. A biostratigraphic study of the Tertiary in the coral range, eastern Taiwan, based on smaller foraminifera (II: Northern part). *Proceedings of the Geological Society of China,* 11: 19–33.

———, 1969. A biostratigraphic study of the Tertiary in the coastal range, eastern Taiwan, based on smaller foraminifera (III: Middle part). *Proceedings of the Geological Society of China,* 12: 89–101.

________. 1972. A biostratigraphic study of the so-called slate formation in Taiwan based on smaller foraminifera: II. West flank of the central range in the Tawushan-Tashulinshan area, southern Taiwan. *Proceedings of the National Science Council,* 5: 101–116.

CHAPRONIERE, G. C. H., 1980. Influence of pl. tectonics on the distribution of late Paleocene to early Neogene larger foraminiferids in the Australasian region. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 31: 299–317.

———, 1983. Tertiary foraminiferids from the northwest margin of the Queensland Pl.au, Australia. *BMR Bulletin,* 217: 31–57.

———, 1984. Oligocene and Miocene larger foraminifera from Australia and New Zealand. *Bureau of Mineral Resources Bulletin,* 188: 1–98.

———, 1984. The Neogene larger foraminiferal sequence in the Australian and New Zealand regions, and its relevance to the East Indies letter stage classification. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 46: 25–35.

CHECCHIA-RISPOLI, G., 1909. La serie nummulitica dei dintorni di Termini-Imerese. I. II Vallone Tre Pietre. *Giornale di Scienze Naturali ed Economiche di Palermo,* 27: 53–137.

———, 1911. Sull'Oligocene dei dintorni di Campofiorito in provincia di Palermo. *Giornale di Scienze Naturali ed Palermo,* 28: 281–303.

CHEN Yin-Ming and WEI Kuo-Yen, 1983. The calcareous nannofossils and larger foraminifera *Lepidocyclina* in the Kangkou Limestone, Coastal Range, Eastern Taiwan. *Ti_Chi*, 4: 51–66. (in Chinese with English abstract)

CHEN Wen-Shan, 1997. Lithofacies analyses of the arc-related sequence in the coastal range, Eastern Taiwan. *Journal of the Geological Society of China,* 40: 313–338.

CHERCHI, A. and SCHROEDER, R., 1978. Revision of the type of *Broeckinella arabica* Henson (Foraminifère du Cénomanien basal de la Montagire du Teruch (Corbières, Pyrenées Francaises). *Comptes Rendus, Académie des Science de Paris, ser. D.,* 290: 319–322.

CIMERMAN, F., 1969. *Halkyardia maxima,* n. sp. (Middle Oligocene) and *Halkyardia minima* (Liebus) (Middle Eocene). *Rocznik Polskiego Towarzystwa Geologicznego* 39: 295–304.

CIZANCOURT, M. de, 1948. Nummulites de l'Ile de la Barbade (petites Antilles). *Mémoires de la Société Géologique de France,* 57: 5–36.

COLE, W. S., 1938. *Stratigraphy and micropaleontology of two deep wells in Florida*. Tallahassee: Florida State Geological Survey. Geological Bulletin 16, 73 pp.

———, 1939. Larger foraminifera from Guam. *Journal of Paleontology,* 13: 183–189.

COLE, W. S., 1941. *Stratigraphic and paleontologic studies of wells in Florida*. Tallahassee: Florida State Geological Survey. Geological Bulletin 19, 91 pp.

———, 1944. *Stratigraphic amd paleontologic studies of wells in Florida. No. 3*. Tallahassee:Florida State Geological Survey. Geological Bulletin 26, 168 pp.

———, 1945, Larger foraminifera. (In Ladd, H. S. and Hoffmeister, A. E., Geology of Lau, Fiji). *Bernice P. Bishop Museum Bulletin,* 181: 272–297.

———, 1950. *Larger foraminifera from the Palau Islands*. Washington, DC:U. S. Geological Survey. Professional Paper 221-B, pp. 21–26.

———, 1954. *Larger foraminifera and smaller diagnostic foraminifera from Bikini Drill Holes*. Washington, DC: U. S. Geological Survey Professional Paper 260-O, pp. 569–608.

———, 1957. *Larger foraminifera (of Saipan)*. Washington, DC: U. S. Geological Survey. Professional Paper 280-I, pp. 321–360.

———, 1957. *Larger foraminifera from Eniwetok Atoll drill holes*. Washington, DC: U. S. Geological Survey. Professional Paper 260-V, pp. 743–784.

———, 1957. Variation in American Oligocene species of *Lepidocyclina. Bulletins of American Paleontology,* 38: 31–51.

———, 1959. Names of and variation in certain Indo-pacific Camerinids. *Bulletins of American Paleontology,* 39: 349–371.

———, 1959. *Asterocyclina* from a Pacific seamount. *Contributions from the Cushman Foundation for Foraminiferal Research,* 10: 10–14.

———, 1960. *Upper Eocene and Oligocene larger foraminifera from Viti Levu, Fiji.* Washington, DC: U. S. Geological Survey. Professional paper 374-A, pp. 1–7.

———, 1960. Variability in embryonic chambers of *Lepidocyclina. Micropaleontology*, 6: 133–140.

———, 1961. Names of and variation in certain Indo-Pacific Camerinids-No. 2. A Reply. *Bulletins of American Paleontology* 43: 111–128.

———, 1961. An analysis of certain taxonomic problems in the larger foraminifera. *Bulletins of American Paleontology* 43: 373–394.

———, 1962. Embryonic chambers and the subgenera of *Lepidocyclina. Bulletins of American Paleontology* 44: 29–60.

———, 1963. *Tertiary larger foraminifera from Guam*. Washington, DC: U. S. Geological Survey. Professional Paper 403-E, 28 pp.

———, 1963. Illustrations of conflicting interpretations of the biology and classification of certain larger foraminifera. *Bulletins of American Paleontology* 46: 5–50.

———, 1963. Analysis of *Lepidocyclina radiata* (MARTIN). *Bulletins of American Paleontology,* 46: 157–185.

———, 1969. *Larger foraminifera from deep drill holes on Midway Atoll.* Washington, DC: U. S. Geological Survey. Professional Paper 680-C. 15 pp.

COLE, W. S. and APPLIN, E. R., 1961. Stratigraphic and geographic distribution of larger foraminifera occurring in a well in Coffee County, Georgia. *Contributions from the Cushman Foundation for Foraminiferal Research,* 12: 127–135.

———, 1970. Analysis of some American Upper Cretaceous larger foraminifera. *Bulletins of American Paleontology,* 58: 38–80.

COLE, W. S. and BERMÚDEZ, P. J., 1944. New foraminiferal genera from the Cuban Middle Eocene. *Bulletins of American Paleontology,* 28: 333–344.

COLE, W. S. and BRIDGE, J., 1953. *Geology and larger foraminifera of Saipan Island*. Washington, DC: U. S. Geological Survey. Professional Paper 253. 45 pp.

COLEMAN, P. J., 1963. Tertiary larger foraminifera of the British Solomon Islands, southwest Pacific. *Micropaleontology,* 9: 1–38.

CORBY, G. W. et al., 1951. *Geology and oil possibilities of the Philippines*. Manila: Department of Agriculture and Natural Resources. Technical Bulletin 21, 363 pp.

COSIJN, A. T., 1938. Statistical studies on the phylogeny of some foraminifera. *Leidsche Geologische Mededeelingen,* 10: 1–62.

CRESPIN, I., 1938. The occurrence of *Lacasina* and *Biplanispira* in the mandated territory of New Guinea and a lower Miocene limestone from the Ok Ti River, Papua. *Paleontological Bulletin, Commonwealth Australia,* 3: 1–12.

———, 1952. Two new species of *Lepidocyclina* from Cape Range, northwestern Australia. *Contributions from the Cushman Foundation for Foraminiferal Research,* 3: 28–32.

CUSHMAN, J. A., 1914. A monograph of the foraminifera of the north Pacific Ocean. *Bulletins of the United States National Museum,* 71: 1–43.

———, 1919. Fossil foraminifera from the West Indies. *Carnegie Institution of Washington, Publications,* 291: 23–71.

———, 1921. *Foraminifera of the Philippines and adjacent sea.* Washington, DC: United States National Museum. Bulletin 4, 608 pp.

———, 1924. Samoan foraminifera. *Carnegie Institution of Washington Publications,* 342: 1–75.

———, 1926. Foraminifera of the typical Monterey of California. *Contributions from the Cushman Laboratory for Foraminiferal Research,* 2: 53–69.

———, 1927. An outline of a reclassification of the foraminifera. *Contributions from the Cushman Laboratory Foraminiferal Research,* 3: 1–105.

———, 1928. *Foraminifera their classification and economic use*. Sharon, MA: Cushman Loboratory for F*oraminiferal Research, Special Publication 1, 401 pp.

———, 1933. The foraminifera of the tropical Pacific collections of the “Albatross”, 1899–1900. Pt. 2. Lageniidae to Alveolinellidae. *Bulletin of United States National Museum,* 161: 1–79.

CUSHMAN, J. A. and BERMÚDEZ, P. J., 1936. Additional new species of foraminifera and a new genus from the Eocene of Cuba. *Contributions from the Cushman Laboratory for Foraminiferal Research,* 12: 55–63.

DAVIES, L. M., 1925. Notes on the geology of Kohat, with reference to the homotaxial position of the Salt Marl at Bahadur Khel. *Journal of the Asiatic Society of Bengal*. 20: 207–224.

———, 1927. The Ranikot beds at Thal (Northwest Frontier Provinces of India). *Quarterly Journal of Geological Society of London,* 83: 260–290.

———, 1932. The genera *Dictyoconoides* Nuttall, *Lockhartia* nov. and fundamental distinction from the *Dictyoconus* group of forms. *Transactions of the Royal Society of Edinburgh,* 57: 397–428.

———, 1940. The upper Khirthar beds of northwest India. *Quarterly Journal of Geological Society of London,* 96: 1–219.

DAVIES, L. M. and PINFOLD, E. S., 1937. The Eocene beds of the Punjab salt Range. *Memoirs of the Geological Survey of India,* 24: 1–79.

DEFRANCE, J. L. M., 1822. *Dictionnaire des Sciences Naturelles, vol. 25.* Paris: F. G. Levrault, 485 pp.

DELAGE, Y. and HEROUARD, E., 1896. *Traité de Zoologie Concrete. Vol. 1. La Cellule et les Protozoaires.* Paris: Schleicher Frères, 584 pp.

DEPRAT, J., 1905. Les depots Éocene neocaledonieus. *Bulletin de la Société Géologique de France* 5: 485–516.

DESHAYES, G. P., 1838. Déscription des coquilles fossiles recuillés en Crimée par M. de Verneuil. *Mémoire de la Société Géologique de France,* 3: 37–69.

DONCIEUX, L., 1926. Catalogue descriptif des fossiles nummulitiques de l’Aude et de l’Herault. 2 partie. Corbières septentrionales. *Annales des Sciénces Naturelles, Université de Lyon,* 45: 1–80.

DOORNINK, H. W., 1932. Tertiary Nummulitidae from Java. *Verhandelingen van het Geologisch Mijnbouwkundig Genootschap voor Nederlandsch Kolonien, Geol. Ser.,* 9: 267–315.

DOUVILLÉ, H., 1905. Les foraminifères dans le Tertiaire de Borneo. *Bulletin de la Société Géologique de France,* 5: 435–464.

———, 1908. Observations sur les faunes à Foraminifères du sommet du Nummulitique Italien. *Bulletin de la Société géologique de France,* 8: 88–95.

———, 1911. Les foraminifères dans le tertiaire des Philippines. *Philippine Journal of Science,* 6: 53–80.

———, 1912. Les foraminifères de l’Ile de Nias. *Beiträge zur Geologie Ost-Asiens und Australiens,* 8: 253–278.

———, 1916. Les foraminifères des couches de Rembang. *Sammlungen des Geologischen Reichs-Museums* In: *Leiden,* ser. I 10: 19–35.

———, 1916. Le Cretacé et l’Éocene du Tibet central. *Memoirs of the Geological Survey of India, Palaeontologia Indica, N. S*., 5: 1–84.

———, 1917. Les Orbitoides de l'ile de la Trinité. *C. R. Hebd. des Sénces de l'Academie des Sciences, Paris,* 164: 841–847.

———, 1919. Les terrain nummulitique du basin de l'Adour. *Bulletin de la Société Géologique de France,* 5: 9–55.

———, 1920. Révision des Orbitoides. Prémière partie: Orbitoides du Cretacés; les *Omphalocyclus. C. R. des Séances, Société géologique de France,* 1920: 166–167.

———, 1922. Orbitoides de la Jamaique. *Pseudorbitoides trechmanni,* nov. gen., nov. sp. *C. R. des Séances, Société Géologique de France,* 1922: 203–204.

———, 1922. Deuxième partie – Orbitoides du Danien et l'Eocene. *Bulletin de la Société géologique de France,* 22: 55–100.

———, 1924–1925. Revision de Lepidocyclines. *Mémoires de la Société Géologiquede France,* Mem. 2, n. ser. 1: 1–50; 2: 1–115.

DROBNE, K., 1974. Les grandes Miliolidés des couches Paléocenes de la Yougoslavie du nord-ouest (*Idalina, Fabularia, Lacazina, Periloculina*). *Rozprave Dissertationes,* 17/3: 129–184.

———, 1975. *Hottingerina lukasi* n. gen., n. sp. (Foraminiferida) iz srednjega Paleocena v severozahodni Jugoslaviji. *Rajprave Slovenska Akademija Znanosti Umnetnosti, Classis IV, Historia Naturalis* 18/8: 249–253.

———, 1977. Alveolines paléogenes de la Slovenie et de L'Istrie. *Mémoires suisses de Paléontologie,* 99. 174 pp.

DROBNE, K. and HOTTINGER, L., 1971. *Broeckinella* und *Sabaudia* (Foraminiferida) aus dem nordwestlichen teil Jugoslawiens, ihre morphologie und ihre stratigraphische verbreitung. *Rozprave 4, rajr. SAZU,* 14: 215–238.

DROBNE, K., OGORELEC, B., PLENICAR, M., ZUCCHI-STOLFA, M. L. and TURNSEK, D., 1988. Maastrichtian, Danian and Thanetian beds in Dolenja Vas (NW Dinarides, Yugoslavia). Mikrofacies, foraminifers, rudists and corals. *Academia Scientiarum et Artium Slovenica* 29: 148–224.

DROOGER, C. W., 1952. "Study of American Miogypsinidae*"*. Utrecht University, unpubl. thesis, 80 pp.

———, 1953. Some Indonesian Miogypsinidae. *Proceedings Koninklijge Nederlandse Akademie van Wetenschappen, ser.* B, 56: 104–123.

———, 1993. Radial foraminifera, morphometrics and evolution. *Verhandelingen der Koninklijke Nederlandse Akademie van Wetenschappen*, 41: 1–212.

DROOGER, C. W. and SOCIN, C., 1959. Miocene Foraminifera from Rosignano, northern Italy. *Micropaleontology,* 5: 415–426.

DROOGER, C. W. and MAGNE, J., 1959. Miogypsinids and planktonic foraminifera of the Algerian Oligocene and Miocene. *Micropaleontology,* 5: 273–284.

EAMES, F. E., BANNER, F. T., BLOW, W. H. and CLARK, W. J., 1962. *Fundamentals of mid-Tertiary stratigraphical correlation.* Cambridge: Cambridge University Press, 163 pp.

EGGINK, J. W. and BAUMFALK, Y. A., 1983. The exceptional reproduction and embryonic morphology of *Orbitoides gensacicus* (Late Cretaceous). *Journal of Foraminiferal Research,* 13: 179–190.

EHRENBERG, C. G., 1839. Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Physikalische Abhandlungen der Koniglichen Akademie der Wissenschaften zu Berlin,* 1838: 59–147.

ERDOGAN, K., 1995. A new genus and species of an orbitoidal foraminifera: *Ilgazina unilateralis,* n. gen., n. sp. *Geological Bulletin of Turkey,* 38: 11–23.

FERRÀNDEZ-CAÑADELL, C., 2002. New Paleocene orbitoidiform foraminifera from the Punjab Salt Range, Pakistan. *Journal of Foraminiferal Research*, 32: 1–21.

FICHTEL, L. von, and MOLL, J. P. C. von, 1798. Testacea microscopica, aliaque minuta ex generibus *Argonauta* et *Nautilus,* ad naturam picta et descripta. Vienna: Camesina, 123+pp.

FORNASINI, C., 1903. Illustrazione di specie orbignyane di Nummulitidae istituite nel 1826. *Bolletino della Società Geologica Italiana,* 22: 395–398.

FORSKÅL, P., 1775. *Descriptions animalium, quae in itinere orientali osservavit Petrus Forskal*. Copenhagen: Hauniae, Carsten Niebuhr.

FOSTER, H., 1965. *Geology of Ishigaki-shima, Ryukyu-retto.* Washinton, DC: U. S. Geological Survey. Professional Paper 399-A, 119 pp..

FRANCISCO, F. C., 1956. Pre-Tertiary rocks of Buruanga Peninsula, Panay Island, Philippines. *Proceeding of Eighth Pacific Science Congress, v.* 2: 482–498.

FROST, S. H., 1974. Evolution in the *Sulcoperculina – Sulcorbitoides* foraminiferal lineage, Upper Cretaceous, Puerto Rico. *Verhandlingen Schweizerische Naturforschende Gesellschaft,* 84: 265–279.

GALLOWAY, J. J., 1928. A revision of the family Orbitoididae. *Journal of Paleontology,* 2: 45–69.

GERVACIO, F. C., 1970. *Geological map of Marinduque. Scale 1:50,000.* Manila: Philippines Bureau of Mines.

GEYN, W. A. E., van de, and VLERK, I. M. van der, 1935. A monograph on the Orbitoididae, occurring in the Tertiary of America compiled in connection with an examination of a collection of larger foraminifera from Trinidad. *Leidsche Geologische Mededelingen,* 7: 221–272.

GLAESSNER, M. F., 1960. Upper Cretaceous larger foraminifera from New Guinea. *Science Reports, Tohoku University, 2nd ser. (Geolog), Special Volume,* 4: 37–44.

GLAESSNER, M. F and WADE, M., 1959. Revision of the foraminiferal family Victoriellidae. *Micropaleontology*, 5: 193–212.

GORSEL, J. T. van, 1972. *Orbitocyclina minima* (H. Douvillé) at its type locality, with remarks about its origin, evolution and systematic place. *Proceedings of the Koninklijge Nederlandse Akademie van Wetenschappen, ser. B*, 75: 339–347.

———, 1973. *Lepidorbitoides* from the Campanian type region. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, ser. B,* 76:260–272.

———, 1975. Evolutionary trends and stratigraphic significance of the late Cretaceous *Helicorbitoides-Lepidorbitoides* lineage. *Utrecht Micropaleontological Bulletin,* 12: 1–99.

GOVINDAN, A., 2003. Tertiary larger foraminifera in Indian Basins: A tie up with standard planktic zones and Letter Stages. *Gondwana Geological Magazine, Special Volume,* 6: 45–78.

GRADSTEIN, F. M., OGG, J. G. and SMITH, A. G., 2004. Geologic time scale, 2004. Cambridge: Cambridge University Press.

GRIMSDALE, T. F., 1952. Cretaceous and Tertiary foraminifera from the Middle East. *Bulletin of British Museum (Natural History),* 1: 221–248.

GRONOVIUS, L. T., 1781. *Zoophylacii Gronoviani. Vol. 3*. Leyden: Theodorus Haak et Soc., pp. 241–380.

GÜMBEL, C. W., 1861. *Geognostische beschreibung des bayerischen Alpengebirges und seines Vorlandes. Vol. 1.* Gotha: T. Perthas, 950 pp.

———, 1870. Beiträge zur Foraminiferenfauna der nordalpinen Eocängebilde. *Abhandlungen der K. Bayerischen Akademie der Wissenschaften, Cl. II*, 10: 1–152.

HANTKEN, M. von, 1876. A *Clavulina szabói* rétegek Faunája. I. Foraminiferek. *Magyar Kiralyi Foldtani Intezet Evkonyve*, 4: 1–82.

HANZAWA, S., 1930. Notes on foraminifera found in the Lepidocyclina-limestone from Pabeasan, Java. *Science Reports of the Tohoku Imperial University, second ser. (Geology),* 14: 85–96.

———, 1931. Note on Tertiary foraminiferous rocks from the Kwanto Mountainland, Japan. *Sience Reports of the Tohoku Imperial University, second ser. (Geology),* 12: 141–157.

———, 1931. On some Miocene rocks with *Lepidocyclina* from the Izu and Boso Peninsulas. *Science Reports of the Tohoku Imperial University, second ser. (Geology),* 12: 159–170.

———, 1931. Notes on some Eocene foraminifera found in Taiwan (Formosa) with remarks on the age of the Hori Slate Formation and crystalline schists. *Science Reports of the Tohoku Imperial University, second ser. (Geology),* 12: 171–194.

———, 1932. A new type of *Lepidocyclina* with a multilocular nucleoconch from the Taito Mountains, Taiwan (Formosa). *Proceedings of the Imperial Academy of Japan* 8: 446–449.

———, 1935. Topography and geology of the Riukiu Islands. *Science Reports of the Tohoku Imperial University second ser. (Geology),* 17: 1–61.

———, 1935. Some fossil *Operculina* and *Miogypsina* from Japan and their stratigraphic significance. *Science Reports of the Tohoku Imperial University second ser. (Geology),* 18: 1–29.

———, 1937. Notes on some interesting Cretaceous and Tertiary foraminifera from the west Indies. *Journal of Paleontology,* 11: 110–117.

———, 1939. On the occurrence of *Lepidocyclina* (s. s.) in Taiwan (Formosa). *Proceeding of the Imperial Academy of Tokyo* 15: 182–185.

———, 1939. Revision of *Nummulites cumingii* (CARPENTER). *Japanese Journal of Geology and Geography* 16: 225–232.

———, 1940. Micropaleontological studies of drill cores from a deep well in Kita-Daito-Zima (North Borodino Island). *Jubilee Publication of Professor H. Yabe's 60th birthday,* 755–802.

———, 1943. Notes on some Miocene foraminifera from the Sagaera oilfield, Japan. *Transactions of the Palaeontological Society of Japan,* 165: 125–135.

———, 1947. Note on *Borelis pygmaeus* (Hanzawa) from the Mariana Island. *Japanese Journal of Geology and Geography* 20: 9–11.

———, 1949. *Borelis philippinensis,* n. sp. from Luzon, P. I. *Japanese Journal of Geology and Geography* 21: 155–157.

———, 1951. Recent and fossil *Cycloclypeus* from the Ryukyu Islands and their adjacent sea. *Short papers of IGPS.* 3: 1–12.

———, 1952. Notes on the Recent and fossil *Baculogypsinoides spinosus* Yabe and Hanzawa from Ryukyu Islands and Taiwan (Formosa) with re+marks on some spinose Foraminifera. *Short papers of IGPS,* 4: 1–22.

———, 1957. *Cenozoic foraminifera of Micronesia.* Boulder: Geological Society of America. Memoir 66, 163 pp.

———, 1959. The foraminifera species *Fabiania cassis* (Oppenheim) in Japan. *Contributions from the Cushman Foundation for Foraminiferal Research,* 10: 119–122.

———, 1962. Upper Cretaceous and Tertiary three-layered larger Foraminifera and their allied forms. *Micropaleontology,*8: 129–186.

———, 1963. Notes on three Cretaceous foraminiferal genera, *Asterorbis, Orbitocyclina* and *Pseudorbitella. Journal of the Geological Society of India,* 4: 26–34.

———, 1965. The ontogeny and the evolution of larger foraminifera. *Science Reports of the Tohoku University, second ser. (Geology),* 36: 239–256.

———, 1965. Notes on some Discocyclinid and Nummulitid foraminifera from Java and Saipan. *Science Reports of the Tohoku University, second ser. (Geology),*37: 41–47.

———, 1967. Three new Tertiary foraminifera from Florida, Saipan, and Guam. *Transactions and Proceedings of the Paleontological Society of Japan,* n. ser. 65: 19–25.

HANZAWA, S. and HASHIMOTO, W., 1970. Larger foraminifera from the Philippines. Part 1. *Geology and Palaeontology of Southeast Asia,* 8: 187–230.

HANZAWA, S. and URATA, H., 1964. Supplementary note to the Nummulitic rocks of Amakusa, Kyushu, Japan. *Reports on Earth Science, Department of General Education, Kyushu University,* 11: 1–12.

HARPE, P. de la, 1879. Dèscription des Nummulites appartenant a la zone supérièure des Falaises des Biarritz. *Bulletins de la Société Borda,* 4: 137–156.

———, 1883. Monographie der in Ägypten und der Libyschen Wüste vorkommenden Nummuliten. *Paleontographica,* 30: 155–216.

———, 1926. Materiaux pour servir a une monographic des Nummulites et Assilines (ed. Rozlozsnik). *Magyar Allami Földtani Intéze,* 27: 1–102.

HASHIMOTO, W., 1939. Stratigraphy of the Philippines. *Jubilee Publication Commemorable Prof. H. Yabe's 60th Birthday,* 1: 381–426.

———, 1973. Larger foraminifera from the Philippines. Part 2. List of larger foraminifera from the Buruanga Peninsula, Panay Island. *Gology and Palaeontology of Southeast Asia,* 11: 125–128.

———, 1975. Larger foraminifera from the Philippines part 4. Larger foraminifera from Mountain Province. *Geology and Palaeontology of Southeast Asia* 16: 127–139.

———, 1981. Geologic development of the Philippines. *Geology and Palaeontology of Southeast Asia,* 22: 83–170.

HASHIMOTO, W. and BALCE, G. R., 1977. A new correlation scheme for the Philippine Cenozoic formations. *Proceeding 1st International Congress Pacific Neogene Stratigraphy, Tokyo,* 119–132.

HASHIMOTO, W. and KURIHARA, K., 1974. *Discocyclina* from the Tsukeng Formation, Nantou, central Taiwan and its geological significance. *Bulletin of the Geological Society of Taiwan* 24: 35–49.

HASHIMOTO, W. and MATSUMARU, K., 1975. On the *Lepidocyclina*-bearing limestone exposed at the Southern Cross Mountain Highway, Taiwan. *Geology and Palaeontology of Southeast Asia* 16: 103–116.

———, 1975. Larger foraminifera from the Philippines Part 3. limestone from eastern coastal ranges of north and central Luzon. *Geology and Palaeontology of Southeast Asia,* 16: 117–125.

———, 1978. Larger foraminifera from the Philippines. Part 8. larger foraminifera from Central Samar. *Geology and Palaeontology of Southeast Asia,* 19: 81–88.

———, 1978. Larger foraminifera from the Philippines. Part 9. larger foraminifera found from the Zigzag Limestone, south of Baguio, Benguest, Luzon, Philippines. *Geology and Palaeontology of Southeast Asia* 19: 89–96.

———, 1981. Larger foraminifera from the Philippines. 11. On the Coal Harbor Limestone, Cagraray Island, Batan Island Group, Albay Province. *Geology and Palaeontology of Southeast Asia,* 22: 56–62.

———, 1981. Larger foraminifera from the Philippines. Part 12. Eocene Limestone from southeastern Luzon. *Geology and Palaeontology of Southeast Asia,* 22: 63–73.

———, 1981. Geological significance of the discovery of *Nummulites fichteli* (Michelotti) from the Sagada Pl.au, Bontoc, Mountain Province, Northern Luzon, Philippines. *Geology and Palaeontology of Southeast Asia,* 22: 75–82.

———, 1982. Larger foraminifera from the Philippines. Part 14. On some larger foraminifera-bearing rocks from Palawan. *Geology and Palaeontology of Southeast Asia* 24: 39–44.

———, 1984. Mesozoic and Cenozoic larger foraminifera of the Philippines and a reference to those found from Borneo by the APRSA's paleontological reconnaissance. *Geology and Palaeontology of Southeast Asia,* 25: 147–166.

HASHIMOTO, W. and SATO, T., 1969. A contribution to the study of geologic structure of the Philippines. *Journal of Geography of Tokyo,* 78: 235–270. (in Japanese)

———, 1978. Larger foraminifera from the Philippines. Part 7. Larger foraminifera from the Lutac Hill Limestone, Pandan Valley, central Cebu. *Geologu and Palaeontology of Southeast Asia,* 19: 73–80.

HASHIMOTO, W., KITAMURA, N., BALCE, G. R., MATSUMARU, K., KURIHARA, K. and ALIATE, E. Z., 1979. Larger foraminiferta from the Philippines. Part 10. Stratigraphic and faunal breaks between the Maybangain and Kinabuan Formations in the Tanay Region, Rizal, Philippines. *Geology and Palaeontology of Southeast Asia,* 20: 143–157.

HASHIMOTO, W., MATSUMARU, K. and ALCANTARA, P. M., 1982. Larger foraminifera from the Philippines.Part 13. Larger foraminifera from the Trankalan limestone and the Escalante (Toboso) Formation, west of Lanao River Valley, NE Occidental Negros. *Geology and Palaeontology of Southeast Asia* 23: 31–38.

HASHIMOTO, W., MATSUMARU, K. and FUCHIMOTO, H., 1980. Consideration on the stratigraphy of the Caraballo Range, northern Luzon: larger foraminiferal range on the Cenozoic of the Philippines. *Geology and Palaeontology of Southeast Asia,* 20: 119–134.

HASHIMOTO, W., MATSUMARU, K. and KURIHARA, K., 1977. Larger foraminifera from the Philippines. Part 5. Larger foraminifera from Cenozoic limestones in the Mansalay vicinity, oriental Mindoro, with an appendix "An Orbitoid-bearing limestone from Barahid, Bongabong". *Geology and Palaeontology of Southeast Asia,* 18: 59–76.

———, 1978. Larger foraminifera from the Philippines. Part 6. Larger foraminifera found from the Pinugay Hill Limestone, Tanay, Rizal, central Luzon. *Geology and Palaeontology of Southeast Asia,* 19: 65–72.

———, 1978. larger foraminifera from the Philippines. Part 7. Larger foraminifera from the Lutac Hill Limestone, Pandan Valley, central Cebu. *Geology and Palaeontology of Southeast Asia* 19: 73–80.

HASHIMOTO, W., MATSUMARU, K. and SUGAYA, M., 1981. Larger foraminifera from the Philippines. Part 11. On the Coal Harbour Limestone, Cagraray Island, Batan Island Group, Albay Province. *Geology and Palaeontology of Southeast Asia.* 22: 55–62.

HASHIMOTO, W., MATSUMARU, K., KURIHARA, K., DAVID, P. P. and BALCE, G. R., 1977. Larger foraminiferal assemblages usefulfor the correlation of the Cenozoic marine sediments in the mobile belt of the Philippines. *Geology and Palaeontology of Southeast Asia,* 18: 103–124.

HENRICH, H., 1934. Foraminiferen aus dem Eocän und Altmiocän von Timor. In:, Boehm, G. and Wanner, J., Eds., *Beiträge zur Geologie Niederlandsch-Indie. Paleontographica, Supplement,* 4: 1–55.

HENSON, F. R. S., 1948. New Trochamminidae and Verneuilinidae from the Middle East. *Annals and Magazine of Natural History,* ser. 11, 14: 605–630.

———, 1948. *Larger imperforate Foraminifera of south-western Asia, families Lituolidae, Orbitolinidae and Meandropsinidae.* London: British Museum (Natural History). 127 pp.

HERON-ALLEN, E. and EARLAND, A., 1911. On the Recent and fossil Foraminifera of the shore-sands of Selsey Bill, Sussex VII. *Journal of the Royal Microscopical Society,* 1911: 298–343.

———, 1915: The foraminifera of the Kerimba Archipelago (Portugese East Africa). Part II. *Transactions of the Zoological Society of London* 20,: 543–794.

———, 1918. The genus *Halkyardia.* In: Halkyard, E., The fossil Foraminifera of the Blue Marl of the Cote des Basques, Biarritz). *Manchester Literary and Philosophical Society Memoirs and Proceedings*. 62, no. 2: 1–145.

HINTE, J. E. Van, 1965. An approach to Orbitoids. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Amsterdam, ser. B*, 68: 57–71.

HOFKER, J., 1927. *The foraminifera of the Siboga Expedition. Part 1. Families Tinoporidae, Rotaliidae, Nummulitidae, Amphisteginidae*. Leiden: E. J. Brill, 78 pp..

———, 1933. Papers from Dr. Th. Mortensen's Pacific Expedition 1914–16. Part 62 – Foraminifera of the Malay Archipelago. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening I Kobenhavn,* 93: 71–167.

———, 1970. Studies of foraminifera. Part 2. Systematic problems. *Publicaties van het Natuurhistorische Genootschap in Limberg,* 20: 1–98.

———, 1971. Studies of foraminifera. Part 3. Systematic problems. *Publicaties van het Natuurhistorische Genootschap in Limberg,* 21: 202 pp.

HOTTINGER, L., 1960. Rechérches sur les Alvéolines du Paléocène et l'Éocène. *Mémoires Suisses de Paléontologie,* 75/76: 1–243.

———, 1977. Foraminifères operculiniformes. *Memoires du Museum National d'Histoire Naturelle,* ser. C, Sci. Terre 40: 159 pp.

HOTTINGER, L. and DROBNE, K., 1980. Early Tertiary conical imperforate foraminifera. *Slovenska Akademija Znanosti* In: *Umetnosti, Classis* 4. *Historia Naturalis, Dissertations,* 22: 187–276.

HOTTINGER, L. and LUTENEGGER, S., 1980. The structure of calcarinid foraminifera. *Schweizersche Palaeontologische Abhandlungen* 101: 115–127.

HOTTINGER, L., HALICZ, E. and REISS, Z., 1991. The foraminiferal genera *Pararotalia, Neorotalia,* and *Calcarina*: Taxonomic revision. *Journal of Paleontology*, 6: 18–33.

HOTTINGER, L., ROMERO, J. and CAUS, E., 2001. Architecture and revision of the Pellatispirines, planispiral canaliferous foraminifera from the Late Eocene Tethys. *Micropaleontology,* 47: 35–77.

HUANG, CHI-YUE, 1979. Biometric study of *Lepidocyclina* in the Kungkuan Tuff of Northern Taiwan. *Acta Geologica Taiwanica, Science Reports of the National Taiwan University,* 20: 41–51.

HUANG, CHI-YUE and CHENG, YING-MIN, 1983. Oligocene and Miocene planktic foraminiferal biostratigraphy of northern Taiwan. *Proceeding of the Geological Society of China,* 26: 21–56.

HUANG, CHI-YUE and YUAN, P. B., 1994. Stratigraphy of the Kangkou Limestone in the coastal range, Eastern Taiwan. *Journal of the Geological Society of China,* 37: 585–605.

HUANG, CHI-YUE, YUAN, P. B. and TENG L., 1988. Paleontology of the Kangkou Limestone in the middle coastal range, Eastern Taiwan. *Acta Geologica Taiwanica, Science Reports of the National Taiwan University,* 26: 133–160.

IBARAKI, M. and TSUCHI, R., 1978. Planktonic foraminifera from *Lepidocyclina* horizon at Namegawa in the Southern Izu Peninsula, Central Japan. *Report of Faculty of Science, Shizuoka University,* 12: 115–130.

ICS [International Commission on Stratigraphy], 2004. Geologic Time Scale, 2004. [cf. Gradstein, et al. 2004]. www.stratigraphy.org.

IONESI, L., 1971. *Flyşul paleogen din Bazinul Vaii Moldovei*. Bucureşti: Editura Academiei Republicii Socialiste Romania*,* 250 pp.

JAEGER, R., 1914. Grundzuge einer stratigraphischen Gliederung der Flyschbildungen des Wienerwaldes. *Mitteilungen der Geologische Gesellschaft, Wien,* 7: 122–172.

JOLY, N. and LEYMERIE, A., 1848. Mémoire sur les Nummulites considéréés zoologiquement et géologiquement. *Mémoire Akadémie des Sciences, Toulouse,* (3), 4:1–70.

JONES, T. R. and CHAPMAN, F., 1900. On the foraminifera of the orbitoidal limestones and reef rocks of Christmas Island. In: Andrews, C. W., Ed., *A monograph of Christmas Island (Indian Ocean)* 226–264. London: British Museum (Natural History),

KACHARAVA, Z. D., 1969. On the phylogenetic sequence of the *Nummulites fabianii* group. *Akademiya Nauk SSSR, Georgia,* 55: 497–500.

KANEKO, I., ISSIKI, N. and ZASHU, S., 1970. K-Ar ages of the Izu-Bonin Islands. *Geochemical Journal,* 4: 53–60.

KEIJZER, F., 1945. "Outline of the geology of the eastern part of the province of Oriente, Cuba." Unoubl. thesis, University of Utrecht.

KOCH, R., 1926. Mitteltertiare Foraminiferen aus Bulongan, Oost-Borneo. *Eclogae Geologicae Helvetiae* 19: 722–751.

KRIJNEN, W. F., 1931. Het genus *Spiroclypeus* in het Indo-Pacifische gebied. *Verhandelingen Geologisch Mijnbouwkundig Genootschap voor Nederlandsch Kolonien, Geol. Ser.* 9: 77–111.

KUDO, R. R., 1931. *Handbook of Protozoology.* Baltimore: C. C. Thomas, 451 pp.

LAMARCK, J. B., 1801. *Systéme des animaux sans vertèbres.* Paris: The Author, 432 pp.

———, 1804. Suit des memoires sur les fossiles des environs de Paris. *Annales Museum National d'Histoire Naturelle,* 5: 179–188.

———, 1816. *Histoire naturelle des animaux sans vertèbres, Vol. 2*. Paris: Verdiere: 568 pp.

LANGE, H., 1968. Die evolution von *Nephrolepidina* und *Eulepidina* in Oligozan und Miozan der inser Ithaka (Westgriechenland). Inaugural-Dissertation, Naturwissenschaftlichen Fakultat der Ludwig-Maximilians-Universitat zu München. Munich: the author, 78 pp.

LE CALVEZ, J., 1949. Révision des foraminiferès Lutétiens du Basin de Paris. II. Rotaliidae et familles affines. *Mémoirès du Service de la Carte Géologique Détailée de la France,* 1–54.

LEE, C. S., 1984. Systematics of *Assilina formosensis* Hanzawa from the slate terrain of Taiwan. *Memoir of the Geological Society of China.* 6: 335–344.

LEMOINE, P. and DOUVILLÉ, R., 1904. Sur le genre *Lepidocyclina* Gumbel. *Mémoires de la Société Géologique de France,* 32: 1–41.

LEPPIG, U., 1988. Structural analysis and taxonomic revision of *Miscellanea,* Paleocene larger foraminifera. *Eclogae Geologicae Helvetiae,* 81: 689–721.

LESS, G., 1987. Paleontology and stratigraphy of the European Orthophragminae. *Geologica Hungarica, Series Palaeontologica,* 51: 373 pp.

LEUPOLD, W. and VLERK, I. M. van der, 1931. The Tertiary. *Leidsche Geologische Mededeelingen, Leiden,* 5: 611–648.

LEYMERIE, A., 1846. Mémoire sur le terrain à *Nummulites* (epicretace) des Corbières et de la Montagne Noir. *Mémoires de la Societé Géologique de France, sér. 2*, 1: 5–41.

———, 1851. Mémoires sur un nouveau type pyrenéen parallele a le Craie proprement dite. *Mémoires de la Societé Géologique de France, sér. 2*, 4: 177–202.

LIEBUS, A., 1911. Die Foraminiferenfauna der Mitteleocenen Mergel von Nordalmatien. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Wien, Mathematisch-Naturwissenschaftliche Klasse*, 120: 805–956.

LLUECA, F. G., 1929. Los Nummulitidos de España. *Comisión de Investigaciones Paleontológicas y Prehistoricas, Memoria,* 36: 400 pp.

LOEBLICH, A. R. Jr. and TAPPAN, H., 1964. Sarcodina chiefly "Thecamoebians" and Foraminiferida. In Moore, R. C., Ed., *Treatise on Invertebrate Paleontology, Part C. Protista* 2. Lawrence, KS: Geological Society of America and University of Kansas Press. 900 pp.

———, 1986. Some new and redefined genera and families of Textularii, Fuslinina, Involutinina, and Miliolina (Foraminiferida). *Journal of Foraminiferal Research,* 16: 334–346.

———, 1988. *Foraminiferal genera and their classification.* Van Nordstrand Reinhold Co., New York, 970 pp.

MAC GILLAVRY, H. J., 1979. Phylomorphogenesis and evolutionary trends of Cretaceous orbitoidal foraminifera. In: von Koeniswald, G. H. R., Emieis, J. D., Buning, W. L. and Wagner, C. W., Eds., *Evolutionary trends in Foraminifera,*139–196. Amsterdam: Elsevier.

MARIE, P., 1955. Quelques genres nouveaux de foraminifères du Crétace à facies recifal. *Compte Rendu 19th Congrés Géologique International, Alger 1952,* Sect 13: 117–124.

MARKS, P., 1957, *Stratigraphic lexicon of Indonesia.* Bandung: Kementerian Perekonomian Pusat Djawatan Geologi, Seri Geologi 31: 233 pp.

MARTIN, K., 1880. *Die Tertarschchten auf Java nach den Entdeckungen von Fr. Junghuhen.* Leiden 1879/1880. 150–164.

———, 1890. Untersuchungen uber den Bau von *Orbitolina* (*Patellina* auct) von Borneo. *Sammlungen des geologischen Reichs-Museum Leiden,* 14: 209–231.

———, 1915. Die Fauna des Obereocäns von Nanggulan auf Java, Rhizopoda. *Sammlungen des geologische Reichs-Museum Leiden,* N. F. 2, 1914/1915.

MASSIEUX, M., 1973. Micropaléontologie stratigraphiques de l'Éocène des Corbières Septentrionales (Aude). *Centre National de Recherche Scientifique,* 1973, 130 pp.

MATHAR, N. S. and JUYAL, K. P., 2000. *Atlas of Early Palaeogene invertebrate fossils of the Himalayan Foothills Belt.* Dehradun: Wadia Institute of Himalayan Geology.Monograph 1, 167 pp.

MATSUMARU, K., 1967. Geology of the Tomioka area, Gunma Prefecture with a note on "*Lepidocyclina*" from the Abuta Limestone Member. *Science Reports of the Tohoku University, second ser. (Geology),* 39: 113–147.

———, 1968. Miogypsinid population from the Tungliang Well TL-1 of the Penghu Islands, China. *Transactions and Proceedings of the Paleontological Society of Japan, New Ser.* 72: 340–344.

———, 1970. *Lepidocyclina californica* Schenck and Childs from the Vaqueros Formation, southern California. *Journal of Saitama University, Faculty of Education,* 19: 57–62.

———, 1971. Studies on the genus *Nephrolepidina* in Japan. *Science Reports of the Tohoku University, second ser. (Geology),* 42: 97–185.

———, 1971. The genera *Nephrolepidina* and *Eulepidina* from New Zealand. *Transactions and Proceedings of the Paleontological Society of Japan, New Ser.* 84: 179–189.

———, 1971. Certain larger foraminifera from Japan. *Journal of Saitama University, Faculty of Education,* 20: 149–159.

———, 1971, Certain larger foraminifera from Japan. *Journal of Saitama University, Faculty of Education,* 20: 149–159.

———, 1973. Larger foraminifera from the Cretaceous and Tertiary in Japan. In: Minato, M,.Asano,. K, and Matsumoto, T., Eds., *Atlas of Japanese Fossils* 22: 1–24. Tokyo: Tsukiji Shoten Publ.(In Japanese)

———, 1974. Larger foraminifera from east Mindanao, the Philippines. *Geology and Palaeontology of Southeast Asia,* 14: 101–115.

———, 1976. Larger foraminifera from the islands of Saipan and Guam, Micronesia. In: Takayanagi, Y. and Saito, T., Eds., *Progress in Micropaleontology,* 190–213. New York: American Museum of Natural History. Micropaleontology Press, Special Paper no. 1 .

———, 1976. Larger foraminifera from the Ryukyu Group, Nansei Shoto Islands, Japan. *Maritime Sediments, Special Publ*. 1: 401–424. 1st International Symposium on Benthonic Foraminifera of Continental margins, Part B. Paleoecology and Biostratigraphy.

———, 1977. Neogene stratigraphy of the northern to northeastern marginal areas of the Kanto Mountainland, central Japan. *Journal of the Geological Society of Japan,* 83: 213–225 (in Japanese with English abstract).

———, 1977. Transition of the Pleistocene larger foraminiferal assemblages from the Ryukyu Group. *Kaiyokagaku,* 9: 602–606. (in Japanese with English abstract).

———, 1978. Biostratigraphy and paleontological transition of larger foraminifera from the Minamizaki Limestone, Chichi-Jima, Japan. *Proceeings of the second Working Group meeting, biostratigraphic datum-planes of the Pacific Neogene. Bandung, 1977*, 63–88. IGCP Project 114,

———, 1981. On *Lepidocyclina (Trybliolepidina) rutteni* Van der Vlerk from Zone N. 17 at Mitsugane, Izu Peninsula, Shizuoka Prefecture, Japan. *Proceedings of the Japan Academy, Ser. B*, 57: 115–118.

———, 1982. On *Miogypsina (Miogypsina) kotoi* Hanzawa from Zone N. 16 on Dogo Island, Oki Islands, Japan. *Proceedings of the Japan Academy, Ser. B,* 58: 52–55.

———, 1986. Biostratigraphy based on the larger foraminifera from the Ryukyu Limestone of Hateruma Jima. *Prof. N. Kitamura Memorial Volume,* 205–217. (in Japanese)

———, 1991. On the evolutionary classification of the Family Lepidocyclinidae (Foraminiferida). *Transactions and Proceedings of the Palaeontological Society of Japan, New Ser.* 164: 883–909.

———, 1992. Some Miocene *Nephrolepidina* (Family Lepidocyclinidae) from the Shimoshiroiwa Formation, Izu Peninsula, Japan. In: Ishizaki, K. and Saito, T., Eds., *Centenary of Japanese Micropaleontology,* 257–265. Tokyo: Terra Publishers.

———, 1994. A megalospheric schizont of *Nummulites perforatus* (Montfort) from the upper Lutetian of the Yusan Formation, Haha-Jima (Hillsborough Island), Ogasawara Islands, Japan. *Revue de Micropaléontologie,* 37: 161–165.

———, 1996. Tertiary larger foraminifera (Foraminiferida) from the Ogasawara Islands, Japan. *Paleontological Society of Japan, Special Papers* 36, 239 pp.

———, 1997. On *Pseudorbitoides trechmanni* Douvillé (orbitoidal foraminifera) from Turkey. *Revue de Micropaléontologie,* 40: 339–346.

———, 1999. A new foraminifera from the upper Middle Eocene of the Ebro Basin, Spain. *Paleontological research* 3/4: 259–267.

———, 2005. *Nummulites junbarensis* and *Assilina formosensis* (late Early to early Middle Eocene) from Taiwan (Formosa). *Revue de Paléobiologie, Geneve,* 24 (2): 551–561.

———, 2011. A new definition of the Letter Stages in the Philippine Archipelago. *Stratigraphy,* 8: 237–252.

———, 2012. Miogypsinid Foraminiferal Biostratigraphy from the Oligocene to Miocene Sedimentary Rocks in the Tethys Region. In: Ahmad Dar, Irma, Ed., *Earth Sciences,* 619–648. InTech, Croatia.

———, 2016. Larger foraminiferal biostratigraphy of the upper Cretaceous (Campanian) to Paleogene (Lutetian) sedimentary rocks in the Haymana and Black Sea regions, Turkey. *Micropaleontology,* 62: 1–68.

MATSUMARU, K. and BARCELONA, B. M., 1982. Tertiary stratigraphy of the Tayabas Isthmus and central part of Bondoc Peninsula, Luzon, the Philippines and larger foraminifera. *Geology and Palaeontology of Southeast Asia,* 23: 77–90.

MATSUMARU, K. and HAYASHI, A., 1980. Neogene stratigraphy of the eastern marginal areas of Kanto Mountains, central Japan. *Journal of the Geological Society of Japan,* 86: 225–242. (in Japanese with English abstract).

MATSUMARU, K. and JAUHRI, A. K., 2003. *Lakadongia,* a new Orbitoidal foraminiferal genus from the Thanetian (Paleocene) of Meghalaya, NE India. *Micropaleontology,* 49: 277–291.

MATSUMARU, K. and KIMURA, K., 1989. Larger foraminifera from the Eocene Shimizu and Miocene Misaki Formations in Tosa Shimizu City, Kochi Prefecture, Shikoku, Japan. *Transactions and Proceedings of the Palaeontological Society of Japan, New Ser.* 156: 255–269.

MATSUMARU, K. and SAKAI, H., 1989. *Nummulites* and *Assilina* from Tansen area, Palpa District, the Nepal Lesser Himalayas. *Transactions and Proceedings of the Palaeontological Society of Japan, new ser.,* 154: 68–76.

MATSUMARU, K. and SARMA, A., 2010. Larger foraminiferal biostratigraphy of the lower Tertiary of Jaintia Hills, Meghalaya, NE India. *Micropaleontology,* 56: 539–565.

MATSUMARU, K. and TAKAHASHI, M., 2004. Studies on the genus *Miogypsina* (Foraminiferida) in Japan. *Journal of Saitama University, Faculty of Education,* 53: 17–39.

MATSUMARU, K., MYINT THEIN, and OGAWA, Y., 1993. Early Miocene (Aquitanian) larger foraminifera from the Shimizu Formation, Ashizuri Cape, Kochi Prefecture, Shikoku, japan. *Transactions and Palaeontological Society of Japan, New Ser.* 169: 1–14.

MATSUMARU, K., SARI, B. and ÖZER. S., 2010. Larger foraminiferal biostratigraphy of the middle Tertiary of Bey Dağlari Autochton, Menderes-Taurus Platform, Turkey. *Micropaleontology,* 56: 439–463.

MICHELOTTI, G., 1841. Saggio storico dei Rizopodi caratteristici dei terreni Sopracretacei. *Memorie di Fisica Societa Italiana della Scienze* 22: 253–302.

———, 1861. Études sur le Miocène inférieur de l'Italie septentrionale. *Schweizerische Palaontologische Abhandlungen* 101: 5–70.

MILLER-MERZ, E., 1980. Strukturanalyse ausgewalter rotaloider Foraminiferen. *Schweizerische Palaontologische Abhandlungen,* 101:5–70.

MISHRA, P. K., 1996. Study of Miogypsinidae and associated planktonics from Cauvery, Krishna-Godavari and Andaman Basins of India. *Geoscience Journal,* 17: 123–251.

MÖBIUS, K. A., 1880. Foraminifera von Mauritius. In: Möbius, K. A., Richter, F. and Martens, E. von, Eds., *Beitrage zur Meeresfauna ser Insel Mauritius und der Seychellen,* 65–112. Berlin: Gutman.

MOHIUDDIN, M. M., OGAWA, Y. and MATSUMARU, K., 2000. Late Oligocene larger foraminifera from the Komahashi-Daini Seamount, Kyushu-Palau Ridge and their tectonic significance. *Paleontological Research,* 4: 191–204.

MOHLER, W. A., 1949. *Flosculinella reicheli,* n. sp., aus dem Tertiär e5 von Borneo. *Eclogae Geologae Helvetiae,* 42: 521–527.

MONTANARI, L., 1961. Das Nummulitikum von Sciacca(Sizilien). *Eclogae Geological Helvetiae,* 54: 570–579.

MONTFORT, D. P. de, 1808. *Conchyliologie systematique et classification méthodique des coquilles. Vol. 1.* Paris: F. Schell, 409 pp.

MORISHIMA, M., 1949. A new Miocene *Lepidocyclina* from Shizuoka Prefecture, Japan. *Journal of Paleontology,* 23: 210–213.

MOULLADE, M., 1965. Contribution an problem de la classification des Orbitolinidae (raminiferida; Lituolacea). *Comptes Rendus Hebdominaires des Séances, Academie des Sciences,* 260: 4031–4034.

MUNIER-CHALMAS, M., 1891. *Étude du Tithonique du Cretacé et du Tertiaire du Vicentin.*These de doctorat. Paris: The Author. 77 pp..

MURRAY, J. W., 1973. Distribution and ecology of living benthic foraminiferids. Heinemann Educational Books, London. 274 pp.

NAGAPPA, Y., 1959. Foraminiferal biostratigraphy of the Cretaceous-Eocene succession in the India-Pakistan-Burma region. *Micropaleontology,* 5: 145–192.

NATORI, H., KADAR, D., SUDIYONO, BIREGAR, P. and HASIBUAN, F., 1978. Foraminifera from Central Jawa. In: Mohamad, U. and Sato, Y., Eds., *Gravity and geological studies* in *Java, Indonesia.* Bandung: Geological Survey of Indonesia. Special Publication, 6: 89–101.

NEAGU, T., 1968. *Andersenia rumana,* n. gen., n. sp. and some taxonomic observations on the subfamily Valvulininae. *Contributions from the Cushman Foundation for Foraminiferal Research,* 19: 120–122.

NEMKOV, G. L., 1967. Nummulitids of the Soviet Union and their biostratigraphic significance. *Proceedings of the study of the geological structure of the USSR, New Ser.* 16: 312 pp.

NEUMANN, M., 1958. Révision des orbitoides du Crétace et l'Éocène en Aquitaine occidentale. *Mémoires de la Societé Géologique de France,* n. ser. 83: 174 pp.

———, 1977. Le genre *Discocyclina* en Mesogee. Valear stratigraphique des differentes especes. *Memoria Segund Congreso Latinoamericano de Geologia. Boletin de Geologia Publ. Especial* 7: 1427–1449.

———, 1987. Le genre *Orbitoides.* I. Reflexions sur les éspèces primitives attribuées a ce genre. *Revue de Micropaléontologie,* 29: 220–261.

———, 1993. Le genre *Orbitoides.* II. Revision des differentes especes. *Revue de Micropaléontologie,* 36: 301–353.

NEWTON, R. B. and HOLLAND, R., 1899. On some Tertiary Foraminifera from Borneo collected by Professor Molengraaff and the late

Mr. A. H. Everett, and their comparison with similar forms from Sumatra. *Annals and Magazine of Natural History,* 3: 245–259.

———, 1902. On some fossils from the Islands of Formosa and Riu-Kiu (= Loo Choo). *Journal of the College of Science, Imperial University of Tokyo.* 17: 1–23.

NOMURA, M. and OHIRA, Y., 1998. Fission track age of the Miocene tuff in the Tomioka area, Gunma Prefecture. *Journal of Gunma Museum of Natural History* 2: 35–42. (in Japanese)

———, 2002. Fission track age of the Miocene Haratajino and Shiohatado tuffs in the Tomioka Group, Gunma Prefecture, central Japan. *Journal of Gunma Museum of Natural History* 6: 75–80. (in Japanese)

NOMURA, M., ISHIKAWA, H., KANEKO, M. and MATSUMARU, K., 2003. The discovery of *Miogypsina* from the Miocene Series of Kameyama Hill, Ota City, Gunma Prefecture, central Japan and its fission track age. *Journal of the Geological Society of Japan* 109: 611–614.(in Japanese)

NUTTALL, W. L. F., 1925. The stratigraphy of the Laki Series (Lower Eocene) of parts of Sindo and Baluchistan (India); with a description of larger Foraminifera contained in those beds. *Quaterly Journal of Geological Society of London,* 81: 417–453.

———, 1925. The zonal distribution of the larger foraminifera of Middle and lower Kirthar Series (Middle Eocene) of parts of western India. *Record of the Geological Survey of India,* 59: 115–164.

———, 1926. A revision of the *Orbitoides* of Christmas Island. *Quarterly Journal of the Geological Society of London,* 82: 22–42.

———, 1926. The larger foraminifera of the Upper Ranikot Series (Lower Eocene) of Sind, India. *Geological Magazine,* 63: 112–121.

———, 1932. Lower Oligocene foraminifera from Mexico. *Journal of Paleontology,* 6: 3–35.

NUTTALL, W. L. F. and BRIGHTON, A. G., 1931. Larger foraminifera from the Tertiary of Somaliland. *Geological Magazine,* 68: 49–65.

OHDE, S. and ELDERFIELD, H., 1992. Strontium isotope stratigraphy of Kita-daito-jima Atoll, North Philippine Sea: implications for Neogene sea-level change and tectonic history. *Earth and Planetary Science Letters,* 113: 473–486.

O'HERNE, L., 1972. Secondary chamberlets in *Cycloclypeus. Scripta Geologica 7: 1–35.*

OPPENHEIM, P. von, 1896. Das Alttertiär der Colli Berici in Venetien, die Stellung der Schichten von Priabona, und die Oligocäne Transgression in alpine Europa. *Zeitschrift der Deutschen Geologischen Gesellschaft,* 48: 27–152.

OPPENOORTH, W. F., 1918. Foraminiferen van de Noordkust van Atjeh. *Verhandelingen van het Geologisch Mijnbouwkundig Genootschap voor Nederlandsch Kolonien, Geol. Ser.* 2: 249–258.

ORBIGNY, A. d', 1826. Tableau méthodique de la classe des Céphalopodes. *Annales des Sciences Naturelles,* 7: 245–314.

———, 1839. Foraminifères. In: Ramon de la Sagra. *Histoire physique, politique et naturelle de l'ile de Cuba.* Paris: Arthus Bertrand, 244 pp.

———, in LYELL, C., 1848. On the relative age and position of the so-called Nummulite limestone of Alabama. *Quarterly Journal of the Geological Society of London,* 4:10–16.

———, 1846. *Foraminifères fossils du Bassin Tertiaire de Vienne (Austriche).* Paris: Gide et Comp. (Copy by McLean Paleontological Laboratory, 310 pp.)

———, 1850. *Prodrome de paleontologie stratigraphique universelle des animaux mollusques et rayorenes,* vol. 2, 427 pp. Paris: V. Masson.

PALMER, D. K., 1934. Some larger fossil foraminifera from Cuba. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Pocy",* 8: 235–264.

PAPP, A., 1954. Über die Entwicklung von *Pseudorbitoides* und *Lepidorbitoides* in Europa. *Verhandlungen Geolologische Bundesanstalt,* 3: 162–170.

PAPP, A. and KUPPER, K., 1953. Die Foraminiferenfauna von Guttaring and Klein St. Paul (Kärnten). II. Orbitoiden aus Sandsteinen von Pemberger bei Klein St. Paul. *Sitzungsberichten der Osterreich Akademie der Wissenschaften, Mathem.-naturw. Kl.,* 162: 65–82.

PARKER, W. K. and JONES, T. R., 1865. On some foraminifera from the north Atlantic and Arctic Oceans, including Davies Straits and Baffin's Bay. *Philosophical Transactions of the Royal Society,* 155: 325–441.

PBM (Philippines Bureau of Mines), 1969. *Geological map of the Philippines. Scale 1:1,000,000.* Manila: Bureau of Mines.

PFENDER, J., 1935. Á propos du *Siderolites vidali* Douvillé et quelques autres. *Bulletin de la Société Géologique de France, ser. 5*, 4: 225–236.

POSTUMA, J. A., 1971. *Manual of planktonic foraminifera*. Amsterdam: Elsevier, 420 pp.

PREMOLI SILVA, I. and BURSA, C., 1981. Shallow-water skeletal debris and larger foraminifers from Deep Sea Drilling Project Site 462, Nauru Basin, western equatorial Pacific. *Initial Report, Deep Sea Drilling Project* 61: 439–473. Washington, D. C.: U. S. Government Printing Office,

PREVER, P. L., 1905. Ricerche sulla fauna di alcuni calcari nummulitici dell'Italia centrale e meridionale. *Bolletino della Società Geologica Italiana,* 24: 1805–1857.

PROVALE, I., 1908–1909. Di alcune Nummulitine e Orbitoidine dell'Isola di Borneo. *Rivista Italiana di Paleontologia* 14: 55–80; 15: 65–76.

PTUKHIAN, A. E., 1964. Ofilogenii gruppy *Nummulites partschi. Voprasy Geologicky. Kavkasa, Erevan.*

RAHAGHI, A., 1978. Paleogene biostratigraphy of some parts of Iran. *National Iran Oil Company Publication,* 7: 1–82.

———, 1983. Stratigraphy and faunal assemblage of Paleocene-lower Eocene in Iran. *National Iran Oil Company Publication,* 10: 1–73.

RAJU, D. S. N., 1974. Study of Indian Miogypsinidae. *Utrecht Micropaleontological Bulletins,* 9: 148 pp.

RAO, S. R. N., 1940. On *Orbitosiphon,* a new genus of Orbitoidal foraminifera from the Ranikot beds of the Punjab Salt Range (N. W. India). *Current Science, Bangalore,* 9: 414–415.

———, 1942. On *Lepidocyclina* (*Polylepidina*) *birmanica* sp. nov. and *Pseudophragmina* (*Asterophragmina*) *pagoda* gen., nov. et sp. nov. from the Yaw Stage (Priabonian) of Burma. *Records of the Geological Survey of India,* 72: 1–17.

———, 1944. A revision of some foraminifera described by Douvillé from the Kampa System of Tibet. *Proceedings of the National Academy of Sciences, India, Allahabad.* 14 (3): 93–101.

REICHEL, M., 1936–1937. Etude sur les Alveolines I. *Schweizerische Palaontologische Abhandlung (1936)* 57: 1–93; II. *Schweizerische Palaontologische Abhandlung (1937),* 59: 95–147.

REISS, Z., 1957. Notes on foraminifera from Israel. 5. Studies on Victoriellidae. *Bulletin of the Geological Survey of Israel,* No. 11 (Art. 5): 1–9.

———, 1963. Reclassification of perforate foraminifera. *State of Israel Ministry of Development Geological Survey Bulletin*, 36: 1–111.

REYES, M. V. and ORDONEZ, E. P., 1970. Philippine Cretaceous smaller foraminifera. *Journal of the Geological Society of Philippines,* 24: 1–67.

RENZ, O., 1936. Stratigraphische und Mikropaleontologische untersuchung der Scaglia (Ober Kreide-Tertiar) im zentralen Apennin. *Eclogae Geologicae Helvetiae,* 29: 1–149.

RENZ, O. and KÜPPER, H., 1946. Über morphogenetische untersuchungen an grossforaminiferen. *Eclogae Geologicae Helvetiae,* 39: 317–342.

RP- Japan Project, **[[??Is this "author" complete???]]** 1972. *Report on geological survey of Eastern Mindanao, Phase* 1: 1–60. Tokyo: Overseas Technical Cooperation Agency, and Metallic Minerals Exploration Agency.

———, 1976. *Report on geological survey of Northeastern Luzon, Phase* 2: 125 pp. Tokyo: Metal Mining Agency, and International Cooperation Agency.

———, 1980. *Report on geological survey of Northwestern Luzon, Phase* 2: 1–42. Tokyo: Metal Mining Agency, and International Cooperation Agency.

———, 1982. *Report on geological survey of Mindoro Island, Phase* 1: 1–35. Tokyo: Metal Mining Agency, and International Cooperation Agency.

RUIZ de GAONA, M., 1946. El terciario nummulitico fertile de Guecho (Vizcaya). *Noticias y Comunicaciónes,* 20: 113–127.

RUTTEN, L. M. R., 1911. Over Orbitoiden uit de omgeving or Balik Papan-baai (Oostkust van Borneo). *Verhandelingen van het Geolgisch Mijnbouwkundig Genootschap voor Nederlandsch Kolonien, Amsterdam,* 1/1122–17/1139.

———, 1912–1914. Studien über foraminiferen aus Ost-Asien. *Sammlung des Geologischen Reichsmuseums in Leiden, ser. 1,* 7 (1912): 201–217; 219–224; 9 (1914): 281–325.

———, 1914. Foraminiferen führende Gesteine von Niederlandsch Neu-Guinea. *Uitkomsten der Nederlandsch Nieuw-Guinea Expeditie in 1903, Geol.*, 6: 21–51.

———, 1917. Rhizopoda, in Martin's die Altmiocene fauna des West Progogebirges auf Java. *Sammlung des Geologischen Reichmuseum* In: *Leiden, (N. S.),* ser. 2: 276–277.

———, 1923. Over de foraminiferenfauna en den ouderdom van kalksteenenuit Zuid-Celebes, afkomstig uit de groep der vischresten-bevattende gesteenten. *Jaarbok Mijnwezen Nederlandsch Oost-Indien,* 1923: 175–183.

RUTTEN, M. G., 1935. Larger foraminifera of northern Santa Clara Province, Cuba. *Journal of Paleontology,* 9: 527–545.

SACCO, F., 1893. Sur quelques Tinoporinae du Miocène de Turin. *Bulletin de la Société Belge de Géologie, de Paléontologie, et d'Hydrologie* (1893–1894), 7: 204–207.

SAITO, T., 1963. Miocene planktonic foraminifera from Honshu, Japan. *Science Reports of the Tohoku University, Second Series (Geology),* 35: 123–209.

SAMANTA, B. K., 1964. The occurrence of Indo-Pacific *Discocyclina* in eastern India. *Micropaleontology,* 10: 339–353.

———, 1965. *Discocyclina* from the upper Eocene of Assam, India. *Micropaleontology,* 11: 415–430.

———, 1967. *Discocyclina* from the early Tertiary sediments of Pondicherry, south India. *Micropaleontolgy,* 13: 233–242.

SCHAFTHÄUTLE, K. E., 1863. *Süd-Bayerns Lethaea geognostica*. Leipzig: L. Voss.

SCHAUB, H., 1951. Stratigraphie und Palaontologie des Schlierenflysches mit besonderer Beruksichtigung der paleocaenen und untereocaenen Nummuliten and Assilinen. *Schweizerischen Palaontologischen Abhandlungen,* 68: 1–222.

———, 1963. Über einige Entwicklungsreihen von *Nummluites* und *Assilina* und ihre stratigraphische Bedeutung. In: von Konigswald, G. H. R., Emeis, J. D., Buning, N. L. and Wagner, C. W.,, Eds., *Evolutionary trends in Foraminifera,*. 282–297. Amsterdam: Elsevier.

———, 1981. Nummulites et Assilines de la Tethys Paleogene. Taxinomie, phylogenese et biostratigraphie. *Memoires suisses de Paléontologie,* 104: 236 pp.

SCHEFFEN, W., 1932. Zur Lepidocyclinen-Bestimmung. *De Mijningenieur,* 1932: 97–99

———, 1932. Zur morphologie und morphogenese der "Lepidocyclinen". *Paleontologische Zeitschrift,* 14: 233–256.

SCHLUMBERGER, C., 1893. Note sur les generes *Trillina* et *Linderina. Bulletin de la Société Géologique de France,* sér. 3, 21: 118–123.

———, 1900. Note sur le genre *Miogypsina. Bulletin de la Société Géologique de France,* sér. 3, 28: 327–333.

———, 1901. Première note sur les orbitoides. *Bulletin de la Société Géologique de France,* ser. 4, 1: 459–467.

———, 1902. Deuxième note sur les orbitoides. *Bulletin de la Société Géologique de France,* ser. 4, 2: 255–261.

———, 1904. Quatrième note sur les orbitoides. *Bulletin de la Société Géologique de France,* 4: 119–135.

SCHLUMBERGER, C. and MUNIER-CHALMAS, E., 1884. Note sur les Miliolidees trematophorees. *Bulletin de la Socété Géologique de France,* ser. 3, 12: 629–630.

SCHUBERT, R. J., 1910. Über Foraminiferen und einen Fischotolithen aus dem fossilen Globigerinenschlamm von Neu-Guinea. *Verhandlungen der Geologischen Reichsanstalt,* 1910: 318–328.

SCHULTZE, M. S., 1854. *Über den Organismus der Polythalamien* (*Foraminiferen*)*, nebst Bermerkungen über die Rhizopoden im Allgemeinen.* Leipzig: Wilhelm Engelmann.

SCHWAGER, C., 1876. Saggio di una classificazione dei foraminiferi avuto riguardo loro famiglie naturali. *Bolletino R. Comitato Geologico d'Italia,* 7: 475–485.

———, 1877. *Quadro del proposto* sistema de classificazione dei foraminifeli con quscio: *Bolletino R. Comitato geolojico d'Italia,* 8: 18–27.

———, 1883. Die Foraminiferen aus den Eocaenablagerungen der libyschen Wuste und Aegyptens. *Palaeontographica,* 30: 79–153.

SCHWEIGHAUSER, J., 1953. Micropaleontologische und stratigraphische untersuchungen im Paleocaen und Eocaen des Vicentin (Norditalien) mit besonderer Berucksichtigung der Discocyclinen und Asterocyclinen. *Schweizerische Palaeontologische Abhandlungen,* 70: 1–97.

SERRA-KIEL, J., 1984. Etudi dels *Nummulites* del grup de *N. perforatus* (Montfort). *Treballs de la Institucio Catalana d'Historia Natural,* No. 11, 244 pp.

SERRA-KIEL, J., HOTTINGER, L., CAUS, E., DROBNE, K., FERRANDES, C., JAUHRI, A. K., LESS, G., PAVLOVEC, R., PIGNATTI, J., SAMSO, J. M., SCHAUB, H., SIREL, E., STROUGO, A., TAMBAREAU, Y., TOSQUELLA, J. and ZAKREVSKAYA, E., 1998. Larger foraminiferal biostratigraphy of the Tethyan Paleocene and Eocene. *Bulletin de la Societé Géologique du France,* 169: 281–299.

SILVESTRI, A., 1907. Probabile origine d'alcune Orbitoidine. *Rivista Italiana di Paleontologia e Stratigrafia,* 13: 79–81.

———, 1907. Fossili dordoniani nei dintorni di Termini-Imerese (Palermo). *Atti della Pontificia Accademia Romana dei Nuovi Lincei,* 60: 105–110.

———, 1910. Lepidocycline sannoisiane di Antonimina in Calabria. *Memorie della Pontificia Accademia Romana dei Nuovi Lincei,* 28: 103–163.

———, 1924. Revisione di fossili della Venezia e Venezia Giulia. *Atti dell'Accademia Scientifica Veneto-Trentino-Istriana, ser. 3*, 14: 7–12.

———, 1924. Fauna paleogenica di Vasciana presso Todi, Part 1. *Bolletino della Societa Geologica Italiana,* 42: 7–29.

———, 1926. Sulla *Patella cassis* Oppenheim. *Rivista Italiana di Paleontologia,* 32: 15–22.

———, 1928. Di alcune facies Litho-Paleontologische del Terziario di Derna, nella Cirenaica. *Bolletino della Societa Geologica Italiana,* 47: 109–113.

———, 1932. Rivisione di Orbitolinie Nordamericane. *Pontificia Accademia della Scienze, Nuovi Lincei, ser. 2*, 16: 371–394.

———, 1937. Foraminiferi dell'Oligocene e del Miocene della Somalia. *Palaeontographia Italica,* 32 (suppl. 2): 45–264.

———, 1938. Foraminiferi dell'Eocene della Somalia, Parte 1: Paleontologia della Somalia. *Paleontographia Italica* 32 (suppl. 3): 49–89.

______, 1939. Foraminiferi dell'Eocene della Somalia, Parte 2: Paleontologia della Somalia. *Paleontolographia Italica,* 32 (suppl. 4): 1–102.

SIROTTI, A., 1978. Discocyclinidae from the Priabonian type section (Lessini Mountains, Vicenza, Northern Italy). *Bolletino della Societá Paleontologica Italiana,* 17: 49–67.

SLITER, W. V., 1989. Biostratigraphic zonation for Cretaceous planktonic foraminifers examined in thin section. *Journal of Foraminiferal Research,* 19: 1–19.

SMITH, W. D., 1906. *Orbitoides* from the Binangonan limestone. *Philippine Journal of Science,* 1: 205.

SMOUT, A. H., 1954. Lower Tertiary foraminifera of Qatar Peninsula. *British Museum (Natural History),* 66–84.

SOWERBY, J. de C., 1840. Systematic list of organic remains, Appendix to Grant, C. W. Memoir to illustrate a geological map of Cutch. *Transactions of the Geological Society of London,* ser. 2, 5: 327–329.

STACHE, G., 1913. Über *Rhipidionina* St. und *Rhapydionina* St. *Jahrbuch der Geologischen Reichsanstalt,* 62: 659–680.

TAKIZAWA, S., HASHIMOTO, W., MATSUMARU, K., SATO, T., ARAKAWA, Y., MIRANDA, F. and SENDON, S. V., 1996. Lower middle Paleogene olistostrome and geological structure of lower grade metamorphic rocks of the Caramoan Peninsula, Camarines Sur, the Philippines. *Prof. H. Igo Commemorial Volume,* 193–199.

TAN SIN HOK., 1930. Over *Cycloclypeus*; voorloopige resultaten eener biostratigrafische studie. *De Mijningenieur,* 1930: 1–9.

———, 1932. Over *Cycloclypeus;* voorloopige resultaten einer biostratigrafische studie. *De Mijningenieur,* 11: 233–242.

———, 1932. On the genus *Cycloclypeus* Carpenter, Part 1; and an appendix on the Heterostegines of Tijmanggoe, S. Bantan, Java. *Dienst van den Mijnbouw in Nederlandsch-Indie, Wetenschappelijke Mededeelingen,* 19: 194 pp.

———, 1935. Die peri-embryonalen Aquatorial-kammern bei einigen Orbitoiden. *Ingenieurin Nederlandsch-Indie, Mijnbouw en Geologie,* 2: 113–126.

———, 1936. Zur Kenntniss der Miogypsiniden. *Ingenieur in Nederlandsch-Indie, IV, Mijnbouw en Geologie* 3: 45–61; 84–98; 109–123.

———, 1936. Zur Kenntniss der Lepidocycliniden. *Natuurkundig Tijdschrift voor Nederlandsch-Indie,* 96: 235–280.

———, 1936. Beitrag zur Kenntnis der Lepidocycliniden. *Verhandelingen der K. Akademie van Wetenschappen,* 39: 990–999.

———, 1936. Over verschillende palaeontologische Criteria voor de geleding van het Tertiair. *Ingenieur in Nederlandsch-Indie, Mijnbouw en Geologie* 3: 173–179.

———, 1937. Weitere Untersuchungen uber die Miogypsiniden I, und II. *Ingenieur in Nederlandsch-Indie, Mijnbouw en Geologie* 4: 35–45; 87–113.

———, 1937. On the genus *Spiroclypeus* H. Douvillé with a description of the *Spiroclypeus vermicularis,* nov. sp. from Koetai in the East Borneo. *Ingenieur in Nederlandsch-Indie, Mijnbouw en Geologie* 4: 177–193.

———, 1939. On *Polylepidina, Orbitocyclina,* and *Lepidorbitoides. Ingenieur in Nederlandsch-Indie,Mijnbouw en Geologie,* 6: 53–84.

THAIDENS, A. A., 1937. Cretaceous and Tertiary larger foraminmifera from southern Santa Clara Province, Cuba. *Journal of Paleontology,* 11: 91–109.

THALMANN, H. E., 1939. Mitteilungen über Foraminiferen IV. *Eclogae Geologicae Helvetiae* 31: 327–333.

TOBLER, A., 1925. Uber eine ostindische *Lepidocyclina* mit mehr kammeringen nucleoconcha. *Eclogae Geologicae Helvetiae,* 19: 269–274.

TODD, R. and POST, R., 1954. *Smaller foraminifera from Bikini Drill Holes*. Washington, DC: U. S. Geological Survey. Professional Paper 260-N, pp. 547–568.

TOUMARKINE, M. and LUTERBACHER, H., 1985. Paleocene and Eocene planktonic foraminifera. In: Bolli, H., Saunders, J. B. and Perch-Nielsen, K., Eds., *Plankton stratigraphy,* 87–154. Cambridge: Cambridge University Press.

UMBGROVE, J. H. F., 1928. Het genus *Pellatispira* in het Indo-Pacifische gebied. *Wetenschappelijke Mededeelingen van de Dienst van de Mijnbouw in Nederlandsch-Oost-Indie,* 10: 43–103.

———, 1931. Tertiary Foraminifera. *Leidsch Geologische Medeelingen,* 5: 35–91.

———, 1936. *Heterospira,* a new foraminiferal genus from the Tertiary of Borneo. *Leidsche Geologische Mededeelingen,* 8: 155–157.

———, 1937. A new name for the foraminiferal genus *Heterospira. Leidsche Geologische Mededeelingen,* 8: 309.

———, 1938. A second species of *Biplanispira* from the Eocene of Borneo. *Leidsche Geologische Mededelingen,* 10: 82–89.

VAN BEMMELEN, R. W., 1949. *The geology of Indonesia*. Den Hague: Government Printing Office, 732 pp..

VAN VESSEM, E. J., 1978. Study of Lepidocyclinidae from Southeast Asia, particulary from Java and Borneo. *Utrecht Micropaleontological Bulletins,* 19: 142 pp.

VARENTSOV, M. J. and MENNER, V. A., 1953. On the age of some horizons of the Paleogene of the Gorysk region of Georgia.[Russian]. *Inf. Sbornik VNIGRI, Moscou.*

VAUGHAN, T. W., 1924. American and European Tertiary larger foraminifera. *Geological Society of America, Bulletin,* 35: 785–822.

———, 1928. Subfamily Miogypsininae Vaughan. In: Cushman, J. A. Ed., *Foraminifera their classification and economic use.* Sharon, Mass: Cushman Laboratory for Foraminiferal Research, Special Publication 1, 401 pp..

———, 1945. American Paleocene and Eocene larger foraminifera. In : *American old and middle Tertiary larger Foraminifera and corals*. New York: Geological Society of America, Memoir 9, 175 pp.

VAUGHAN, T. W. and COLE, W. S., 1932. Cretaceous orbitoidal foraminifera from the Gulf States and central America. *Proceedings of the Natural Academy of Science,*18: 611–616.

———, 1941. *Preliminary report on the Cretaceous and Tertiary larger foraminifera of Trinidad, British West Indies*. New York: Geological Society of America. Spacial Paper 30, 137 pp..

VELLA, P., 1957. Studies in New Zealand foraminifera. *Paleontological Bulletin, Wellington,* 28: 1–64.

VERBEEK, R. D. M., 1871. Die Nummuliten des Borneo-Kalkstein. *Neues Jahrbuch fur Mineralogie, Geologie, und Paleontologie,* 1871: 1–14.

———, 1874. De Nummulieten uit den eoceenen kalksteen van Borneo. *Jaarboek van het mijnwezen in Nederlansch-Oost-Indië, der de jaargang, tweede deel,* 133–162.

———, 1892. Voorloopig bericht over Nummuliten, Orbitoiden en Alveolinen van Java, en over den ouderdom der gesteenten waarin zij optreten. *Natuurkudige Tijdschrift voor Nederlandsch Indie,* 51: 101–139.

VLERK, I. M. van der, 1922. Studien over Nummulitidae en Alveolinidae. *Verhandelingen van het Geologische Mijnbouwkundig Genootschap voor Nederlandsch Kolonien, Geol. Ser.* 5: 329–466.

———, 1923. Een nieuwe Cycloclypeussoort van Oost-Borneo. *Sammulungen des Geologischen Reichs-Museums in Leiden, ser. 1,* 10: 137–140.

———, 1923. Een overgangsvorm tuuschen *Orthophragmina* en *Lepidocyclina* uit het Tertiair van Java. *Verhandelingen van het Geologisch-Mijnbouwkundig Genootschap voor Nederlandsch Kolonien , Geol. Ser.,* 7: 91–98.

———, 1924. Foraminiferen uit het Tertiary van Java. *Wetenschappelijke Mededeelingen van de Dienst van de Mijnbouw in Nerderlandsch-Oost-Indie,* 1: 17–36.

———, 1924. *Miogypsina dehaartii,* nov. species de Larat (Moluques). *Eclogae Geologicae Helvetiae,* 18: 429–432.

———, 1925. A study of Tertiary foraminifera from the Tidoengsche Landen (E. Borneo). *Wetenschappelijke Mededeelingen van de Dienst van de Mijnbouw in Nederlandsch-Oost-Indie,* 3: 13–32.

———, 1928. Het genus *Lepidocyclina* in het Indo-Pacifische gebied. *Wetenschappelijke Mededeelingen van de Dienst van de Mijnbouw in Nedelandsch-Oost-Indie,* 8: 7–88.

———, 1929. Groote foraminiferen van N. O. Borneo. *Wetsnschappelijke Mededeelingen van de Dienst ven de Mijnbouw in Nederlandsch-Oost-Indie,* 9: 1–45.

———, 1948. Stratigraphy of the Cenozoic of the East Indies based on Foraminifera. *International Geological Congres, Report of 18th Session, Great Britain, Part 15*: 61–63.

———, 1955. Correlation of the Tertiary of the Far East and Europe. *Micropaleontology,* 1: 72–75.

———, 1959. Problems and principles of Tertiary and Quaternary stratigraphy. *Quarterly Journal of the Geological Society of London,* 115: 46–63.

———, 1961. *Lepidocyclina radiata* (K. Martin), 1880. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, Amsterdam, ser B*, 64: 620–626.

———, 1966. *Miogypsinoides, Miogypsina, Lepidocyclina* et *Cycloclypeus* de Laat (Moluques). *Eclogae Geologicae Helvetiae,* 59: 421–429.

VLERK, I. M. van der and UMBGROVE, J. H. F., 1927. Tertiary Gidsforaminiferen van Nederlandsch-Oost-Indie. *Wetenschapelijke Mededeelingen van de Dienst van de Mijnbouw in Nederlandsch-Oost-Indie,* 6: 3–35.

VOIGT, E., 1963. Orbitoidenfuhrendes Kieselgestein als nordisches Geschiebe aus der Umgebung von Hamburg. *Geologische Jahrbuch* 80: 495–511.

WEIJDEN, W. J. M. van der, 1940. "Het genus *Discocyclina* in Europa". Unpubl. Thesis Universite de Leiden, 116 pp..

WHIPPLE, G. L., 1932. Eocene Foraminifera (In: Hoffmeister, I. E., Geology of Eua, Tonga). *Bulletin of the Bernice P. Bishop Museum,* 96: 79–90.

———, 1934. Larger foraminifera from Vitilevu, Fiji. *Bulletin of the Bernice P. Bishop Museum* 119: 141–153.

YABE, H., 1906. On the orbitoid limestone from Kuboi on the lake Kawaguchi and from Nakaosaka. *Journal of the Geological Society of Japan* 13: 317–320. (in Japanese)

———, 1918. Notes on *Operculina*-rocks from Japan, with remarks on *"Nummulites" cumingi* Carpenter. *Science Reports of the Tohoku Imperial University, second ser. (Geology)* 4: 104–126.

———, 1919. Notes on *Lepidocyclina*-limestone from Cebu. *Science Reports of the Tohoku Imperial University, second ser. (Geolog)* 5: 37–51.

———, 1921. Notes on some Eocene foraminifera. *Science reports of the Tohoku Imperial University, second ser. (Geology)* 5: 97–100.

YABE, H. and HANZAWA, S., 1922. *Lepidocyclina* from Naka-Kosaka, Province of Kozuke, Japan. *Journal of Geology and geography* 1: 45–50.

———, 1924. A Lepidocyclina-limestone from Sagkoelirang, D. E. Borneo. *Japanese Journal of the Geology and Geography,* 3: 71–76.

_______,1925. A *Lepidocyclina*-Limestone from Klias Peninsula, B. N. Borneo. *Gedenkboek Verbeek, Verhandelingen van het Geologisch-Mijnbouwkundig Genootschap voor Nederlandsch Kolonien, Geol. Ser.,* 8: 617–632.

———, 1925. A geological problem concerning the Raised Coral-Reefs of the Riukiu Islands and Taiwan; A consideration based on the fossil foraminifera faunas contained in the Raised Coral-Reef foraminifera and the youngest formation underlying it. *Science Reports of the Tohoku Imperial University, second ser. (Geology),* 7: 29–56.

_______, 1925. Notes on some Tertiary foraminiferous rocks from the Philippines. *Science reports of the Tohoku University, second series. (Geology),* 7: 97–109.

———, 1929. Tertiary foraminiferous rocks of the Philippines. *Science Reports of the Tohoku University, second series (Geology),* 11: 137–190.

———, 1930. Tertiary foraminiferous rocks of Taiwan (Formosa). *Science Reports of the Tohoku University, second series* (*Geology*). 14: 1–46.

ZUFFARDI-COMERCI, R., 1929. Di alcuni Foraminiferi Tertziari dell'isola di Borneo*. Bolletino della Società Geologica Italiana,* 47: 126–148.