OCCURRENCE OF PHILLIPSITE MINERAL IN SUB-SEAFLOOR OF ROO RISE-INDIAN OCEAN : A TECTONIC EROSION SYNTHESIS

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ABSTRACT

A single deep-sea core (MD982156) of 30.30 meters long which is obtained during the MD III-IMAGES IV Expedition from Roo Rise - Indian Ocean in 1998 was studied. Down to 30 meters of the core length, the sediment consists of abundance planktonic foraminiferas. Below 30 meters, it is mostly composed of phillipsite mineral-rich sediment that is associated with nannoplanktons.
The Paleocene authigenic phillipsite minerals associated with nannoplanktons is separated from Late Miocene to Holocene planktonic foraminiferas rich-sediments by hiatus. This hiatus or non depositional in Roo Rise suggest be triggered by long Cenozoic tectonic erosion.

Keywords: phillipsite, Roo-Rise, Indian Ocean, authigenic, hiatus, tectonic erosion

1. INTRODUCTION

In 1998, the MD III-IMAGES IV Expedition in the Indonesian waters and the Indian Ocean has been conducted in the framework of IMAGES Program (*International Marine Global Changes Study*), in which, deep sea floor sediment coring program from IGBP-PAGES (*International Geosphere–Biosphere Program Past Global Changes*) affiliated with SCOR (*Scientific Committee on Oceanic Research*) has also been taken. The aim of the expedition was to take inventory the sea floor sediment samples from the Indonesian waters with a giant piston core. This expedition was executed using the France RV Marion Dufresne. Two scientists from the Marine Geological Institute of Indonesia were involved and worked on biostratigraphy aspect of core MD982156 taken from 11Ú 33.31'S and 112Ú 19.72' E (Figure 1), precisely at the northern slope of Roo Rise toward the Java Trench - Indian Ocean at water depth 3884 meters (Figure 2).

Adisaputra and Hartono (2004) stated that the lower part of the MD982156 core (30 - 30.30 m bsf) consisted of nannoplanktons rich-sediments without foraminiferas content. In contrast; from 30 m bsf to the sea floor, it consisted of planktonic foraminiferas rich-sediments. On the basis of Scanning Electron Microscope (SEM), Adisaputra dan Hartono (2007) indicated the occurrence of phillipsite mineral at 30 m to 30.30 m bsf.

The origin of phillipsite mineral in deep marine environment has been the topic of considerable discussion among mineralogists (Knox et al, 2003 and Diekmann et al, 2004). However, this article tries to describe the occurrence of Paleocene phillipsite-rich sediments observed in sub-seafloor samples MD982156 drilled and collected during the MD III-IMAGES IV Expedition at the Roo Rise-Indian Ocean in 1998. The aim of the study is to synthesize the absence of post Paleocene phillipsite mineral within the core since it was obtained from the pelagic sediments. The mineral is presumed to be preserved within the long succession of the sediments and free from erosion as well.

Fifty mg from the top part of each sample was then sorted using 150 mµ shaver and dried at 50 ºC. A small part of each samples were then used

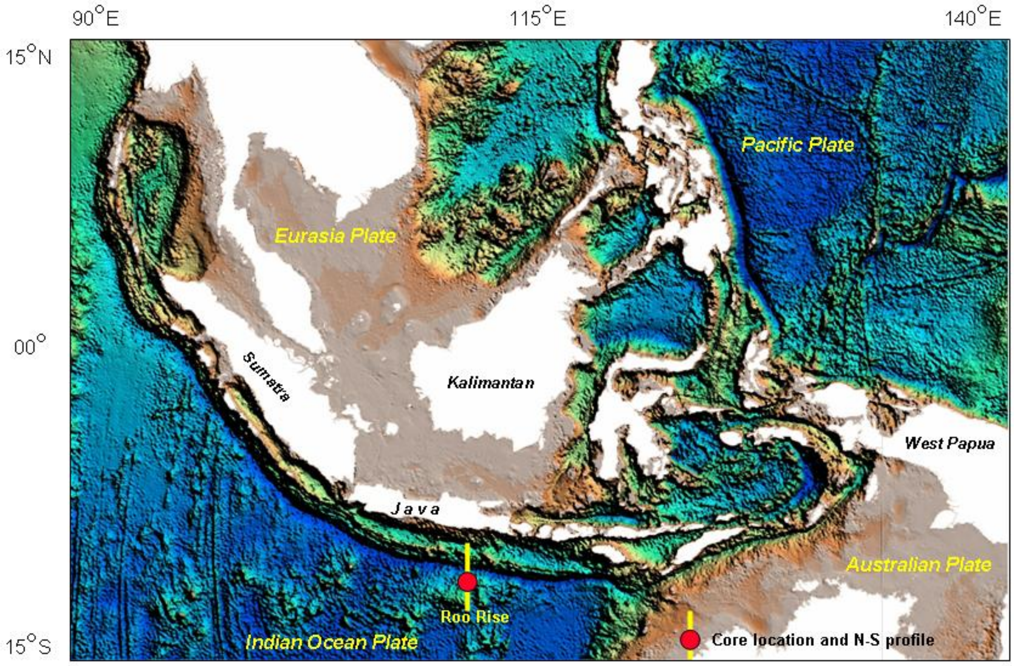

Figure 1. Map showing the location of core MD982156 in the Roo Rise produce in Figure 2

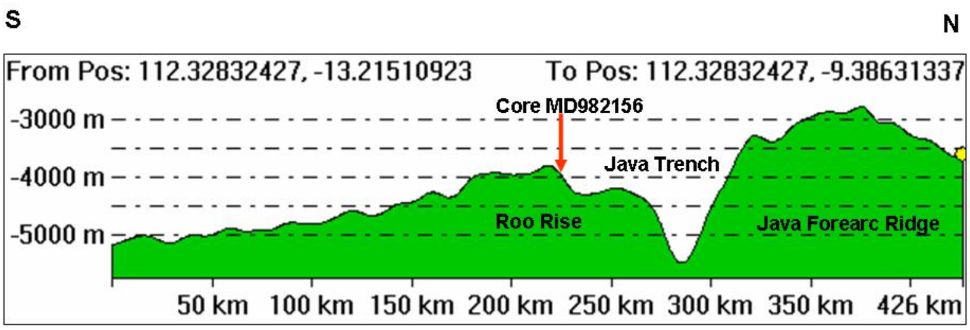

Figure 2. N-S profile across Roo Rise - Java Forearc Ridge where Core MD982156 is location

2. STUDY METHOD

Sediment samples were taken from every 1.50 meters interval of 30.30 meters length of core MD982156. Therefore, 21 samples were obtained.

for Scanning Electron Microscope (SEM) purposes with magnification of 20,000x for individual photographs. Time boundaries within core MD982156 were adopted from the time zone interval made by Adisaputera and Hendrizan (2008).

3. RESULTS

In general, sediments within core MD982156 (Figure 3) consist of calcareous clays and marls, brownish-white to grayish-white tuffaceous clay. It contains abundance of foraminiferas and nannoplanktons until 30 meters depth of the core. Down from 30 to 30.30 meters (bsf) of the core, the sediments consist of phillipsites minerals with various forms. The Scanning Electron Microscope (SEM) photograph indicates that the basic forms of phillipsite minerals is bounded by cement/matrix dominated by nannoplanktons. The planktons form various binding such as straight, T-form, diagonal etc (Figure 4). These phillipsites contains open channels (Figure 5). Other cryptocrystalline mass within core are gibbsite or hydragilites associated with nannoplanktons. The thickness and extension of this layer are still unknown.

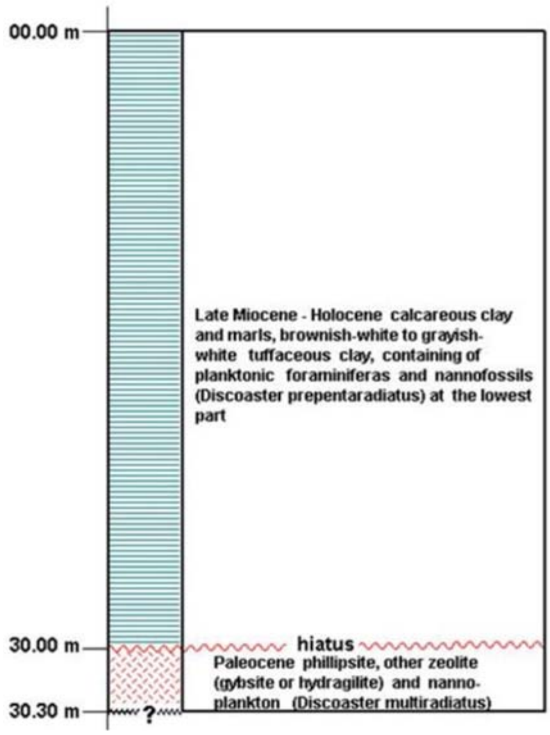

Figure 3. Stratigraphic column of core MD982156

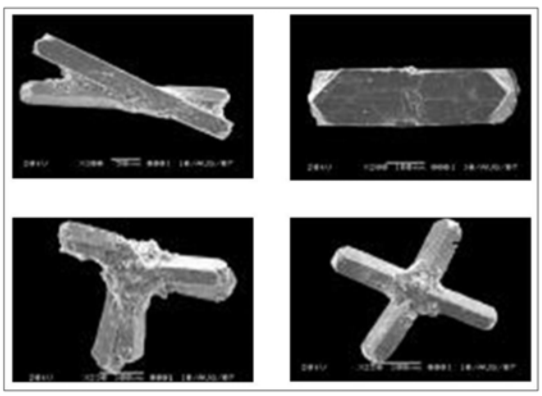

Figure 4. Various binding of phillipsite mineral in the study are Photograph coutesy of Adisaputra 2008

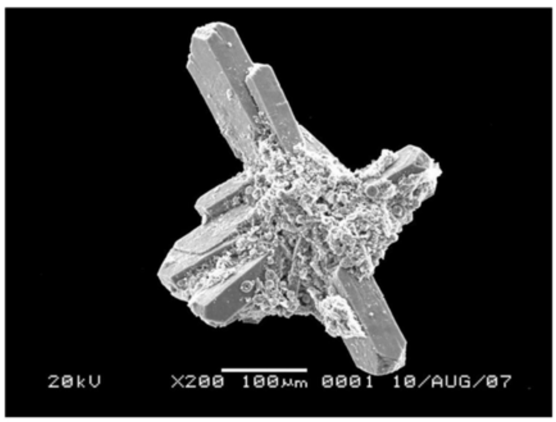

Figure 5. Phillipsite minerals bounded by matrix nannoplanktons. Photograph coutesy of Adisaputra 2008

According to Husaini (2006), phillipsite mineral was never found in Indonesia as its studies so far were mainly conducted on land. Adisaputra and Hartono (2007) stated that the mineral was only found as authigenic origin within the deep sea. It possibly derived from tephra as the volcanic product. According to *Amethyst Galleries Inc.* (2008), phillipsite is one of the rarest zeolites and forms interesting aggregates that are commonly clustered into bright white sphericules or balls with a rough crystalline or silky surface. Empirical formula of phillipsite is $KCaAl_3Si_5O_{16}$-$6H_2O$, while environmentally it is found as common zeolite in volcanic rocks, ore veins, diagenetically altered rhyolitic vitric tuffs, saline lake deposits, and ocean floor sediments.

Gibbsite or hydragilite in the study area (Figure 6) forms cryptocrystalline masses, goldish-white colour and pearly lustre. According to Betekhtin in Adisaputra and Hartono (2007), it was possibly derived from the decomposition and hydrolysis of aluminium-bearing silicates, partly in the course of hydrothermal process at a comparatively low temperature, but chiefly from surface weathering, mainly under tropical and subtropical climate conditions.

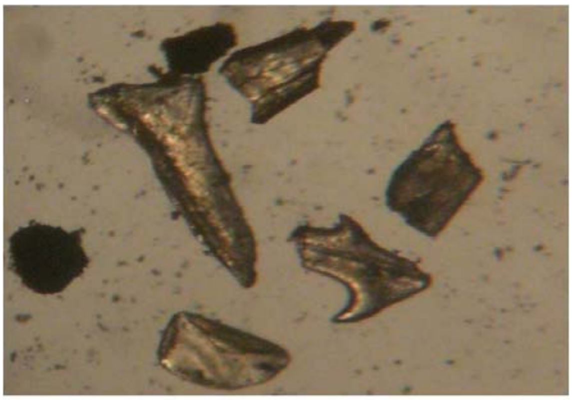

Figure 6. Gibbsite from the study area from cryptocrystaline masses

4. DISCUSSION

Phillipsite is now known to be an abundant constituent of surface sediment covering vast areas of the Pacific seafloor where sedimentation rate are low and occur as an encrusting precipitate around hot springs (Ghosh and Mukhopadhyay, 1995). However, phillipsite is more commonly found in the vesicles or bubbles of volcanic rock as are most other zeolites. The well-preserved Late Miocene to Holocene sediment record within core MD982156 possibly shows evidence of a hitherto unknown Eocene to Middle Miocene tectonic circumstances. Lithological and biogenic variations present within core give insights into possibly mid-Cenozoic environmental changes in terms of tectonic activities.

Diekmann et al (2004) stated that the original deep sea phillipsite minerals, formed from surfaced rock fragment, derived from volcanic products. This nucleus was later altered to phillipsite under alkaline, silica-undersaturated, low-temperature conditions through the length of sedimentary rock. Paleo-location of Paleocene phillipsite formation of this study can be presumed at least at the flank of mid-oceanic ridge and far from the present location.

Present tectonic framework off Java is characterized by convergence between Indian Oceanic – Australian Continental Plates with Eurasian Plate that established since Late Neogene. Recently, Kopp et al (2006) gave the evidence for oceanic Roo Rise erosion on the basis of a newly acquired geophysical data off central Java. They indicate the local erosive processes in the wake of seamount subduction and documented by high-resolution bathymetric survey and show irregular trend of the deformation front sculpted by seamount collision scars. Further, the authors indicate a subduction of oceanic basement relief which leads to large-scale uplift of the forearc and outer arc ridges (seamount?) giving way to isolate topographic elevations such as Roo Rise. These tectonic evidences, presumes that the hiatus recorded within core MD982156 is possibly caused by tectonic erosion of Roo Rise. A well preserved Late Miocene to Holocene sedimentary in study area indicates the relatively stable tectonic conditions since Late Miocene. Therefore, why it is only the Paleocene phillipsite rich-sediments are left in the study area.

5. CONCLUSION

The occurrence of phillipsite at the lowest part of core MD982156 obtained from Roo Rise suggested a volcanic activity during Paleocene. These minerals were formed authigenically in deep sea. The Paleocene phillipsite rich-sediments, overlain by Late Miocene to Holocene foraminiferas rich-sediments indicates the occurrence of hiatus or non depositional since Eocene to Middle Miocene. The hiatus or non depositional recorded within core presumed was caused by tectonic erosion or slumping of Eocene to Middle Miocene sedimentary covers of Roo Rise off Java at least since late Neogene tectonic activities.

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REFERENCES

Adisaputra, M.K. and Hartono, 2004. Late Miocene – Holocene Biostratigraphy of Single Core in Roo Rise, Indian Ocean, South of East Java. *Bull. Marine Geological Institute, Vol 19, No.1,* p. 27-48.

Adisaputra, M.K. and Hartono, 2007. The Phillipsite Mineral in Deep Sea Sediment from Single Core in Roo Rise-Indian Ocean, South of East Java, *Indonesian Mining Journal, Vol. 10, No. 9*, p.39-43.

Adisaputra M.K. dan M. Hendrizan, 2008. "Hiatus pada Kala Eosen-Miosen Tengah di Tinggian Roo, Samudera Hindia, Selatan Jawa Timur, Berdasarkan Biostratigrafi Nannoplankton", *Jurnal Geologi Kelautan*, Vol. 6, No.3.

Amethyst Galleries Inc., 2008. *http://www.galleries.com*, 8.11 AM, April 27th 2009.

Diekmann, B, G.Kuhn, R. Gersonde and A. Mackensen, 2004. Middle Eocene to early Miocene environmental changes in the sub-Antarctic Southern Ocean: evidence from biogenic and terrigenous depositional patterns at ODP Site 1090, *Global and Planetary Change, Vol. 40*, Issues 3-4., p. 295-313.

Ghosh, K. and R. Mukhopadhyay, 1995. Large Phillipsite Crystal as Ferromanganese Nodule Nucleus, *Geo-Marine Letters, Vol. 15, No.1*, p. 59-62.

Husaini, 2006. Peningkatan Pendayagunaan Zeolit Alam dan Prospeknya di Indonesia. *Pidato pengukuhan Profesor Riset Bidang Teknologi Pemrosesan Mineral,* Puslitbang Teknologi Mineral dan Batubara, Bandung.

Knox, A.S., Kaplan, D.I. Adriano, D. Hinton, C.T. and Wilson, M.D., 2003. Apatite and Phillipsite as Sequestering Agents for Metals and Radionuclides, *J. Environ. Qual.* 32, p. 515–525.

Kopp, E., R. Flueh, C.J. Petersen, W. Weinrebe, A. Wittwer and Meramex Scientists, 2006. The Java margin revisited: Evidence for subduction erosion off Java, *Earth and Planetary Science Letters, Vol. 242*, Issues 1-2, p. 130-142.