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Development of Precise Radiation Mapping of Sedimentary Cores Using Imaging Plate

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Abstract. The marine sedimentary cores were measured by using imaging plate (IP), which is a 2-D radiation detector and has high-resolution, high-sensitivity and detectability of several type of radiation. The same cores were measured by two different devices to evaluate the measuring ability of IP, one is Natural Gamma Logger (NGL), which is a radiation detector in practical use, and another one is X-ray CT Scanner, whose unique value "CT Value" is considered to be proportional to density. Although characteristic dose distributions were found in the organism layer and the volcanic ash layer by using IP, they were not observed by NGL result. It means IP have enough resolution and sensitivity to comprehend the distribution of substances in the marine sediment. The dose distributions measured by using IP and CT Values showed good correlations. Taken into consideration the fact that CT Value is proportional to density, it could be said that doses tend to depend density in marine sediments. The high-dose point was found by using IP, but it was not observed by the results of NGL and X-ray CT scanner. It implies that IP could be a new nondestructive device to discover the target point.

Keywords: Natural radioactivity, Radiation image, Imaging plate, Marine sediment
PACS: 93.85.Np

INTRODUCTION

Imaging plate (IP) is a 2-D radiation-imaging sensor using the photo-luminescence phenomenon, which has excellent performance for radiation detection, and its advantages include the ease of use, a high position resolution, a large detection area, a high detection sensitivity with high signal-to-noise ratio, extended time dose accumulation, dose linearity, an extremely wide dynamic range of dose, and an erasing capability for reuse [1,2].

Imaging Plate was tried to apply to measuring the surface of rocks [3-5] and Radon emitted from rocks [6-8] before now.

Suppose marine sediments are measured by using IP, a lot of environmental information will be obtained in nondestructive because IP can get precise and wide-range dose distribution of the sedimentary structure. Information of precise sedimentary structure allows us to estimate past events in detail. However, the estimation method of the dose distribution of sediments using IP is not established and furthermore the measuring method of sediments using IP is not discussed yet. In this study, basic matters of the application of radiation-imaging using IP to marine sediments are argued.

EXPERIMENTAL

In order to evaluate the performance of Imaging Plate (IP), two types of marine sediments were measured by using IP and Natural Gamma Logger (NGL), and in order to comprehend the relationship between radiation measured by IP and physicality, they were also measured by using X-ray CT Scanner.

Imaging Plate (IP)

IP is a storage film coated with photostimulated phosphor (BaFBr: Eu2+), and currently and widely used in various fields [9-11]. The latent images produced by superficial scanning with stimulation light and are reconstructed as two-dimensional dot images on a computer display [12].

Figure 1 shows the experimental configuration of IP and marine sedimentary core. Whole round marine sedimentary cores were divided into two half for duplicate and they were covered with a plastic wrap. IP (BAS-MS2040 Fujifilm Co. Ltd., 20×40 cm^2) was cut into rectangular five pieces (4×40 cm^2), and they were put along the center line of plane side of half

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round of sedimentary cores. The exposure was for 48 hours in a shield box, where the temperature is 2 °C and the moisture is 80 %. The latent images produced by irradiation of the IP were read out by using the BAS-2500 imaging analyzer (Fujifilm Co. Ltd.). Radiation dose of IP is output as PSL value, that is unique dose units and quantities of IP system. Position resolution was set to 50 μm.

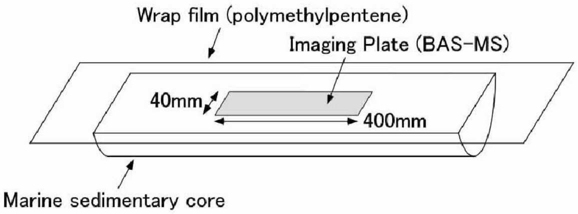

FIGURE 1. The experimental location of IP and the sedimentary core for exposuring.

Natural Gamma Logger (NGL)

Natural Gamma Logger (NGL, GEOTEK Co. Ltd.) is a gamma-ray detecting device of sedimentary cores currently in practical use. The sensor itself comprises at least two 3"×3" NaI detectors housed in 6" diameter lead shields. A detector comprises a NaI crystal optically coupled to a photomultiplier tube and connected to a bias base that supplies the high voltage power and a signal pre-amplifier.

The positional resolution is set to 4cm and measuring time of each point for detecting gamma ray is set to 2 minutes.

X-ray CT Scanner

X-ray CT Scanner (Hitachi Medical Corporation) is used for comprehending the distribution of physicality of sedimentary cores and CT Value, which is a unique unit of X-ray CT Scanner system, is used for estimating density. CT Value is shown as (a). k is a constant and μ is X-ray attenuation coefficient of measuring object, and μ_{H2O} is X-ray attenuation coefficient of H_2O.

$$CTValue = k \cdot \frac{\mu - \mu_{H_2O}}{\mu_{H_2O}} \qquad (a)$$

From this formula it can be said that CT Value is proportional to μ. Taken in consideration the fact that μ is proportional to the density, it can be said that CT Value proportional to the density.

In this study, marine sedimentary cores were scanned using X-ray CT Scanner by 2 mm intervals. The averages of CT Values whose region of interests are under the setting area of IP are used to compare with the radiation distribution of IP (Fig. 2).

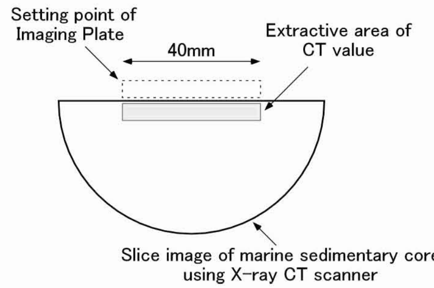

FIGURE 2. The slice image of X-ray CT scanner for the sedimentary core and the region of interest of CT Value.

RESULTS

Figures 3 and 4 shows the result of measurement to marine sediments by IP, NGL and X-ray CT Scanner. From the left side, a high-contrasted core scanner image of a sedimentary core, a 2-D dose distribution image using IP, a graph that the sums of doses in the horizontal direction of 2-D dose distribution image are set to abscissa axis, a graph that gamma counts by second using NGL is set to abscissa axis, and a graph that the averages of CT Value of scanning area shown at Fig. 2 are set to abscissa axis are shown. Vertical axis of each graph corresponds to the core scanner image.

In Fig. 3 and Fig. 4, there are dark and bright layers in the core scanner images. The dark layers in Fig. 3 and Fig. 4 are considered to contain high concentration of organic matters, and on the other hand the bright layers contain low one. In Fig. 4, volcanic ashes accumulate at 290-330 mm.

TABLE 1. Comparison between IP and NGL about Principle, Dimension, Positional Resolution and Radiation Type.

	Imaging Plate	Natural Gamma Logger
Principle	Photo Luminescence	NaI Scintillation
Dimension	2	1
Positional Resolution	25～200 μm	Several cm
Radiation Type	Several Type	Gamma Ray

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About the IP radiation image in Fig. 3, a spot of high radiation is observed at the left side of 245mm.

About the dose distribution graph using IP, peaks with high doses are found at 30-60 mm, 100-120 mm, and 330-340 mm in Fig. 3. In Fig. 4, peaks of very high doses are found at 260-280 mm and 290-330 mm in the dose graph of IP.

About the gamma count graph using NGL, an increasing tendency of dose is found at 0-100 mm and in the underside of it about the same amounts of gamma counts are found in Fig. 3. In Fig. 4, about the same amounts of gamma counts are wholly observed.

About the CT Value distribution graph using X-ray CT Value, peaks with high doses are found at 30-60 mm, 100-120 mm, and 330-340 mm in Fig. 3. In Fig. 4, peaks of very high doses are found at 210-220 mm, 260-280 mm and 290-330 mm in the dose graph of IP.

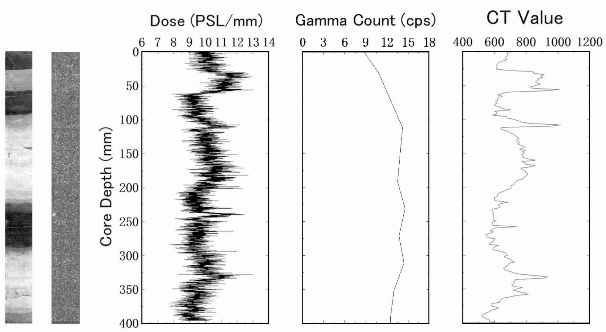

FIGURE 3. The core scanner image, 2-D radiation image of IP, the dose distribution graph of IP, the gamma count graph of NGL and CT Value graph of X-ray CT scanner.

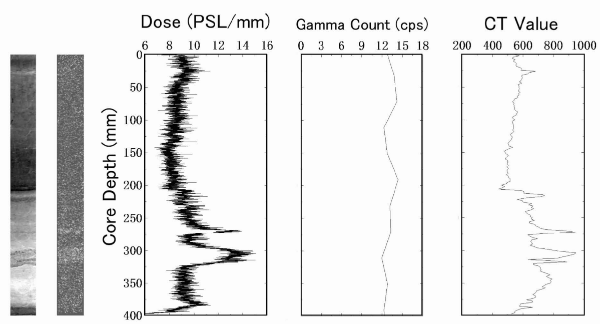

FIGURE 4. The core scanner image, 2-D radiation image of IP, the dose distribution graph of IP, the gamma count graph of NGL and CT Value graph of X-ray CT scanner.

DISCUSSION

In Fig. 3 and Fig. 4, lower doses are found in dark layers than bright ones. It is considered that the concentration of organic matters that have lower radioactivity than other sedimentary contents may dilute the concentration of radioactive substances in the sediment.

In Fig. 4, high doses are found at volcanic ash layer. It is considered that minerals that have high radioactivity such as K-feldspar that has potassium concentrate thickly in the high-peak layers. From this fact, it may be said that volcanic ashes have high radioactivity among the contents of marine sediments. Although according to the core scanner image conspicuous changes like at 290-330 mm are not found at 260-280 mm, it could also be said that volcanic ashes exist at 260-280 mm, because the same degree of dose is found at 260-280 mm compared with 290-330 mm.

In Fig. 3 and Fig. 4, dose distributions measured by using IP show good respondences with sedimentary layers scanned by using a core scanner, for example especially at 0-100 mm in Fig. 3 and 290-340 mm in Fig. 4. On the other hand, any respondence is not found at the same place according to a graph of gamma count measured by NGL. It can be said that by using IP it is possible to detect the dose distribution accurately that reflects the contents in sediments, in contrast the dose distribution obtained by using NGL that is in practical use don't reflect enough.

High similarities are found between distribution of dose using IP and CT Value using X-ray CT scanner in both Fig. 3 and Fig. 4. In order to compare in numerical value about dose and CT Value, Fig. 5 and Fig. 6 are prepared. The vertical axis shows dose obtained by using IP and abscissa axis shows CT Value. The each plot shows dose and CT Value at the same core depth. In order to find coefficient of correlation, linearization using least squares method is applied and it shows high values, 0.777 in Fig. 5 and 0.800 in Fig. 6. Taken in consideration the dependence of CT Value on density, it may be said that dose measured by using IP have high correlation with density. This means there is a possibility that doses are affected by densities of sedimentary cores and the accurate distribution of densities are comprehended by using IP.

A spot of high dose is found at the left side of 245 mm in the radiation image of IP in Fig. 3. But any thing conspicuous is not found in core scanner image, distribution of gamma count and distribution of CT Value. It implies that something that has high radioactivity and not-high density exist there. But it would not become clear by using NGL and X-ray CT scanner. It could be said that IP made it possible to discover the new target point in sedimentary core. From this fact, it might be said that IP could be a new nondestructive device to discover the new target point.

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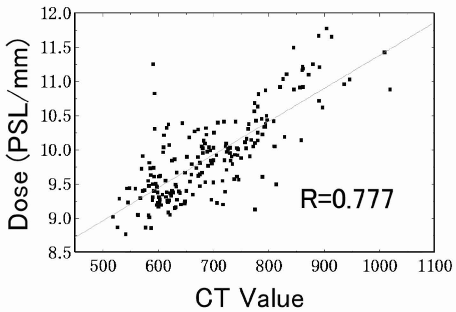

FIGURE 5. Comparison of dose and CT Value, each point shows dose and CT Value at the same core depth.

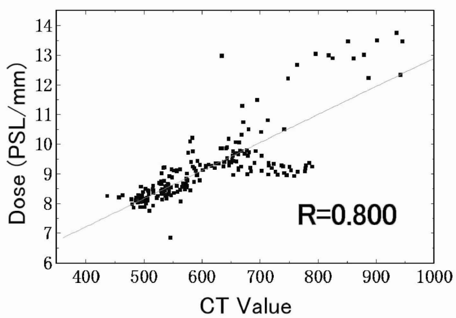

FIGURE 6. Comparison of dose and CT Value, each point shows dose and CT Value at the same core depth.

CONCLUSION

- Low doses are found at the layer of high organic concentration and high doses are detected at volcanic layer using Imaging Plate (IP). They are not discovered using Natural Gamma Logger (NGL), which is the dose-distribution-detecting device in practical use.
- High correlations between doses measured by IP and CT Values that are considered to be proportional to density are found. It could be said that doses measured by IP depend on density.
- High dose spot is observed in the radiation image of IP, and it is not found in the result of NGL and X-ray CT scanner. IP could be a new nondestructive device to discover and narrow the target point.

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REFERENCES

1. K. Kohda and J. Miyahara, *RADIOISOTOPES* **41**, 35-40 (1992).
2. M. Takebe, K. Abe, M. Souda, Y. Satoh and Y. Kondo, *Nucl. Inst. Meth.* **A 359**, 625-627 (1995a).
3. M. Hareyama, N. Tsuchiya and M. Takebe, *Proc. 9th Int. Sympo. Water-Rock Inter.*, 835-838 (1998).
4. N. Tsuchiya, M. Hareyama and M. Takebe, *KEK-Proc.* **98-4**, 313-322 (1998).
5. M. Hareyama, N. Tsuchiya, M. Takebe, and T. Chida, *Geochem. J.* **34**, 1-9 (2000).
6. K. Ishii, N. Tsuchiya, M. Takebe, *RADIOISOTOPES* **48**, 441-449 (1999).
7. T. Hatsukari and N. Tsuchiya, *Non-Destructive Testing in Civil Engineering 2000, Elsevier,* 435-442 (2000).
8. C. Shiro, N. Tsuchiya, M. Takebe, *Shigen-to-Sozai* **116**, 497-501 (1999).
9. K. Takahashi, *Ionizing Radiation* **14**, 80-89 (1987).
10. Y. Amemiya, T. Matsuxhita, A. Nakagawa, Y. Satow, J. Miyahara and J. Chikawa, *Nucl. Inst. Meth.* **A266**, 645-653 (1988).
11. C. Mori, *Ionizing Radiation* ***20***, 13-20 (1994).
12. M. Takebe, K. Abe, M. Souda, Y. Satoh and Y. Kondo, *Nucl. Inst. Meth.* **A 363**, 614-615 (1995b).

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