INDONESIAN MINING JOURNAL Vol. 13, No. 1, February 2010 : 34 - 38

BARIUM CONCENTRATION IN DEEP SEA SURFACE SEDIMENTS FROM TOMINI BASIN: VERTICAL DISTRIBUTION AND OCCURRENCE

DIDA KUSNIDA, P.H. WIJAYA and J. WIDODO
Marine Geological Institute of Indonesia
Jalan Dr. Djundjunan 236, Bandung-40174
e-mail: didakusnida@mgi.esdm.go.id

ABSTRACT

The concentrations of trace elements (Th, Zr, Ba, Ce, Nb and Sr) in the sediments core from Tomini Basin, Sulawesi were studied to establish their vertical distributions and occurrence. However, the highest concentration of trace elements was dominated by barium (>300 ppm). Results indicate that barium composition in the surface sediments generally increase downward. Vertical distribution of barium in Tomini Basin indicates that its sedimentary environment has a high palaeo-productivity.

Keywords: barium, trace elements, deep sea, surface sediments, Tomini Basin

INTRODUCTION

Regional deep sea marine geological survey in Tomini Basin has been executed in the framework of deep sea geological thematic mapping conducted by Marine Geological Institute of Indonesia in 2005. The study was executed using geophysical and geological instruments such as depth sonar and single beam echo sounder 10.000 m (EA500). The Tomini Basin is geologically considered less studied and relatively unknown particularly on seafloor mineralogy. The aim of this study was to inventory the trace, minor and major elements in surface sediments of the basin. To determine the vertical distribution of these trace elements, core sample GRT-05-03 was taken by the Marine Geological Institute of Indonesia at site on the sea floor of the basin at a water depth >2000 meters.

In Tomini Basin, the highest concentration of trace elements recorded in the sedimentary core was dominated by barium (>300 ppm). According to Weast (1969) and http://en.wikipedia.org/ (2010), barium is a soft silvery metallic alkaline earth metal that never found in nature in its pure form due to its reactivity with air. The most common naturally occurring minerals are the very insoluble barite ($BaSO_4$), and witherite ($BaCO_3$).

However, there are several opinions arise concerning the origin of barium in deep sea sediments. Leong (2001) and Masayasu et al (2002) have proposed that the flux of bio-barium to the seafloor may depend on dissolved barium concentrations in intermediate and deep waters which are significantly high. In contrast, Pirrung et al (2008), indicate that most of the barium in the marine surface sediments is terrigenous and not biogenic origin. For this reason, it was decided to conduct this study to synthesize the distribution and occurrence of barium in Tomini Basin with considerable interest for both scientific and academic purposes.

GEOLOGICAL BACKGROUND

The Tomini Gulf (Figure 1) is characterized by a bathymetric low of slightly below 2000 meters in Tomini Basin to the west, and a bathymetric low of a slightly below 4000 meters depth in Gorontalo Basin to the east. The Gulf of Tomini is considered to be one of the 37 sedimentary basins present in Central and Eastern Indonesia and relatively still unexplored and geologicaly is a suture basin (Dirjen Migas, 2003). To the north, the gulf is bordered by the north arm of Sulawesi and to the south is bordered by East Sulawesi Ophiolite and Old Mélange Complexes. The islands group

 Received : 01 December 2009, first revision : 31 December 2009, second revision : 03 February 2010, accepted : February 2010

of Togian characterizing the NE-SW traversed highs together with the Una-Una islands where the Colo Volcano is situated, separate the Tomini Basin from the Gorontalo Basin (Parr and Zulkarnain, 2001; Parr and Hananto, 2002).

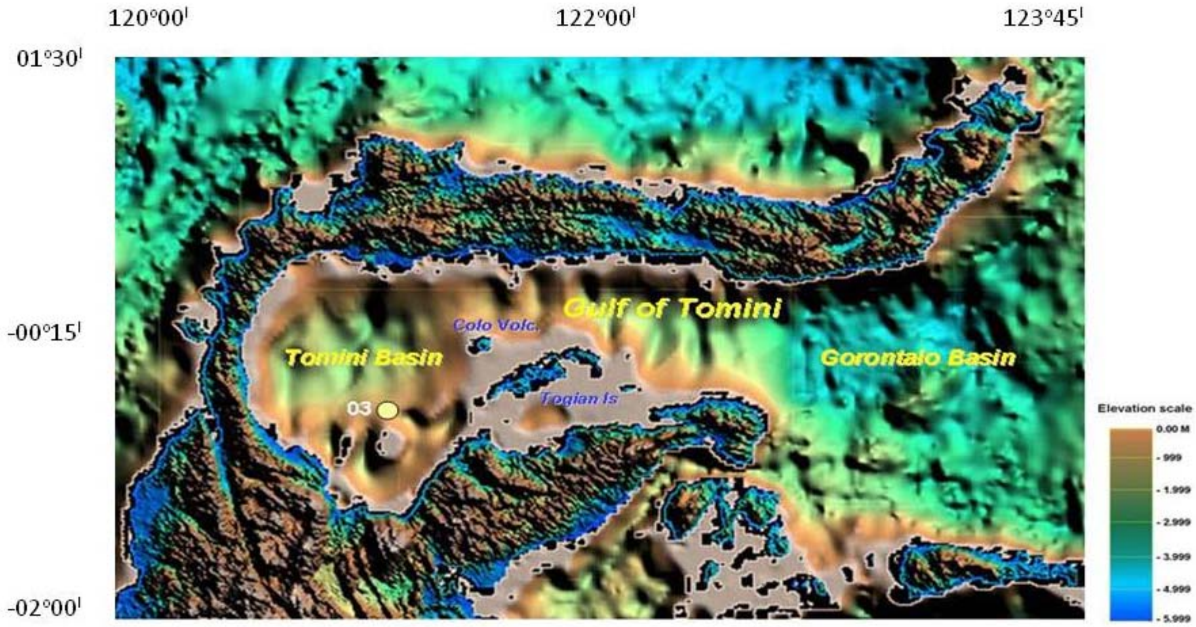

Figure 1. Map of Tomini Basin shows Core-03 location and the overall bathymetry
Map source: SRTM and DEM of NASA (2000)

According to Permana et al (2002), the present of dunite in Colo volcanic products may indicate that the magma source had through an oceanic material that possibly is part of East Sulawesi Ophiolite Complex. Kusnida et al (2009) based on their study on magnetic anomalies indicate that the Tomini Basin is underlain by oceanic-like crust (*peridotite?)* and dominated by the NE-SW direction of steep graben-like structure. These may correspond to Hinschberger et al (2005) who stated that the Tomini Basin have been formed as the result of opening and rotating of northern Sulawesi in Neogene about 3,5 Ma.

Kadarusman et al (2004) stated that the Tomini Basin was formed by block-faulting during southeastward thrusting of Eastern Arm of Sulawesi Ophiolite due to collision of Banggai-Sula microcontinent. However, in an actual condition, this basin acts as a back-arc relatively to Banggai-Sula collision and the activities of Colo Volcanic.

METHOD

Sediment sampling method was gravity corer, subsampling 1-15 corer made of PVC with diameter of 10 cm and height of 15 cm. Sampling and handling procedures for all trace elements such as Th, Zr, Ba, Nb, Ce and Sr were those used in general analytical practice using X-ray fluorescence (XRF) method. The navigation in the surveyed area was carried out by means of Global Positioning System (GPS) using EIVA A/S NAVIpac software.

RESULTS AND DISCUSSION

Seismic study (Kusnida and Subarsyah, 2008) in combination with magnetic study (Kusnida et al, 2009) revealed that Tomini Basin is filled by more than 1500 m thick, wedge-shaped body of Late Tertiary-Quaternary sediments that mostly composed by muddy sediments with variable amounts of opaque minerals and organic. The depositional pattern in the basin suggests that sediments redistribution surrounding the terranes are eroded and re-deposited as turbidites at the lower slope and as pelagic sediments at the basin floor. In this study, the data used is limited to core GRT 05–03 (Figure 2) that obtained from coordinate 000°31.699' S; 120°51.979' E at the water depth of 2013 meters. Megascopic descriptions of the core indicate that most surface sediments composed by sticky greenish-gray sandy clay with opaque minerals, micas and foraminiferous, sometimes methanous.

XRF analysis results are shown in Table 1. Barium (Ba) seems to increase from 124 ppm at the top to 320 ppm at the bottom. This trend phenomenon is followed by thorium (Th) from 14 to 45 ppm and strontium (Sr) from 37 ppm at the top to 55 ppm at the bottom. Cerium (Ce) concentration along the core seems to be constant that is less than10 ppm. In contrast, zircon (Zr) and niobium (Nb) show a different trend compared to Ba, Th and Sr. These two trace elements seem to have their maximum concentration in sub-sample GRT-05-03F and GRT-05-03H as indicated by concentration of ± 44-45 ppm. Zr has concentration of 21 ppm at the top, 46 ppm at the middle and 28 ppm at the bottom of the sample. Likewise, Nb seems to have the same trend with Zr, where it has concentration of 15 ppm at the top, 45 ppm at the middle and 30 ppm at the bottom of the core.

The conspicuous occurrence of barium in Tomini Basin (Figure 3) possibly can be explained by study of Leong (2001) which stated that barium has a good correlation with organic matter. Therefore, sedimentation of barium can possibly be controlled largely by the biogenic matter, although the detritus fraction in Tomini Basin was dominant in the sediments. Likewise, Masayasu et al (2002) explained that the authigenic barium (Ba_{ex}) correlates with gradual change in sedimentation environment during glacial ages. The Ba_{ex} may relate to calcareous organisms besides siliceous ones. Further, Masayasu et al (2002) explained that the Ba_{ex} was reduced to sulfide and dissolved away in a strongly anoxic environment during biologically productive period.

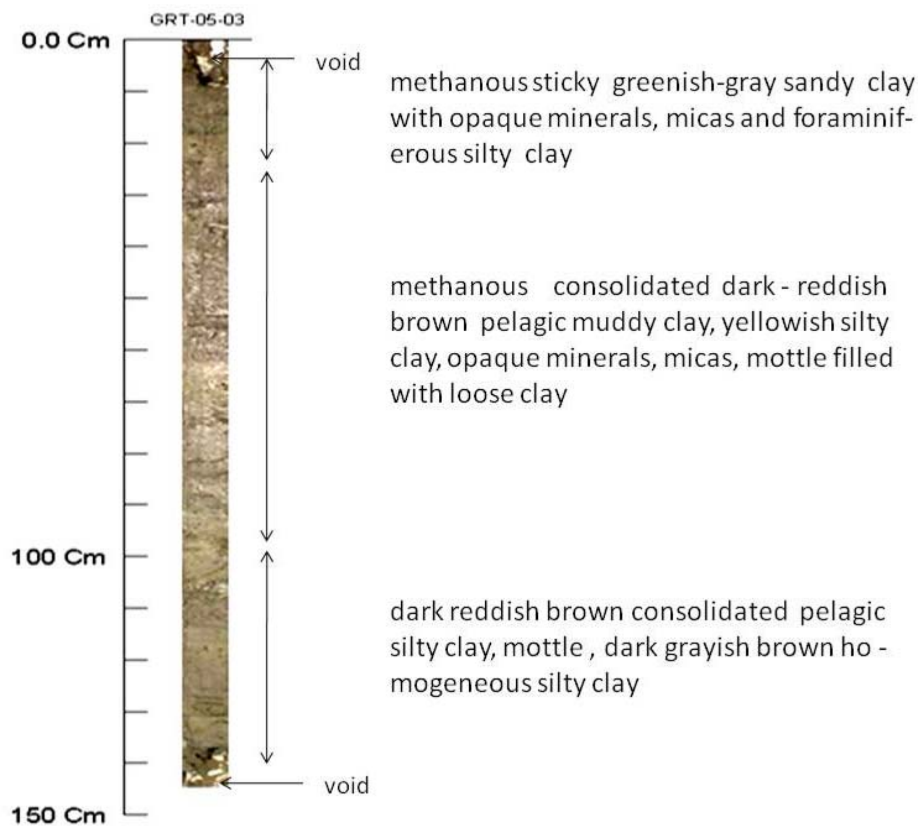

Figure 2. Core samples of GRT-05-03 used in this study

Table 1. Trace elements analysis results of sediment sample

No	Samples Code	Chemical Composition					
		Th (ppm)	Zr (ppm)	Ba (ppm)	Nb (ppm)	Ce (ppm)	Sr (ppm)
01	GRT-05-01(TOP)	14	21	124	15	< 10	37
02	GRT-05-01(BOT)	14	23	120	15	< 10	40
03	GRT-05-02(TOP)	20	32	133	17	< 10	35
04	GRT-05-02(BOT)	20	32	133	17	< 10	35
05	GRT-05-03 A	34	41	276	45	< 10	65
06	GRT-05-03 C	34	41	276	45	< 10	60
07	GRT-05-03 D	30	44	245	45	< 10	64
08	GRT-05-03 E	34	44	280	45	< 10	67
09	GRT-05-03 F	33	46	289	45	< 10	67
10	GRT-05-03 H	32	44	278	45	< 10	67
11	GRT-05-04 A	45	28	328	30	< 10	50
12	GRT-05-04 B	46	28	327	30	< 10	56
13	GRT-05-04 C	46	25	326	30	< 10	55
14	GRT-05-04 D	45	25	333	30	< 10	55
15	GRT-05-04 F	45	28	320	30	< 10	55
METHOD		XRF	XRF	XRF	XRF	XRF	XRF

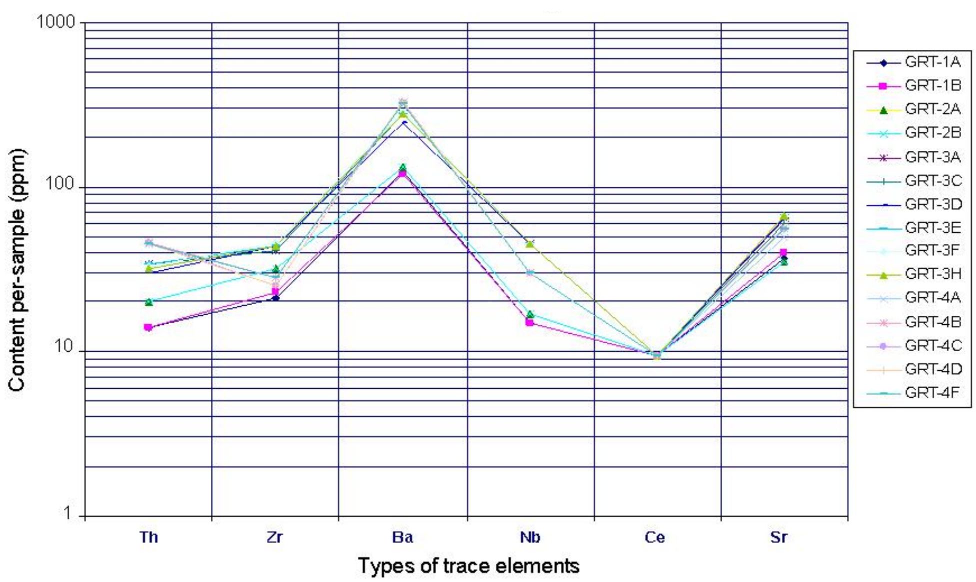

Figure 3. Content of trace elements in 15 sub-samples of GRT-05-03

Paytan et al (2007) observed the increasing of barite burial at continental margin and shelf of Peru and indicate the occurrence of suboxic conditions, leading to Ba release into the water column. These authors also stated that sediments from the Peru shelf are lack of any barium enrichment, but this element is significantly enriched in slope and basinal deposits in water columns deeper than 2000 m. If this nature seems to be compatible with Tomini Basin, then the barium distribution in sedimentary oxic and suboxic environments at deep water depositional sites in Tomini Basin can also probably has a high potential as a palaeoproductivity indicator.

The occurrence and vertical distribution of barium in surface sediments in Tomini Basin can be explained by considering of two opposite opinions related to the origin and formation of barium as represented by Masayasu et al (2002) and Pirrung et al (2008). The downward increase of barium concentration in Tomini Basin suggests that the particulate barium uptake and flux is enhanced by higher barium concentration in the deep waters of the Tomini Basin. According to Masayasu et al (2002), barium fluxes indicate a relationship between upper ocean biological processes and barium flux to the seafloor; hence the ratio of organic carbon to barium decreases systematically with water depth. Consequently**,** the systematic upward decrease of barium with decreasing core depth in Tomini Basin can possibly synthesized as the results of simultaneous decomposition of organic matter and uptake of barium in settling particles.

CONCLUSION

Within all sub-samples of Core GRT-05-03 were found opaque minerals and micas possibly originated from metamorphic rocks (gneiss and schist). The general trace elements occurrence also indicates that sediments were mostly originated from the eastern and the southern terranes that are composed mainly by ophiolite rocks. Barium concentration in deep-sea sediments in Tomini Basin might be expected in areas of high paleoproductivity and associated high barium.

ACKNOWLEDGEMENTS

This study has been conducted with the financial support the Marine Geological Institute of Indonesia. The authors wish to thanks the Director of Marine Geological Institute, Ir. Subaktian Lubis M.Sc. for allowing working on the material and using the data. Thanks also directed to the scientific team who involved during deep sea sediment sampling, especially Ir. Nur Adi Kristanto, M.T.

REFERENCES

Dirjen Migas, 2003. Kebijakan dan Program Subsektor Migas dalam Mempercepat Pembangunan Kawasan Timur Indonesia. *Forum Litbang ESDM*. Jakarta.

http://en.wikipedia.org/wiki/Barium : January 4th, 2010, 07.58 a.m.

Hinschberger, F., Malod, J.A., Rehault, J.P., Villeneuve, M., Royer, J.Y. and Burhanuddin, S., 2005. Late Cenozoic geodynamic evolution of eastern Indonesia, *Tectonophysics*, Vol. 404, pp. 91-118.

Kadarusman, A., Miyashita, S., Maruyama, S., Parkinson, C.D., Ishikawa, A., 2004. Petrology, geochemistry and paleogeographic reconstruction of the East Sulawesi ophiolite, Indonesia. *Tectonophysics. Vol.392*, p. 55-83.

Kusnida, D. and Subarsyah, 2008. Deep Sea Sediment Gravity Flow Deposits in Gulf of Tomini, Central Indonesia, *Indonesian Journal of Geology, Vol.3, No.4*.

Kusnida, D., Subarsyah and B. Nirwana, 2009. Basement Configuration of Tomini Basin Deduced from Marine Magnetic Interpretation, *Indonesian Journal of Geology, Vol.4, No. 4*.

Leong, H. F., 2001. Geochemical proxy for mangrove forest of Pulau Sekeping, Kemaman. *Final year report*, Bachelor Science (Marine Science), Faculty of Applied Science and Technology, Universiti Putra Malaysia Terengganu. 7l p.

Masayasu M. Sato, Hisashi Narita and Shizuo Tsunogai, 2002. Barium Increasing Prior to Opal during the Last Termination of Glacial Ages in the Okhotsk Sea Sediments, *Journal of Oceanography*, *Vol. 58, No.3*, p.461-467.

Parr, J. and Hananto, N.D. (ed), 2002. IASSHA 2001 CRUISE REPORT Baruna Jaya VIII, 1st - 15th June 2001, Vol.2: Leg A Tomini – Gorontalo Basins. *CSIRO Exploration and Mining Report 983F*.

Parr, J and Zulkarnain, I. (ed), 2001. *IASSHA 2001 CRUISE REPORT Baruna Jaya VIII 16th - 30th June 2001*.

Paytan, A., Averyt, K., Faul, K., Gray, E. and Thomas, E., 2007. Barite accumulation, ocean productivity, and Sr/Ba in barite across the Paleocene–Eocene Thermal Maximum, *Geology, v. 35, no. 12*, p. 1139-1142.

Permana, H., Hananto, D.H., Gaol K.L., Utomo, E.P., Burhanuddin, S., Hidayat, S., Triarso, E., Pratomo, I., Helfinalis , Binns, R., Parr, J. 2002. Abstract. IASSHA Cruise 2001 result (Leg A): tectonic of Tomini-Gorontalo basin. Inferred from new petrological and geophysical data. *PIT IAGI*, Surabaya.

Pirrung, M., Illnerand, P. and J. Matthiessen, 2008. Biogenic Barium in surface sediments of the European Nordic Seas , *Marine Geology*, *Vol. 250, Issues 1-2, 21*, p. 89-103.

Weast, R.C., 1969. *Handbook of Chemistry and Physics*, 50th Eds., the Chemical Rubber Co., Cleveland, Ohio.