Sediment supply and transport pass inferred from magnetic susceptibility of submarine fan deposits of the Kazusa Group

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Abstract

Field study using magnetic susceptibility instrument enables to detect deposit properties of the lower Pleistocene Otadai Formations of the Kazusa Group in Boso Peninsula, central Japan, that is, time series variation and regional variation of submarine fan deposits in relation to sea-level change. Oxygen isotope stages of the Otadai Formation of submarine fan have been determined in detail by Tsuji et al. (2005).

In upper submarine fan, maximum magnetic susceptibility of sandstones is almost ten times higher in lowstand interval than highstand intervals. Maximum magnetic susceptibility of turbidite sands is poorly controlled by grain size. In addition, turbidute sands are thick and more frequent during lowstand stages. Such a trend is also observed in the JNOC TR-3 drill site at 5km east. There is little sandstone layer in western slope facies. It is, therefore, thought that the sediment properties are different between lowstand and highstand stages. Magnetic susceptibility of mudstones is higher in the lowstand intervals than in highstand intervals. Although there is no distinct difference in grain size (sand content) between them, magnetic susceptibility of mudstones of submarine fan is higher than that of shelf and slope in the lowstand stages. This evidence suggests magnetite–rich source material for submarine fan during lowstand stages.

At that time of 1 Ma, submarine fan reflected change in sediments source and transport path from land areas corresponding to a minor change in sea-level at most 90m, and showed a remarkable variation in magnetic susceptibility of sediments. Such eustatic change thus can be detected by magnetic susceptibility of submarine fan deposits other than shallow marine or marine biogenic evidence.

Keywords: magnetic susceptibility, turbidite, sea-level change

1. Introduction

Modeling distributed of turbidite sands out of which a reservoir of petroleum and a methane hydrate is formed occupies the important location in resource-searching. Submarine fan has been studied by seismic prospecting, chemical analysis, and isotopic measurement with a main method. But it took for time and the expenses before these methods got a result, and the individual variation was also big in a judgement of a result.

This study used magnetic susceptibility for the purpose of efficiency, quantification and labor-saving. The susceptibility of the submarine fan deposits shows the content of the magnetite and shows the aspect of the mineral composition. Magnetic susceptibility meter enables to measure directly at the site.

In the present study, we derive correlativity between maximum magnetic susceptibility of sandstones and glacio-eustatic sea-level change. We then deduce sediment supply and transport pass of submarine fan deposits of the Kazusa Group. Examples discussed in this paper are the Lower Pleistocene Otadai Formation in the Boso Peninsula, Japan (Fig. 1)

2. Geologic setting

The Otadai Formations constitute the lower part of the Kazusa Group (Fig1). The group is up to 3000-m thick and represents the infill of the Pliocene Pleistocene Kazusa forearc basin.

The Otadai Formation is up to 540-m thick and includes a great number of sandstone beds and hemipelagic siltstone beds. The Otadai Formation consists of interbedded some volcanic ash beds (such as O26 , O18 and O7) which are found in large region (Ito and Katsura, 1992).

Oxygen isotope stages of the Otadai Formation of submarine fan have been determined in detail by Tsuji et al. (2005).

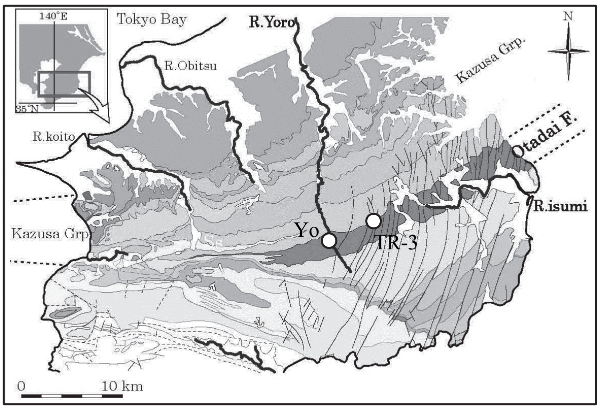

Fig. 1 Geological sketch map of the central part of the Boso Peninsula.

Modified from Ito (1998). Yo-Section shows study area. TR-3 shows bowling site (Tsuji et al., 2005)

3. Method

Magnetic susceptibility was measured at the outdoors using magnetic susceptibility meter (WSL-B made by Tanaka geological consultant). Since putting it in the magnetic measurement, we formed an outcrop face and made the magnetic susceptibility meter body stick to an outcrop perpendicularly. We measured the magnetic susceptibility of most beds in the study area. Highest magnetic susceptibility in vertical direction in sandstone layer is called maximum magnetic susceptibility in this paper.

4. Result

The following 4 points became clear as a result of the study.

4.1 The susceptibility (the content of the magnetic mineral) becomes higher in lowstand interval than highstand intervals

Fig.2 draws up a chronology of maximum magnetic susceptibility of sandstones. Maximum magnetic susceptibility of sandstones shows the maximum of the vertical direction in sandstone bed. Axis of ordinate shows total sum of siltstone bed thickness in study area. The study area is comparable to marine isotope stage 29 to 33 (Tsuji et al., 2005). The susceptibility becomes higher in lowstand interval than highstand intervals. Maximum magnetic susceptibility of sandstones is almost ten times higher in lowstand interval than highstand intervals.

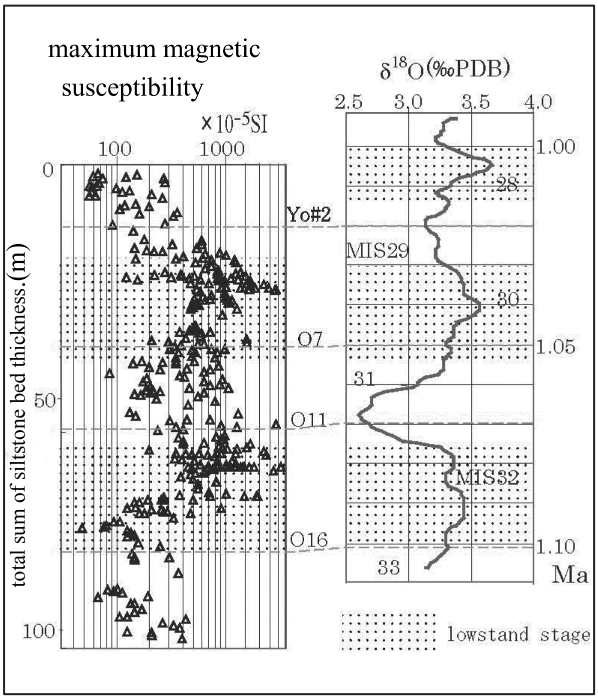

Fig. 2 Maximum magnetic susceptibility and sea-level change.

Oxygen isotope curve of Tsuji et al. (2005). Stratigraphic positions of some volcanic ash beds are indicated on the right side of the oxygen isotope curve.

4.2 Maximum magnetic susceptibility is poorly controlled by grain size

A relation between magnetic susceptibility variation in vertical direction in sandstone layer and sedimentary structure can be classified into 3 types.

a) Graded bedding
   Magnetic susceptibility is most high at the bottom mostly, and the upper part is low.
b) Massive
   Whether magnetic susceptibility is almost fixed, the upper part is low.
c) Thickened very fine sand in layer
   Magnetic susceptibility is highest at the thickened very fine sand.

Most of the magnetic susceptibility variation in vertical direction in sandstone layer is highest at the bottom or the thickened very fine sand. But, maximum magnetic susceptibility is unrestricted in sedimentary structure. The maximum magnetic susceptibility also becomes different respectively at the same type of sandstone bed. The maximum susceptibility becomes high in lowstand interval at every type of sandstone bed.

4.3 Periodic sand rich alternate layer appears only in submarine fan deposit

Submarine fan facies are compared with shelf and slope. Stratigraphic positions of some volcanic ash beds are indicated on the oxygen isotope curve.

Shelf facies are affected at bioturbation. Sandstone bed accumulate only a little in slope facies.

Sand rich alternate layers and silt rich alternate layers are repeated in submarine fan. Sand rich alternate layers grow in lowstand stages. Silt rich alternate layers grow in highstand stages. Submarine fan facies show a variation which corresponds to sea-level change.

4.4 Turbidute is frequently transported to submarine fan in lowstand stages

Thickness of sandstone bed and number of sandstone bed per 1 meter of siltstone are compared (Fig.3). Turbidute sands are more than 3 times thicker in lowstand interval than highstand intervals. Number of turbidute sand bed is almost 2.5 times in lowstand interval than highstand intervals. When deposition rate of siltstone was fixed, amount of turbidute sand is increase and grow in frequency. Turbidute sand is frequently transported to submarine fan in lowstand stages.

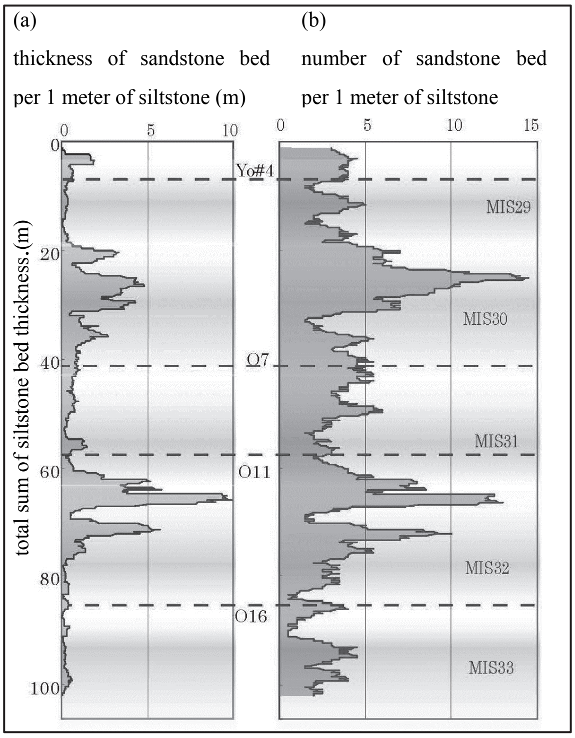

Fig. 3 Amount of sandstone.

Fig. 3(a) shows thickness of sandstone bed per 1 meter of siltstone. Fig. 3(b) shows number of sandstone bed per 1 meter of siltstone.

5. Consideration

In upper submarine fan, maximum magnetic susceptibility of sandstones is higher in lowstand interval than highstand intervals. Maximum magnetic susceptibility of turbidite sands is poorly controlled by grain size. The maximum susceptibility becomes high in lowstand interval. Sandstone bed accumulate only a little in slope. It is suggested that there was a submarine valley. Sediment supply was directly transported by way of submarine valley to submarine fan in lowstand stages. In addition, turbidute sands are thick and more frequent during lowstand stages.

On the other hand, depositional facies in shelf and slope do not show a variation which corresponds to sea-level change. Turbidute sands accumulate only a little. Sediment supply of submarine fan deposits is different from sediment supply of shelf and slope. It is suggested that sediment supply of submarine fan deposits is transported to submarine fan through a submarine valley every time.

There are generally few heavy minerals including magnetite in river sand at the offshore more than a foreshore much. Therefore while a little sand of magnetite of shallow sea was supplied in highstand stages, a possibility that sand rich in magnetite in land was supplied is considered in lowstand stages. Shelf and slope Deposits were supplied by a current and a storm to a submarine valley in highstand stages. In lowstand stages, river sand has been supplied to a submarine valley directly for approach (or directly-connected) with an estuary and a submarine valley by emergent of river plain and delta or bed slope steeply-inclined.

At that time of 1 Ma, submarine fan reflected change in sediments source and transport path from land areas corresponding to a minor change in sea-level at most 90m, and showed a remarkable variation in magnetic susceptibility of sediments. Such eustatic change thus can be detected by magnetic susceptibility of submarine fan deposits other than shallow marine or marine biogenic evidence.

6. Conclusions

This study is discussed sediment supply and transport pass inferred from magnetic susceptibility.

Magnetic susceptibility is easy at the outdoors using magnetic susceptibility meter and, can measure quickly, and is available as a numerical data.

Magnetic susceptibility becomes high in lowstand interval. Maximum magnetic susceptibility is poorly controlled by grain size.

Magnetic susceptibility shows a possibility that it can fit as an index of sea-level change and a climate change.

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