Jurnal Geologi Indonesia, Vol. 5 No. 1 Maret 2010: 49-56

Paleocene postgenetic Accumulation of Nannoplankton on the Phillipsite Minerals in Roo Rise, Indian Ocean

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Abstract

The sample studied was derived from the base of core MD 982156, one of the boreholes obtained during the IMAGES Expedition. The expedition was carried out as a research cooperation between Indonesia and French Governments using Marion Dufresne Research Vessel, belonging to IFRTP (*French Institute for Polar Research*). Within this sample, the phillipsite minerals were firstly found by the first author. Using SEM *(Scanning Electron Microscope)* at the magnification of x1,000 for group and up to x20,000 for individual photos, the nannoplanktons were shown to accumulate on the phillipsite minerals as a binding matrix. Different directions and velocity of the bottom current when the phillipsite minerals were originated, might have contributed in binding of the various mineral shapes. The calcareous nannoplankton in the studied area is preserved within the sediments between 3880 m to 3914 m depths below sea level (bsl). This interval possibly located between Lysocline and Carbonate Compensation Depth (CCD), is indicated by the presence of well preserved calcite minerals and calcareous nannoplankton within sediments. *Discoaster multiradiatus,* the dominant fossil within the sediments in the studied area, is Paleocene in age. Therefore, the binding of nannoplakton accumulation as a matrix of the phillipsite minerals occurred as a postgenetic deposition.

Keywords: Paleocene, postgenetic, nannoplankton, phillipsite, Roo Rise, Indian Ocean

Sari

Percontoh batuan sedimen berasal dari bagian dasar sumur pemboran MD 982156 yang diambil dari salah satu sumur pemboran hasil ekspedisi kelautan IMAGES, suatu kerja sama penelitian antara Indonesia dan Pemerintah Perancis dengan menggunakan Kapal Riset Marion Dufresne milik institusi IFRTP (French Institute for Polar Research). Di dalam percontoh ini mineral phillipsit pertama kali ditemukan oleh penulis pertama. Dengan menggunakan SEM (Scanning Electron Microscope) pada perbesaran 1000x untuk foto kelompok dan 20.000x untuk foto individu, nanoplankton tampak terakumulasi sebagai matriks pengikat mineral phillipsit. Perbedaan arah dan percepatan arus bawah laut ketika mineral phillipsit terbentuk mungkin mengakibatkan pengikatan yang membuka jalan terjadinya berbagai bentuk mineral. Nanoplankton di daerah penelitian terawetkan dengan baik antara kedalaman 3880 m - 3914 m di bawah permukaan laut. Kedalaman ini mungkin berada di antara zona Lisoklin dan Kedalaman Kompensasi Karbonat. Hal ini diindikasikan oleh kehadiran mineral kalsit dan nanoplankton gampingan, yang terawetkan baik dalam sedimen. Discoaster multiradiatus merupakan fosil yang dominan di dalam batuan sedimen berumur Paleosen, di daerah penelitian. Terjadinya pengikatan nanoplankton terhadap mineral phillipsit setidaknya terjadi setelah pengendapannya.

Kata kunci: *Paleosen, pascagenesis, nanoplankton, phillipsit, Tinggian Roo, Samudra Hindia*

Introduction

In 1998, the phillipsite minerals were firstly found by the first author, in a biostratigraphic study of planktonic foraminifera located in the Roo Rise, Indian Ocean. The samples were taken from one of the boreholes (Core MD 982156, Figure 1) that were obtained during the IMAGES Expedition, a research cooperation between Indonesia and French Governments using RV Marion Dufresne Research

Naskah diterima: 15 November 2009, revisi kesatu: 26 Januari 2010, revisi kedua: 11 Februari 2010, revisi terakhir: 17 Februari 2010

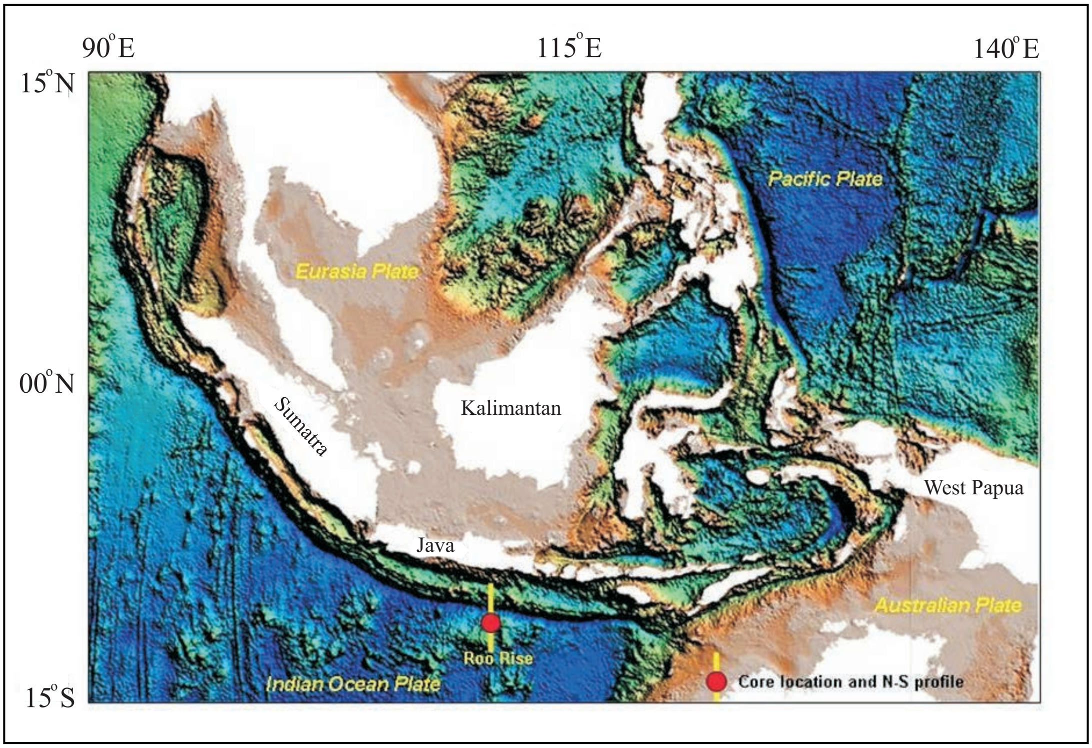

Figure 1. Locality map of the studied area (after Smith and Sandwell, 1997).

Vessel that belongs to IFRTP (*French Institute for Polar Research*). A north-south cross section of well location reconstructed by the second author is shown in Figure 2.

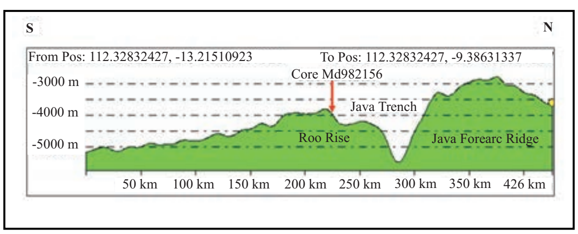

Figure 2. Cross section site of the studied area (Kusnida, 2009).

Adisaputra and Hartono (2004) informed that this phillipsite mineral-bearing layer occurred as the basement of Late Miocene to Holocene succesions in this location. Further study, in 2007, Adisaputra and Hartono discussed the various forms of this mineral inspite of its genetics.

The authors are interested in the identification of these minerals in detail from various views, using Scanning Electron Microscope (SEM) from x1000 to x10.000 magnification.

Inasmuch as the nannofossil - bearing sediments are also present from the base to the top part of the core, Adisaputra and Hendrizan (2008) studied the biostratigraphy of this core on the basis of nannoplankton. In this study, they suggested that a hiatus present was a deposition level marked between the phillipsite mineral-bearing sediments and the phillipsite mineral-barren sediments. This hiatus occurs between the Eocene and at least the Late Miocene age. However, Kusnida (2009) synthesized that this hiatus or nondepositional recorded within core was presumably caused by a tectonic erosion or slumping of Eocene to Middle Miocene sedimentary covers of the Roo Rise off Java at least since Late Neogene tectonic activities. On the basis of the abundance of the species *Discoaster multiradiatus*, the age of the phillipsite mineral is Paleocene. This fossil dominates the sediments at the base of core MD 982156. Nannoplankton is known as a calcareous fossil derived from plants.

The phillipsite mineral is one of the common three important types of zeolite within marine sediments. This group tends to be particularly abundant in marine volcanoclastic deposits, and have been recorded as forming up to 80% of altered tephra horizons (Rothwell, 1989).

The distribution of the phillipsite mineral is suggested to be more abundant in the Pacific and Indian Ocean sediments than in the Atlantic (Kolla and Biscaye, 1973; and Stonecipher, 1976; in Rothwell, 1989). Kolla and Biscaye (1973; in Rothwell, 1989) also recorded the main occurrences of the mineral in the Indian Ocean, so far, are from the Central Indian and Wharton Basins and from parts of the Mid-Indian Ocean and Ninety-East Ridges.

In 2009, Kusnida *et al.* described the phillipsite mineral in detail concerning its physical characteristic and tectonic erosion.

In this paper, the authors discuss the origin and occurrence of binding of the phillipsite mineral leading to its shape variation.

Methods

There is only a small part of the sediments taken from the studied site core MD 982156 that has been prepared on the stub and determined under Scanning Electron Microscope (SEM) with the magnification of x1000 for group and up to x20,000 for individual species.

The determination of nannoplankton taxa is referred to the description of nannofossil taxonomy by Perch-Nielsen (1985), Hamilton and Hojjatzadah (1982), Hasjim, (1988), and Bown (1999). While identification of minerals are referred to Dana (1916), Betekhin (1960; in Rothwell, 1989), and Read (1970; in Rothwell, 1989).

Photos were taken on a Scanning Electron Microscope (SEM), in Geological Survey Institute, Geological Agency, Ministry of Energy and Mineral Resources, Bandung.

Results of the Study

The accumulation of nannoplankton occurs within the phillipsite-bearing sediments at 3914 m depth below sea level. This accumulation binds the phillipsite mineral leading to its various shapes.

The SEM analysis with the magnification of x1000 conducted on the sediments, shows the presence of well preserved calcite minerals with two specimens of nannoplankton fossils known as *Discoaster multiradiatus* (Figure 3). According to Perch-Nielsen (1985), this fossil was deposited in the Paleocene epoch.

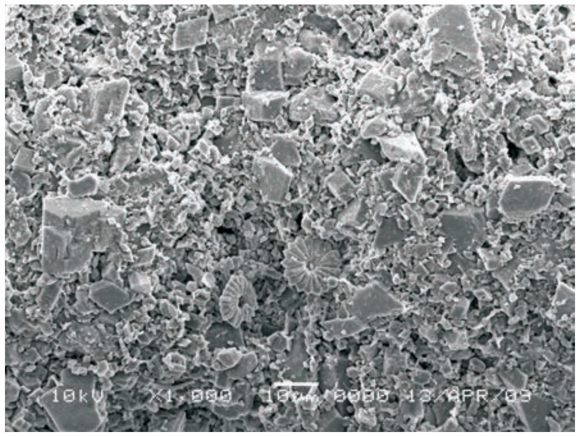

Figure 3. Sediments composed of calcite with Paleocene *Discoaster multiradiatus* fossils.

The basic shape of the phillipsite mineral before binding is monocline as shown in Figure 4. This form is commonly found in the sediments. The nannoplankton (*Discoaster multiradiatus*) fossil is scattered on the surface of this mineral. From this point of view, it is obvious that this fossil accumulated and bound the phillipsite mineral after the deposition of mineral itself.

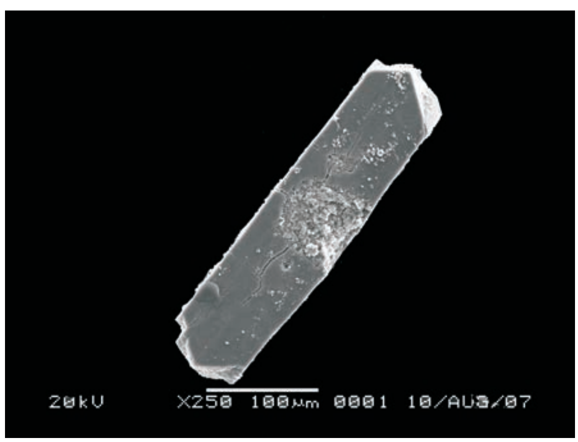

Figure 4. The basic shape of the phillipsite mineral before binding is monocline (Adisaputra and Hartono, 2007).

The accumulation of the fossil mentioned above would become solid as a matrix, mixed with claystone to bind two or more minerals. Some matrices bound in the centre of phillipsite mineral form a cross shape (Figure 5), whereas in Figure 6 some fossils are scattered on the surface of the mineral.

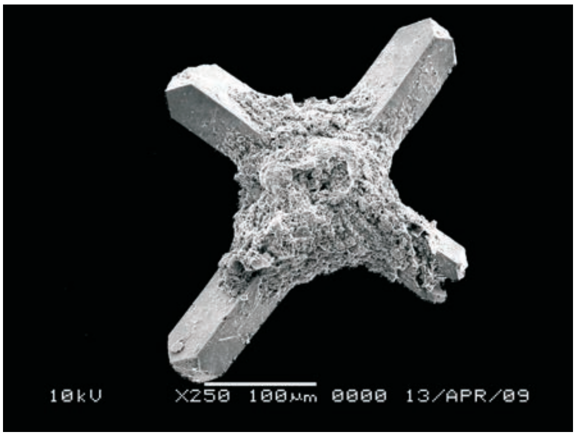

Figure 5. Phillipsite mineral bound by nannoplankton fossils forming cross shape.

Figure 6. *Discoaster multiradiatus* fossils on the phillipsite mineral.

At the magnification of x2500, the nannoplankton fossils are much less in size compared to the phillipsite mineral present as their background (Figures 7 and 8).

The various types of the phillipsite mineral after binding by Paleocene nannoplankton are shown in Figures 9a-y.

Figure 7. *Discoaster strictus* scattered on the phillipsite mineral, as a part of Figure 8 (see the square).

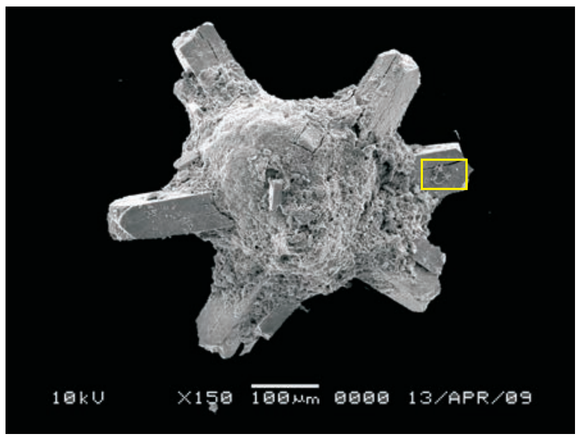

Figure 8. Phillipsite mineral in a radier pattern magnification x150. The square indicates the position of Figure 7.

Discussion

The variations of phillipsite mineral in the studied area can be detected on the SEM at more than x150 magnification, whereas the material composition of the matrix can only be shown at more than x1000 magnification.

According to Betekhtin (1960; in Rothwell, 1989) and Read (1970; in Rothwell, 1989) the phillipsite mineral has different shapes varying from straight (columnar), T-shapes, cruciform twinning to radiating aggregates, and reddish white to grey in colour. The chemical analysis indicates that this mineral is composed of silicatalumina sodium, potasium hidros / $K_{2,8}$ $Na_{1,6}$ $Al_{4,4}$ $Si_{11,6}$ O_{32}. 10 H_2O

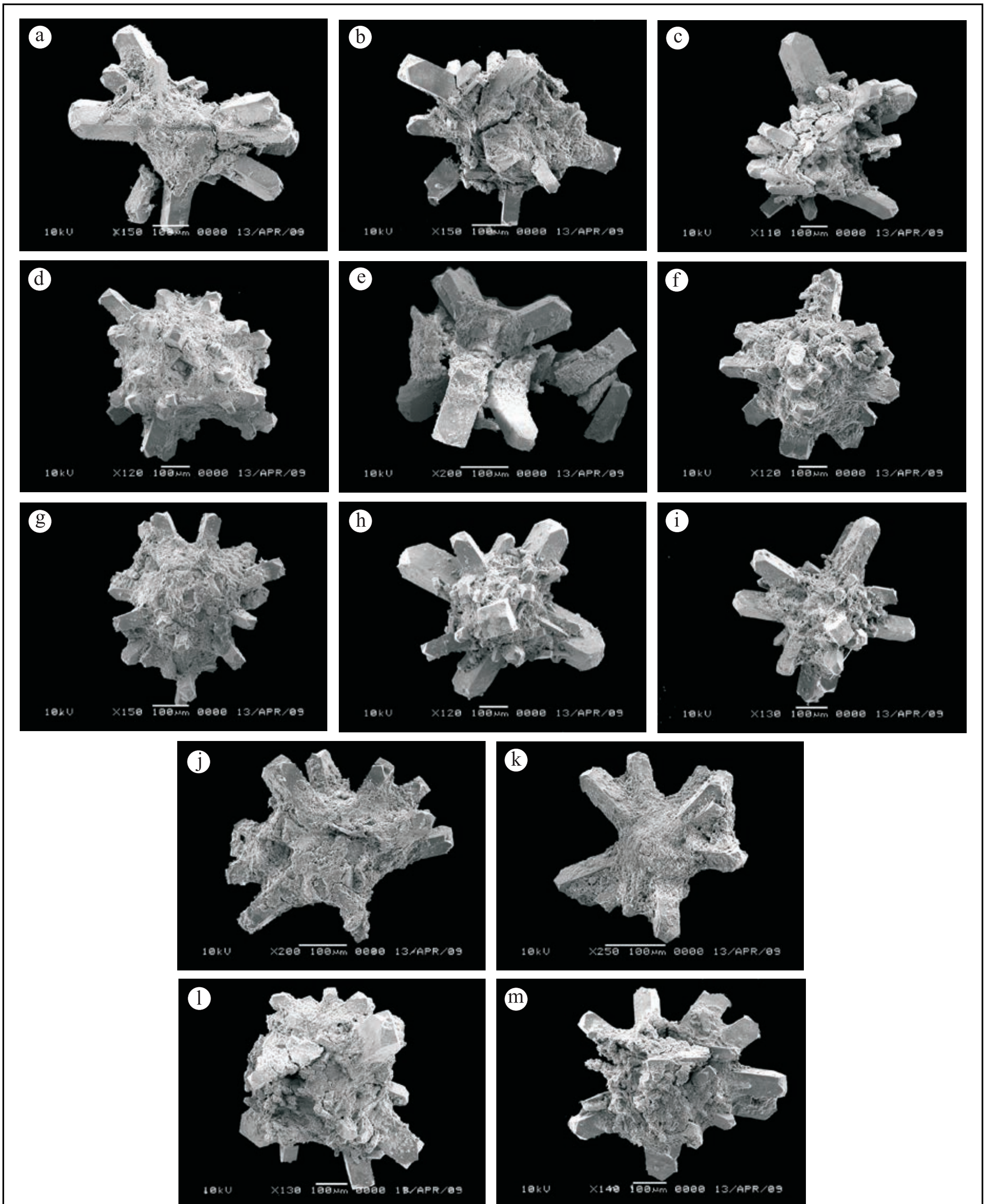

Figure 9. Various types of the phillipsite mineral after being bound by Paleocene nannoplankton; (a-m). complexly intergrown with partly broken crystals.

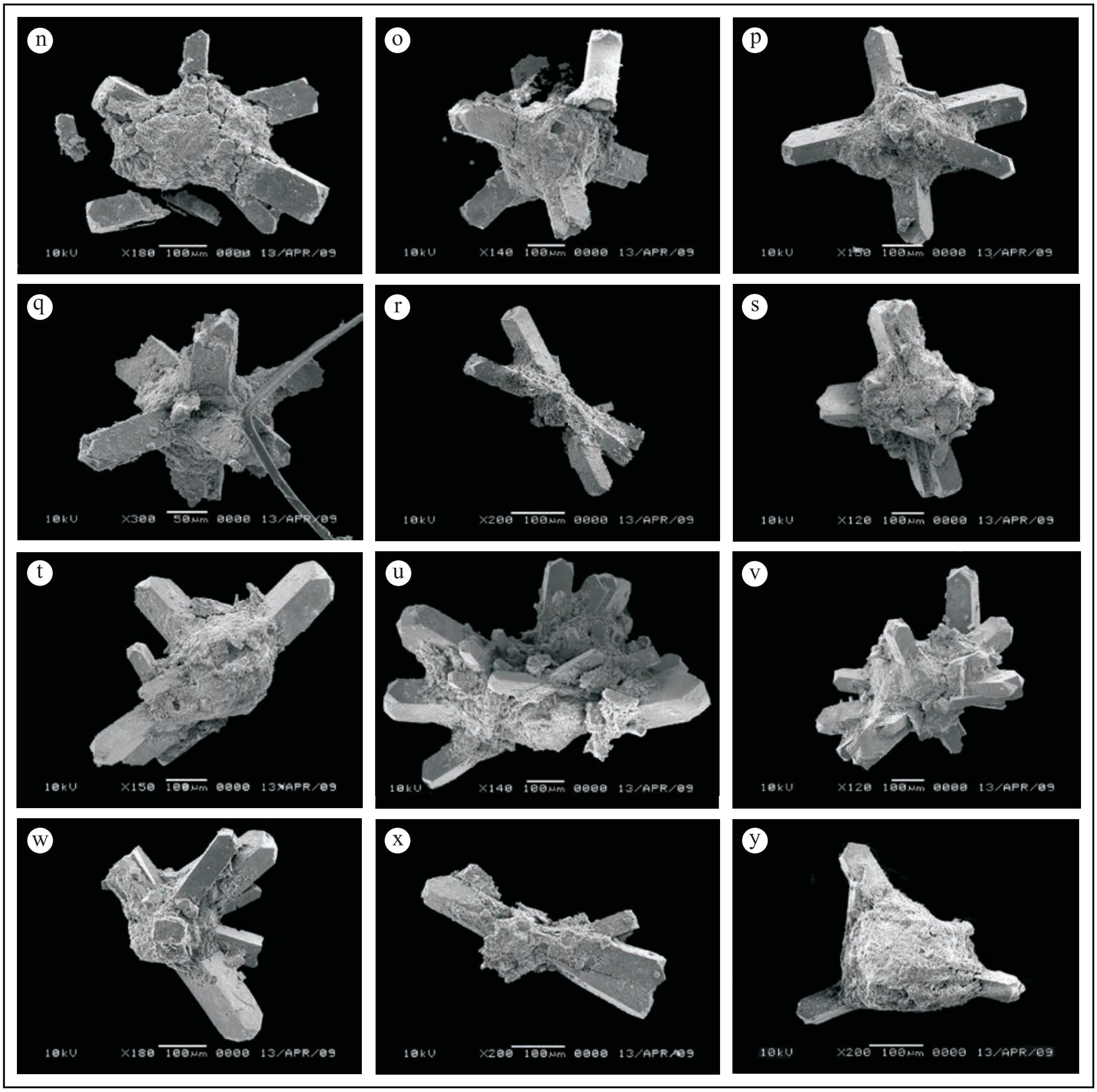

Figure 9. Continued .... (n-q). radiate crystals, partly broken; (r-t). cruciform twinning, s and t partly broken with different angles; (u-x). rossete crystals; y. broken specimen.

(Stonecipher, 1977, 1978, and Kastner, 1981, in Rothwell, 1989).

Dana (1916) described that the crystal system of phillipsite mineral is monoclinic, uniformly penetration-twins, but often simulating orthorhombic or tetragonal forms; twins sometimes, but rarely simple. The crystals either isolated, or grouped in tufts or spheres, radiated, and bristled with angles at surface and brittle, vitreous luster, white colour, sometimes are reddish, with uncoloured streak, translucent to opaque. The position of inclination varies between 15°-75°. However, he did not describe why the isolated crystal became grouped.

In the studied area, Adisaputra and Hartono (2007) recorded that the variation shapes of the phillipsite minerals from sample MD 982156 are straight (columnar), cross in different angles, T-shapes, and twinning to radiating aggregates.

Moreover, Adisaputra and Hendrizan (2008) found that the nannoplanktons were scattered from the core base to the top. However, at the base of the core, calcareous nannoplankton plays as a matrix binding in a basic monocline shape of the phillipsite mineral (Figure 4) into various types (Figure 9). These various types might be due to a different direction and acceleration of the bottom current when the phillipsite mineral was originated.

Furthermore, the calcareous nannoplankton in the studied area is preserved within the sediments between 3880 m to 3914 m depths below sea level (bsl). This interval is possibly located between the Lysocline and Carbonate Compensation Depth (CCD) zones. The occurrence of well preserved calcite minerals and calcareous nannoplankton within sediments indicates that this interval is located between those depths.

Berger (1970; in Bignot 1985) placed the Lysocline in the South Pacific around 4000 m and CCD around 4500 m below sea level. Adisaputra (1985) considered that the Lysocline in the Savu and Lombok Basins were located between 4500 - 5000 m depths below sea level (bsl). The shape of phillipsite mineral in the studied area is elongate euhedral or subhedral prismatic crystal. No crystal shows an etching nor corrosion. Bonatti (1963; in Rothwell, 1989) suggested that the well crystal shapes indicated an *in-situ* growing.

As shown in Figure 9 a - m, the crystals may be complexly intergrown with partly broken. The crystals often contain abundant inclusions indicating the fast growth of the crystals themselves. Cronan (1980; in Rothwell, 1989) stated that these shapes occurred restricted in a low sedimentation rate region, below the calcium compensation depth (CCD). It is especially common in altered tephras.

Some other crystal shapes are radiate (Figures 9 n - q which partly broken), cruciform twinning (Figures 9 r - t; s and t are partly broken and they have different angles), rossette (Figures 9 u - x), and another broken specimen (Figure 9 y).

Kolla and Biscaye, 1973; and Stonecipher, 1976; in Rothwell, 1989. Stated that phillipsite appears to determinate geological age. The mineral is less common in pre-Miocene sediments; more abundant in the Pacific and Indian Ocean sediments than in those of the Atlantic. In the studied area, the age of this mineral is Paleocene or younger based on the matrix binding the mineral.

Conclusions

- Nannoplankton fossil occurring within the sediments in the studied area is found as a matrix binding the phillipsite minerals.
- The calcareous nannoplankton studied is preserved within the sediments between 3880 m - 3914 m depth bsl. This interval is possibly located between the Lysocline and Carbonate Compensation Depth (CCD) zones.
- *Discoaster multiradiatus,* the dominant fossil within the sediments is Paleocene in age. Before the fossils accumulated, the phillipsite minerals had been deposited. Therefore, the binding of nannoplakton accumulation as a matrix of the phillipsite minerals is suggested to be a postgenetic deposition.
- This binding will give a way to the various types of the shapes of the mineral that might be due to the different directions and velocity of the bottom current, when the phillipsite mineral was originated.
- The hiatus or non depositional feature recorded in core was probably due to a tectonic erosion or slumping in the Eocene to Middle Miocene sedimentary covers of the Roo Rise off Java, taking place at least since Late Neogene tectonic activities.

Acknowledgments---The authors would deeply like to thank Frank BASSINOT and François GUICHARD of the Laboratory of CEA-CNRS, Centre des Faibles Radioactivités for enabling the study of material from IMAGES IV EXPEDITION. Deeply appreciation is directed to Ir. Subaktian Lubis, M. Sc., the Director of Marine Geological Institute for his interest in the author’s work. The authors are very grateful to Dr. Nur Hasjim, S.E. and Prof. Dr. Sapri Hadiwisastra, professional colleagues, for their useful critiques in finishing this manuscript. Thanks are also directed to Wikanda, Geological Survey Institute of Indonesia, Geological Agency, in preparing sample for SEM analysis.

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