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Late Miocene Calcareous Nannofossils from Danao Basin, Bohol (Visayan Basin), Philippines

Allan Gil S. Fernando[1], Adrian Raymund C. Fernandez[1], Yolanda Maac-Aguilar[2], Yukito Kurihara[3] and Tomoki Kase[3]

[1] National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City 1101, Philippines
E-mail: afernando@nigs.upd.edu.ph; agsfernando@yahoo.com
[2] Petrolab, Mines and Geosciences Bureau, North Ave., Diliman, Quezon City, Philippines
E-mail: yolagui@yahoo.com
[3] Department of Geology and Paleontology, National Museum of Nature and Science,
3–23–1 Hyakunin-cho, Shinjyuku, Tokyo 169–0073 Japan
E-mail: kurihara@kahaku.go.jp; kase@kahaku.go.jp

Abstract This paper presents the results of the calcareous nannofossil investigation of 29 samples collected from an unnamed shallow marine, mollusk-bearing clastic formation in the Danao basin of central Bohol, Philippines. The study was conducted in order to refine the stratigraphy and age of the Neogene formations in the island. Based on the occurrence of *Discoaster quinqueramus* and *Discoaster berggrenii*, the nannofossil NN11 zone is recognized. This suggests a Late Miocene age for the sandstone-siltstone sequences with calcarenite interbeds exposed in Danao, which have been previously mapped as part of the Middle Miocene Carmen Formation. The presence of cooler oceanographic conditions during the Late Miocene in the Visayan Basin is also suggested.

Key words: Biostratigraphy, Bohol, Philippines, calcareous nannofossils, Late Miocene, Visayan Basin.

Introduction

Bohol Island in central Philippines occupies the southern part of the Visayan Basin (or Visayan Sea Basin) and lies within the Philippine Mobile Belt. Rock units identified in the island consist of the basement Cretaceous ophiolite complex and the overlying Miocene to Pleistocene carbonate and clastic sedimentary rocks that were deposited in deep to shallow marine environments (Corby *et al*., 1951; Bureau of Mines and Geosciences, 1982; Porth *et al*., 1989; Mula and Maac, 1995; Faustino *et al*., 2003; Aurelio and Peña, 2004). Previous studies in the island agreed in recognizing the Wahig Limestone, Ilihan Shale, Carmen Formation, Sevilla Marl, Sierra Bullones Limestone and Carcar or Maribojoc Limestone. Detailed ages of these Neogene formations, as well as their distribution and stratigraphic relationships, however, still remain unsettled. As detailed stratigraphic studies and age controls are indispensable in understanding the younger Cenozoic geology of Bohol Island, the present study provides an opportunity to establish and elucidate the stratigraphy of the island.

Since 2003, the Mines and Geosciences Bureau, Philippines (MGB) and the National Museum of Nature and Science, Tokyo (NMNS) have jointly launched a research program on the Cenozoic molluscan faunal study and refinement of Cenozoic formations in the Philippines. As part of this program, a fieldwork was conducted in Danao, Bohol in May of 2008, in cooperation with the University of Philippines, in order to refine the Neogene stratigraphy and to collect fossil mollusks from the different sedimentary formations exposed in this area. Although the primary aim of the project was to determine the distribution and identify fossil mollusks in the Danao basin, samples were also collected for calcareous nannofossil analysis to establish the age of the mollusk-bearing layers/units. The present paper reports and illustrates the nannofossils recovered from the Danao samples and will briefly discuss implications of the resulting nannofossil-derived age of the sedimentary units in the area.

Study Area

Danao Basin is located in the central part of Bohol and approximately 6 km and 5 km long along its north-south and east-west axes, respectively (Fig. 1). The basin is separated from the main basin of the Carmen Formation in the east (Carmen-Pilar-Alicia area) by the Cretaceous basement complex (see Porth *et al*., 1989). The clastic formation in the basin is at least 300 m thick, and consists of dark-gray, gently dipping and weakly consolidated silty sandstones, with intercalations of calcarenite and coralline limestone beds (Fig. 2). Molluscan assemblages obtained during the fieldwork show that the sediments of the clastic formation were deposited under an upper subtidal, shallow marine environment. The formation is unconformably underlain by the Cretaceous basement rocks and, in turn, most probably overlain unconformably by the Sierra Bullones Limestone. The clastics were earlier mapped as the northwestern extension of

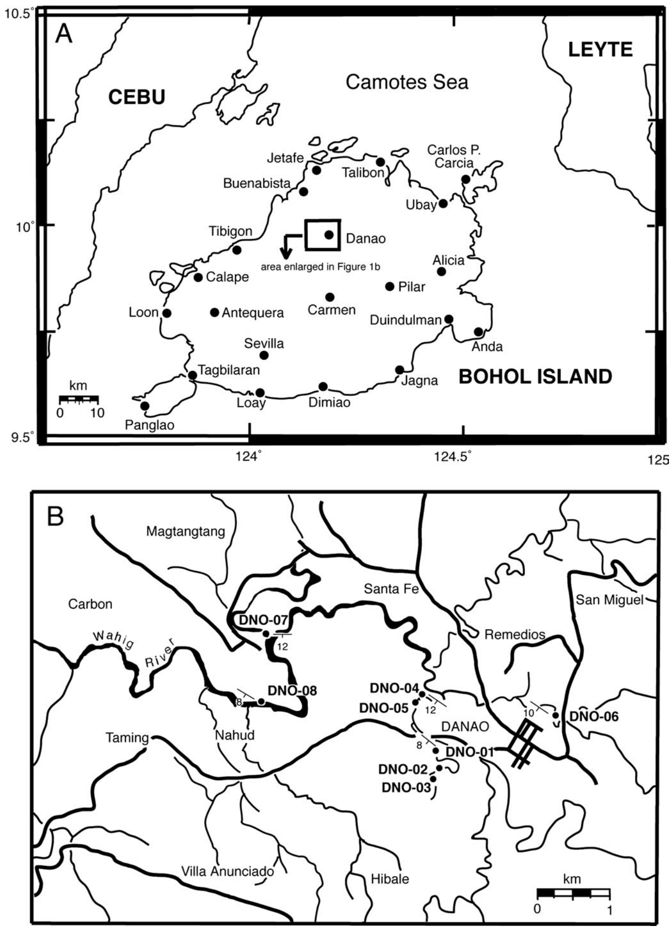

Fig. 1. A. Map of Bohol Island showing the location of the Municipality of Danao. B. Map showing the sampling stations in the Danao basin (see Tables 1 and 2 for sample numbers).

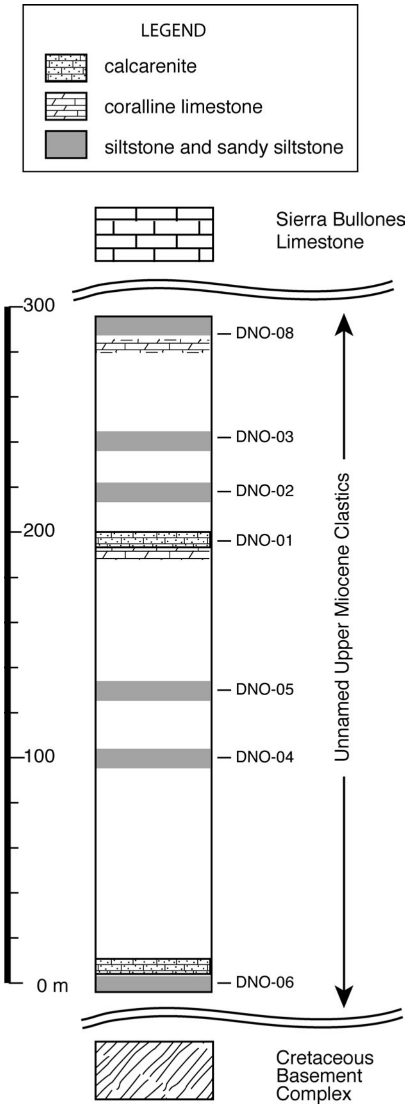

Fig. 2. Columnar section showing the stratigraphic positions of the sampling stations in the unnamed clastic sediments in the Danao basin, central Bohol.

the Middle Miocene Carmen Formation (Porth *et al*., 1989). Our results, however, show that the sedimentary formation in the Danao Basin is Late Miocene in age and, therefore, younger than the exposures of Carmen Formation southeast of the study area. These findings necessitate the separation of the Danao clastics from the Carmen Formation. Proposing a new formation, however, remains pending up until the stratigraphic relationships with other formations in Bohol Island are clarified.

Materials and Methods

A total of 29 samples were collected from seven stations along the Wahig River (or Inabanga River) for calcareous nannofossil analysis (Figs. 1B, 3, 4; Table 1). The lithology of the samples includes non-fossiliferous and fossiliferous mudstones to fine-grained sandstones and calcareous siltstones. Figure 2 shows the composite columnar section of the sedimentary succession in the Danao basin and the stratigraphic position of each sampling station. As indicated in the stratigraphic column, station DNO-06 is the lowest and station DNO-08 is the highest. The stratigraphic position of DNO-07 with respect to the other stations in the area, however, is uncertain due to its different bed orientation (Fig. 1B). It is highly possible that station DNO-07 is correlatable to stations DNO-01, DNO-02 and DNO-03.

Following standard sample preparation techniques (Bown and Young, 1998), smear slides were prepared from the samples and examined under a polarizing microscope at 1000Å~ magnification. Calcareous nannofossil taxa, particularly the index markers, were tallied and photo-documented. Relative abundance categories presented in the nannofossil distribution chart (Table 2) were adapted from Bown (1998). The zonation scheme used in this study is the NN zonation scheme of Martini (1971), correlated to the CN scheme of Okada and Bukry (1980). Identification of nannofossils and biostratigraphic ranges of the marker taxa were based on Perch-Nielsen (1985) and Young (1998). Samples and original photos are stored at the Nannoworks Laboratory of the National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City (UP-NIGS), and smear slides are stored separately at UP-NIGS and the Department of Geology and Paleontology, National Museum of Nature and Science, Tokyo.

Fig. 3. Location of the samples in station DNO-04 along Wahig River, Danao, Bohol (see Fig. 1B for station location). The fossiliferous outcrop is approximately 2 m high and 10 m long. Dominant lithology is mudstone and siltstone.

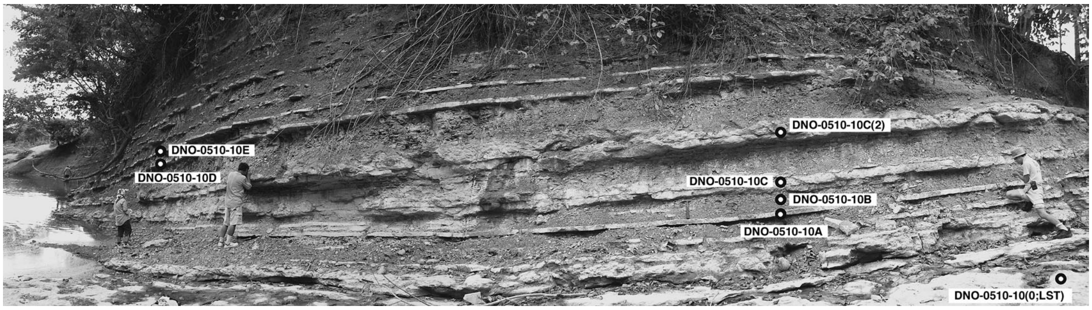

Fig. 4. Location of the samples in station DNO-07 along Wahig River, Danao, Bohol (see Fig. 1B for station location). The outcrop is approximately 4 meters high and 20 meters long. Dominant lithology is calcareous siltstone. The lowermost sample (i.e., DNO-0510-0LST) is from the underlying limestone unit.

Table 1. List of stations and number of samples collected in each station. No samples were collected in station DNO-03. Out of the 29 samples, only 1 sample is barren of calcareous nannofossils.

Station number	Number of samples	Number of barren samples
DNO-01	3	0
DNO-02	4	0
DNO-03	0	0
DNO-04	4	0
DNO-05	4	1
DNO-06	1	0
DNO-07	7	0
DNO-08	6	0
Total	29	1

Results

Table 2 shows the calcareous nannofossil species observed in each sampling station and the nannofossil-derived age of the mollusk-bearing sedimentary units. All species identified in the samples are listed in Table 2 and selected taxa are illustrated in Figures 5–7.

Calcareous nannofossils in the samples range from rare to abundant and are generally moderately-preserved. The most common species are *Discoaster* spp. (except in station DNO-07 samples where they are totally absent), *Helicosphaera carteri*, *Reticulofenestra* spp. (*R. haqii*; *R. pseudoumbilicus*), *Sphenolithus abies* and *Umbilicosphaera* spp. (*U. jafari*; *U. rotula*). The nannofossil zone assignments of the seven stations are discussed below.

Table 2. Calcareous nannofossil distribution and abundance in the investigated sections in Danao, Bohol, Philippines. Abbreviations: Preservation—P=poor, M=moderate; Abundance—R=rare, VF=very few, F=few; C=common, A=abundant.

STATION/ SAMPLE NUMBER	PRESERVATION	ABUNDANCE	Ascidian spicules	*Calcidiscus leptoporus*	*Calcidiscus macintyrei*	*Calciosolenia murrayi*	*Coccolithus pelagicus*	*Discoaster asymmetricus*	*Discoaster berggrenii*	*Discoaster braarudii*	*Discoaster brouweri*	*Discoaster calcaris*	*Discoaster challengeri*	*Discoaster* cf. *D. exilis*	*Discoaster pentaradiatus*	*Discoaster quinqueramus*	*Discoaster surculus*	*Discoaster triradiatus*	*Discoaster variabilis**	*Discoaster* spp.	*Florisphaera profunda*	*Gephyrocapsa* spp.	*Helicosphaera carteri*	*Helicosphaera intermedia*	*Pontosphaera* spp.**	*Reticulofenestra haqii*	*Reticulofenestra minuta*	*Reticulofenestra* cf. *R. minutula*	*Reticulofenestra pseudoumbilicus*	*Rhabdosphaera claviger*	*Sphenolithus abies*	*Syracosphaera* spp.	*Umbilicosphaera jafari*	*Umbilicosphaera rotula*	AGE
1. DNO-01																																			
0509-03	P-M	F-C	—	×	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×	—	×	×	×	×	×	×	—	×	—	×	×	×	×	
0509-01	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	×	—	—	×	Late
0509-02	P-M	F	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×	×	×	—	—	×	—	—	×	Miocene
2. DNO-02																																			
0509-04	M	C	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×	—	×	×	—	—	×	×	×	×	—	×	×	×	×	
0509-05	M	C-A	—	×	×	—	×	×	×	—	×	×	—	×	—	×	×	×	×	×	—	—	×	×	×	×	×	—	×	—	×	×	×	×	Late
0509-06	M	C-A	—	×	—	—	×	—	×	—	×	—	—	×	—	×	—	—	×	×	—	—	×	×	×	×	×	—	×	—	×	—	×	×	Miocene
0509-07	P-M	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	×	—	—	—	—	—	—	—	
3. DNO-03	no sample for nannofossil analysis																																		
4. DNO-04																																			
0510-02	P	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
0510-01	M	C	—	×	—	—	—	—	×	×	×	—	—	—	×	×	—	—	—	×	—	—	×	×	×	×	×	—	×	—	×	×	×	×	Late
0510-03	M	C	×	—	—	—	—	×	×	—	×	—	—	—	—	×	—	—	—	×	—	—	×	—	—	×	×	—	—	—	×	×	×	×	Miocene
0510-04	M	C	—	×	—	—	×	—	—	—	×	—	—	—	—	×	×	—	—	×	—	×	×	—	—	×	×	—	×	—	×	×	×	×	
5. DNO-05																																			
0510-08	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	×	—	×	—	—	—	Late
0510-07	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	×	—	—	—	×	—	—	×	Miocene
0510-05	barren of calcareous nannofossils																																		
0510-06	P-M	VF	—	—	—	—	—	—	×	—	—	—	—	—	—	×	—	—	—	×	—	—	—	—	—	×	×	—	×	—	×	—	—	—	
6. DNO-06																																			
0510-09	P	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	indete- minate
7. DNO-07																																			
0510-10e	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	—	×	—	—	—	
0510-10d	M	F	—	×	×	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	×	—	×	×	×	—	×	—	×	×	

Table 2. Continued.

STATION/ SAMPLE NUMBER	PRESERVATION	ABUNDANCE	Ascidian spicules	*Calcidiscus leptoporus*	*Calcidiscus macintyrei*	*Calciosolenia murrayi*	*Coccolithus pelagicus*	*Discoaster asymmetricus*	*Discoaster berggrenii*	*Discoaster braarudii*	*Discoaster brouweri*	*Discoaster calcaris*	*Discoaster challengeri*	*Discoaster* cf. *D. exilis*	*Discoaster pentaradiatus*	*Discoaster quinqueramus*	*Discoaster surculus*	*Discoaster triradiatus*	*Discoaster variabilis**	*Discoaster* spp.	*Florisphaera profunda*	*Gephyrocapsa* spp.	*Helicosphaera carteri*	*Helicosphaera intermedia*	*Pontosphaera* spp.**	*Reticulofenestra haqii*	*Reticulofenestra minuta*	*Reticulofenestra* cf. *R. minutula*	*Reticulofenestra pseudoumbilicus*	*Rhabdosphaera claviger*	*Sphenolithus abies*	*Syracosphaera* spp.	*Umbilicosphaera jafari*	*Umbilicosphaera rotula*	AGE
7. DNO-07																																			
0510-10c2	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	×	—	—	—	older
0510-10c	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	—	×	×	—	×	than
0510-10b	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	—	×	—	—	×	Early
0510-10a	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	—	×	—	×	×	Pliocene
0510-10 -0LST	P-M	VF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	—	×	—	—	—	
8. DNO-08																																			
1. 0511-06	P-M	VF	—	—	—	—	—	—	×	—	—	—	—	—	—	×	—	—	—	—	—	—	×	—	—	×	×	—	—	—	×	—	—	×	
2. 0511-02	M	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	×	—	×	×	×	—	×	—	×	—	×	×	Late
3. 0511-03	M	C-A	×	×	×	×	×	—	×	—	×	—	×	—	—	×	—	—	×	×	—	—	×	×	×	×	×	—	×	—	×	—	—	×	Miocene
4. 0511-01	M	F	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	×	×	—	×	—	×	—	—	×	
5. 0511-04	M	F-C	×	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	×	×	×	—	×	×	×	—	×	×	
6. 0511-05	M	C	×	×	×	—	—	—	×	—	—	—	—	—	—	×	×	—	—	×	—	—	×	×	×	×	×	—	×	—	×	×	×	×	

* *Discoaster variabilis* consists of *D. variabilis decorus* and *D. variabilis pansus*.
** *Pontosphaera* spp. consist of *P. discopora* and *P. japonica*.

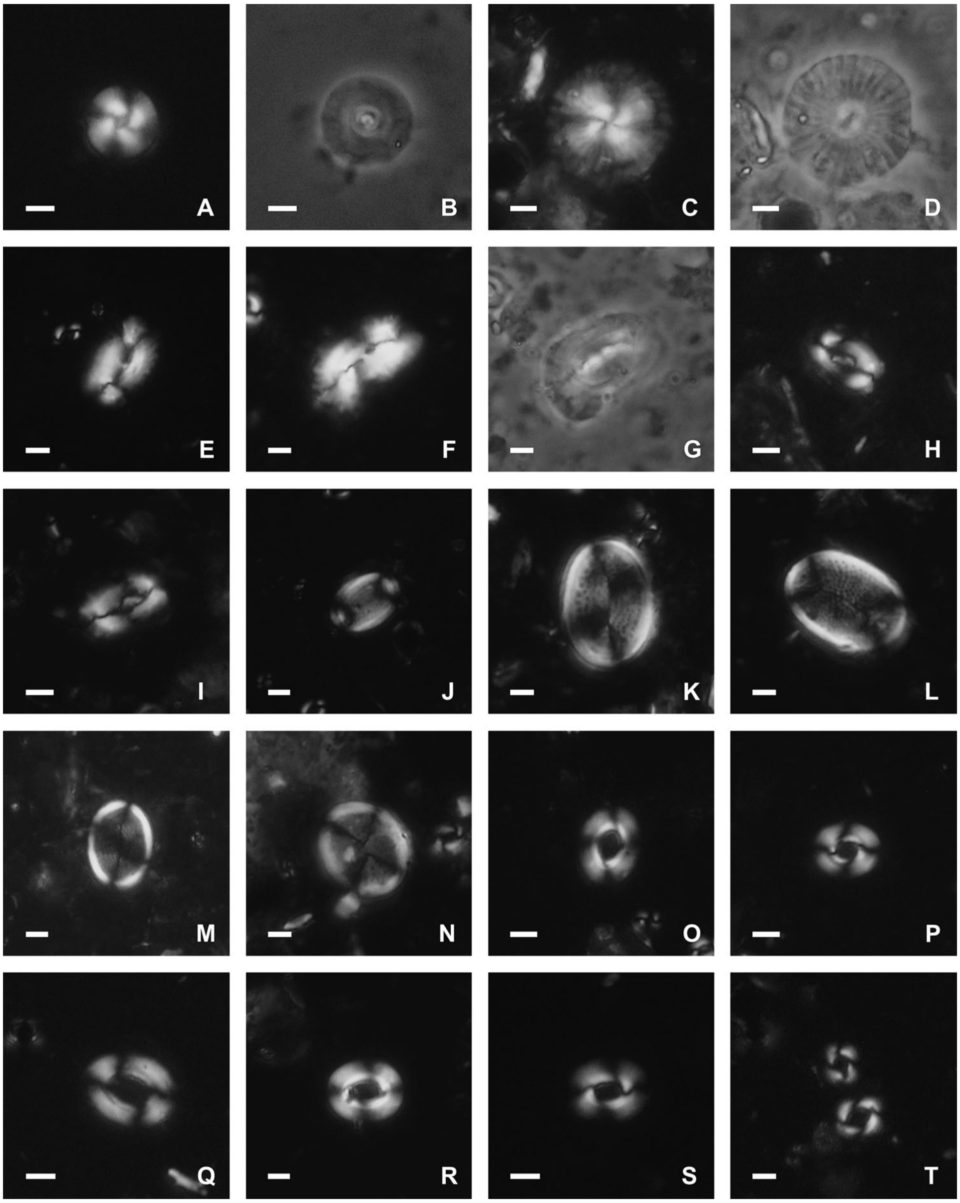

Fig. 5. Optical micrographs of calcareous nannofossils from Danao, Bohol. Scale bars=2 μm. XPL=cross polarized images. PC=phase contrast images. **A–D.** *Calcidiscus leptoporus*. 0510-04 (A–B), 0511-03 (C–D), XPL (A, C), PC (B, D). **E–G.** *Helicosphaera carteri*. 0509-06 (E), 0509-05 (F–G), XPL (E–F), PC (G). **H–I.** *Helicosphaera intermedia*. 0509-05, XPL. J. *Pontosphaera* cf. *P. discopora*. 0509-06, XPL. **K–N.** *Pontosphaera discopora*. 0509-05 (K), 0510-01 (L–M), 0511-03 (N), all XPL. **O–S.** *Reticulofenestra pseudoumbilicus*. 0509-05 (O, S), 0509-06 (P), 0510-01 (Q–R), all XPL. **T.** *Reticulofenestra haqii*. 0509-05, XPL.

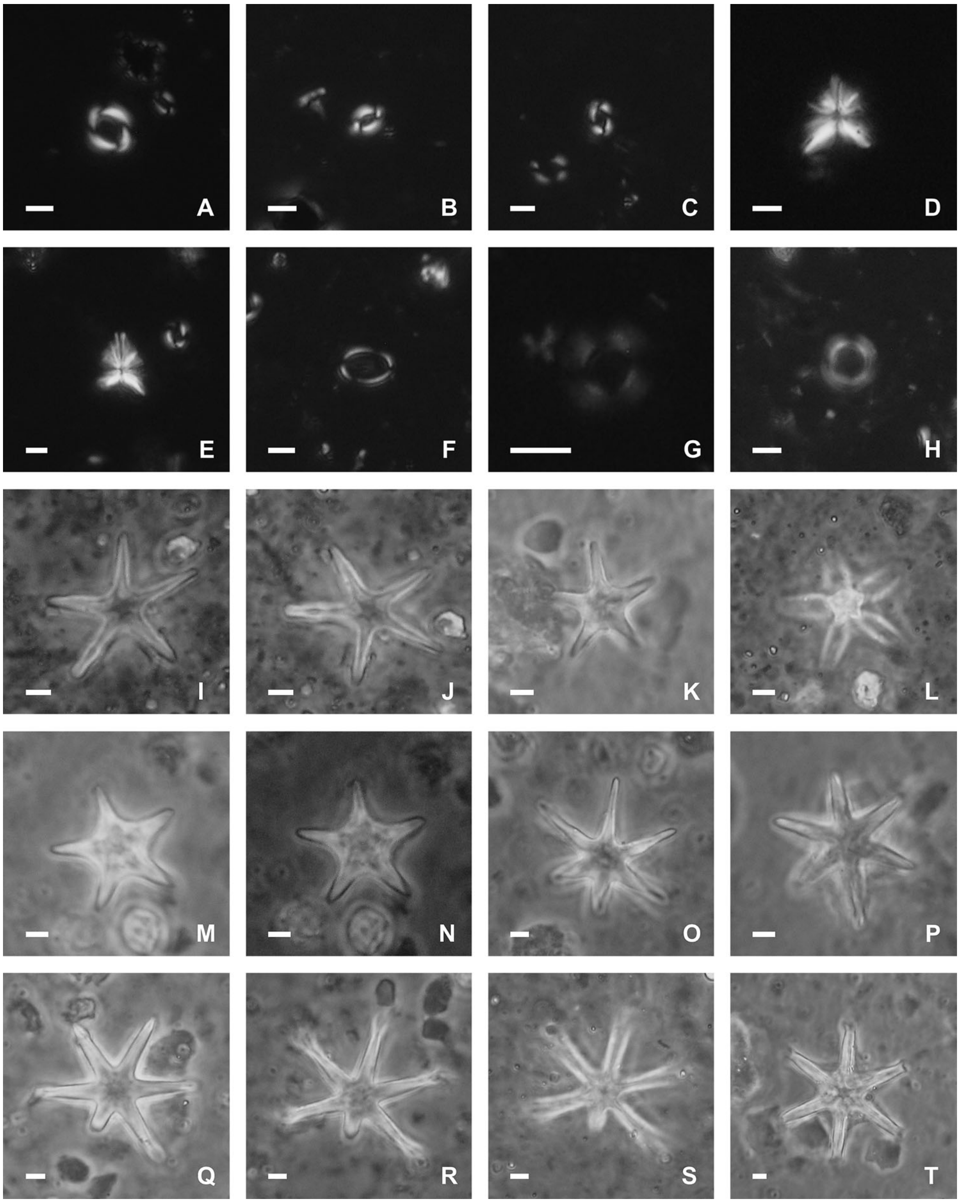

Fig. 6. Optical micrographs of calcareous nannofossils from Danao, Bohol. Scale bars=2 μm. XPL=cross polarized images. PC=phase contrast images. **A.** *Reticulofenestra* haqii. 0510-01, XPL. **B–C.** *Reticulofenestra* minuta. 0510-01, XPL. **D–E.** *Sphenolithus abies*. 0509-06, XPL. **F.** *Syracosphaera* sp. 0509-05, XPL. **G.** *Umbilicosphaera jafari*. 0509-05, XPL. **H.** *Umbilicosphaera rotula*. 0509-05, XPL. **I–J.** *Discoaster asymmetricus*. 0509-05, PC. **K.** *Discoaster* cf. *D. berggrenii*. 0509-06, PC. **L–N.** *Discoaster berggrenii*. 0510-01, PC. **O–Q.** *Discoaster brouweri*. 0509-05 (O), 0509-06 (P), 0510-01 (Q), all PC. **R–T.** *Discoaster* cf. *D. exilis*. 0509-05 (R–S), 0509-06 (T), PC.

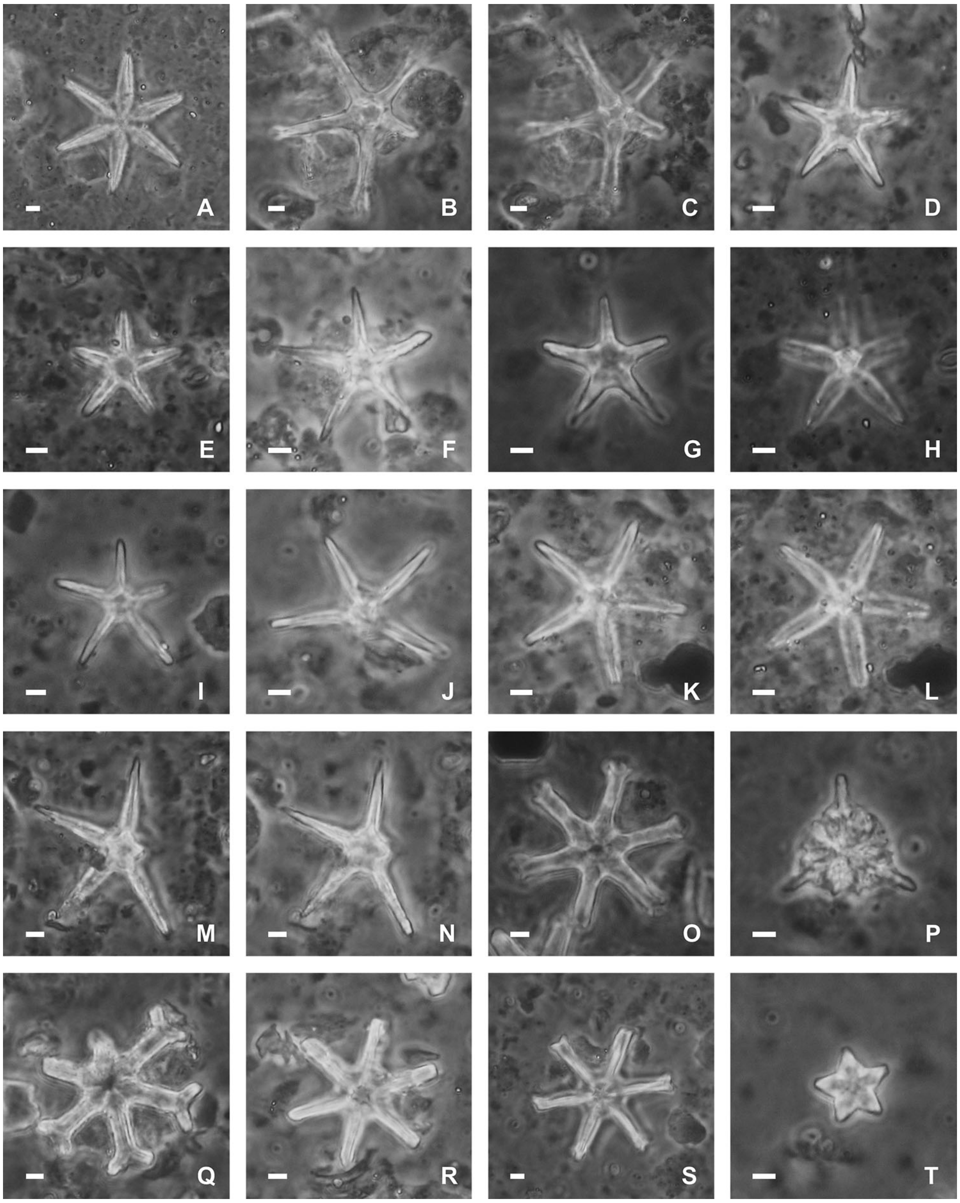

Fig. 7. Optical micrographs of calcareous nannofossils from Danao, Bohol. Scale bars=2 μm. All phase contrast images. **A.** *Discoaster* cf. *D. exilis*. 0509-06. **B–C.** *Discoaster pentaradiatus*. 0510-01. **D–E.** *Discoaster* cf. *D. quinqueramus*. 0511-03. **F–N.** *Discoaster quinqueramus*. 0509-05 (F–I; M–N), 0510-01 (J–L). **O.** *Discoaster surculus*. 0509-05. **P.** *Discoaster triradiatus*. 0509-05. **Q.** *Discoaster variabilis pansus*. 0511-03. **R–S.** *Discoaster variabilis decorus*. 0509-05 (R), 0509-06 (S). **T.** *Discoaster* sp., central area. 0510-01.

1. DNO-01

Calcareous nannofossil zone: NN11 (CN9).
Age: Late Miocene.
Remarks: All three samples collected in this station contain few to common calcareous nannofossils. Based on the presence of *Discoaster quinqueramus*, the section is within the NN11 zone, which is equivalent to Late Miocene age.

2. DNO-02

Calcareous nannofossil zone: NN11A (CN9a).
Age: Late Miocene.
Remarks: All four samples collected in this station contain rare to abundant calcareous nannofossils. Based on the presence of *D. quinqueramus*, the section also falls within the NN11 zone. The presence of *Discoaster berggrenii* in two samples, further limits the zone assignment of the station to NN11A, which is also within the Late Miocene.

3. DNO-03

No samples were collected in this station. The station, however, is stratigraphically higher than stations DNO-01 and 02.

4. DNO-04

Calcareous nannofossil zone: NN11A (CN9a).
Age: Late Miocene.
Remarks: Four samples were collected from four levels in this station (Fig. 3). All the samples contain few to common calcareous nannofossils. Based on the presence of *D. quinqueramus* in all the samples, the section is assigned to the NN11 zone. Similar to DNO-02, the presence of *D. berggrenii* in two samples further delimits the zone to NN11A, which also falls within the Late Miocene.

5. DNO-05

Calcareous nannofossil zone: NN11 (CN9).
Age: Late Miocene.
Remarks: Three out of four samples contain very few calcareous nannofossils. Based on the presence of *D. quinqueramus* in one sample, the section is assigned to the NN11 zone. One specimen similar to *D. berggrenii* was also encountered in a sample. The age of the section is also considered as Late Miocene.

6. DNO-06

Remarks: Only one sample with rare nannofossil content was collected in this station. Specimens observed in the sample are dominantly *Sphenolithus abies*. The LO of *S. abies* defines the top of the NN15 zone (Early Pliocene). Because of the absence of other marker taxa, the sample cannot be assigned to any specific zone. Based on the occurrence of *S. abies*, however, the age of the section can be considered to be not younger than NN15 (i.e., older than Early Pliocene).

7. DNO-07

Remarks: Seven samples were collected from seven levels in this station (Fig. 4). All the samples contain calcareous nannofossils. Marker taxa belonging to the genus *Discoaster* were not observed in any of the samples, although small *Reticulofenestra* spp., *S. abies* and *R. pseudoumbilicus* were observed to be common in the assemblages. The presence of the latter two taxa is used to delineate the top of the NN15 zone (Early Pliocene). Similar to station DNO-06, therefore, the age of this sampling station can be considered as not younger than NN15 (i.e., older than Early Pliocene).

8. DNO-08

Calcareous nannofossil zone: NN11 (CN9).
Age: Late Miocene.
Remarks: All six samples collected from this station were found to contain calcareous nannofossils (very few to abundant). Based on the presence of *D. quinqueramus* at the base and top of the section, the outcrop can be assigned to the NN11 (CN9) zone. *D. berggrenii* was also observed at the base of the section (i.e., lowermost sample), but is absent in the uppermost samples. The lower and upper parts of the section, therefore, can be assigned to the NN11A (CN9a) and NN11B (CN9b) zones, respectively. The age of the section is assigned to Late Miocene.

Discussion and Conclusions

Results of the present study demonstrate that the clastic formation exposed in the Danao basin is assigned to Martini's (1971) NN11 nannofossil zone, specifically to NN11A to NN11B subzones, which are considered middle Late Miocene in age. *Discoaster*s, compared to the other nannofossil taxa observed in the samples, are generally dissolution-resistant. Their absence in the samples from station DNO-07, therefore, is notably interesting. Müller *et al*. (1989) mentioned that this phenomenon is typical in the Pliocene of the Visayan Basin. Based on the stratigraphic position of DNO-07 in relation to the other stations in the study area, however, the station is still within the NN11 nannofossil zone (i.e., near stations DNO-01, 02 and 03; Fig. 2). *Discoaster*s, in general, are considered warm-water taxa. Their absence in some portion of the column, therefore, suggests that cooler oceanographic conditions prevailed in the Visayan Basin during the Late Miocene. More studies are needed to confirm this speculation.

The result of the present study is in contrast to the earlier stratigraphic assignment of the Danao clastic units to the Middle Miocene Carmen Formation as published in previous geologic maps of the area (e.g., Mula and Maac, 1983; Porth *et al*., 1989). The Carmen Formation in the Carmen–Pilar–Alicia area (central and northeastern parts of Bohol) overlies the Wahig Limestone (10–15 m thick). The lower part of the Carmen Formation consists of deep water, partly tuffaceous and fossiliferous marl with limestone layers and carbonate breccias. The upper part of the formation, on the other hand, consists of shallow-marine, less fossiliferous alternation of claystones, thinly bedded sandstones and conglomerates (Porth *et al*., 1989). The Carmen Formation is assigned to the NN5 to NN6 nannofossil zones and Blow's N8 to N11 planktonic foraminiferal zones, which are both equivalent to Middle Miocene (Müller *et al*., 1989; Mula and Maac, 1995). The age gap between the Carmen Formation and the clastic units in the Danao basin is considerably large (ca. 3 million years), spanning the NN7 to NN10 nannofossil zones. This time gap may correspond to the interval between the second and third cycles of marine sedimentation widely recognized in the Visayan Basin (Porth *et al*., 1989). Therefore, there is a possibility that the Danao sedimentary units are not the northwestern extension of the Carmen Formation.

The stratigraphic relationship between the Danao clastic units and the Sevilla Marl/Sierra Bullones Limestone exposed along the eastern coast of Bohol is difficult to clarify at this stage. The stratigraphy of the Sierra Bullones Limestone and Sevilla Marl differs considerably among authors. According to Corby *et al*. (1951) and Mula and Maac (1995), the Sierra Bullones Limestone is underlain by the Sevilla Marl. Porth *et al*. (1989), on the other hand, regarded the Sierra Bullones Limestone as a limestone facies within the Sevilla Marl. Müller *et al*. (1989) and Mula and Maac (1995) dated the Sierra Bullones Limestone/Sevilla Marl as Late Miocene to Early Pliocene in age (NN11 to NN15 nannofossil zones and Blow's N16 to N19 planktonic foraminiferal zone). One possible interpretation on the stratigraphy of the clastic sediments in the Danao basin, therefore, is that it is the equivalent of the basal part of the Sierra Bullones Limestone/Sevilla Marl exposed along the eastern coast of Bohol. However, such an interpretation is difficult to accept because the clastic units are most provably overlain unconformably by the Sierra Bullones Limestone/Sevilla Marl in the Danao basin. To solve this problem, a more detailed biostratigraphic study is required for the Sierra Bullones Limestone/Sevilla Marl. In any case, the recognition of middle Late Miocene shallow marine sediments in the Danao basin is important in understanding the geology of Bohol Island.

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