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Deep-sea sedimentation controlled by sea-level rise during the last deglaciation, an example from the Kumano Trough, Japan

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ABSTRACT

An approach combining interpretation of seismic reflection data with analysis of core lithology, especially analysis of the depositional ages of turbidites, showed that depositional patterns in the deep-sea basin of the eastern Kumano Trough, which is a forearc basin along an active convergent plate margin, were different during sea-level lowstand, slow transgressive, rapid transgressive, and highstand stages. During the lowstand and early transgressive stages, turbidites were deposited on the deep-sea basin floor where they formed a submarine fan composed of terrigenous sediments supplied by rivers via a submarine canyon. Subsequent coastline retreat and bay development during the rapid transgression stage caused a decrease in the amount of coarse-grained terrigenous sediments reaching the basin floor. However, turbidites were still deposited within the submarine canyon during the rapid transgressive and highstand stages. These deposits contain shelf sediments that have been reworked by tidal currents and storms, and sediments from slope failures caused by submarine earthquakes, but they do not contain the terrigenous sediments that are characteristic of the turbidites of the lowstand and slow transgression stages.

1. Introduction

Sea-level changes associated with global climate change affect not only coastal environments and landforms, but also the processes by which sediments are transported and deposited on the deep-sea floor. Simple depositional models developed for passive continental margins suggest that turbidite deposition via submarine canyons ceases when sea level rises (e.g. Shanmugam and Moiola, 1982; Vail, 1987; Posamentier et al., 1988). This phenomenon has been recognized in the Amazon deep-sea fan, the Bengal fan, and at other passive and active margins, from analyses of seismic data and the lithological, geochemical, and physical properties of sediments (e.g. Schlünz et al., 1999; Orpin, 2004; Kessarkar et al., 2005; Wien et al., 2006). However, other studies have suggested that the frequency and distribution of turbidites cannot be clearly related to sea-level changes, but may be subject to other controlling factors. These include climatic changes in the source area on land (e.g. Zühlsdorff et al., 2007), autocyclic sediment supply (e.g. Nakajima et al., 1998; Prins et al., 2000; Garziglia et al., 2008), and seismic activity (e.g. Lebreiro et al., 1997).

Variations of depositional patterns in response to sea-level change depend on the characteristics of the local geological setting, such as topography and bathymetry. Large volumes of terrigenous sediment flow into the sea at active plate margins, especially in east Asia (Milliman and Syvitski, 1992). To understand the relationship between sea-level change and deep-sea sedimentation at an active plate margin, we need to understand the origin of the terrigenous clastic sediments that are transported and deposited in the deep sea.

In this study of an active convergent plate margin off Honshu island, Japan, we investigated deep-sea turbidite deposition during the late Pleistocene and Holocene. This period provides good data to investigate sea-floor depositional processes because consideration of the transport routes of clastic sediments can be based on present-day topography and bathymetry. The purpose of this study was to elucidate the relationships among deep-sea sedimentation, coastal environmental change, and relative sea-level rise. Previous studies have reported the deposition of turbidites in deep-sea basins around active plate margins during sea-level highstand (e.g. Weber et al., 1997, 2003; Mullenbach et al., 2004; Kessarkar et al., 2005; Orpin et al., 2006; Blumberg et al., 2008). We also examined the differences of the origins of the turbidites at these active margin basins with those of our study area. To achieve this aim, we analyzed the frequency of deposition of turbidites from sediment cores and deep-sea seismic profiles.

2. Regional setting

Our study area is in the Kumano Trough, which lies off the Kii and Atsumi peninsulas of central Japan (Fig. 1). The Kumano Trough is a

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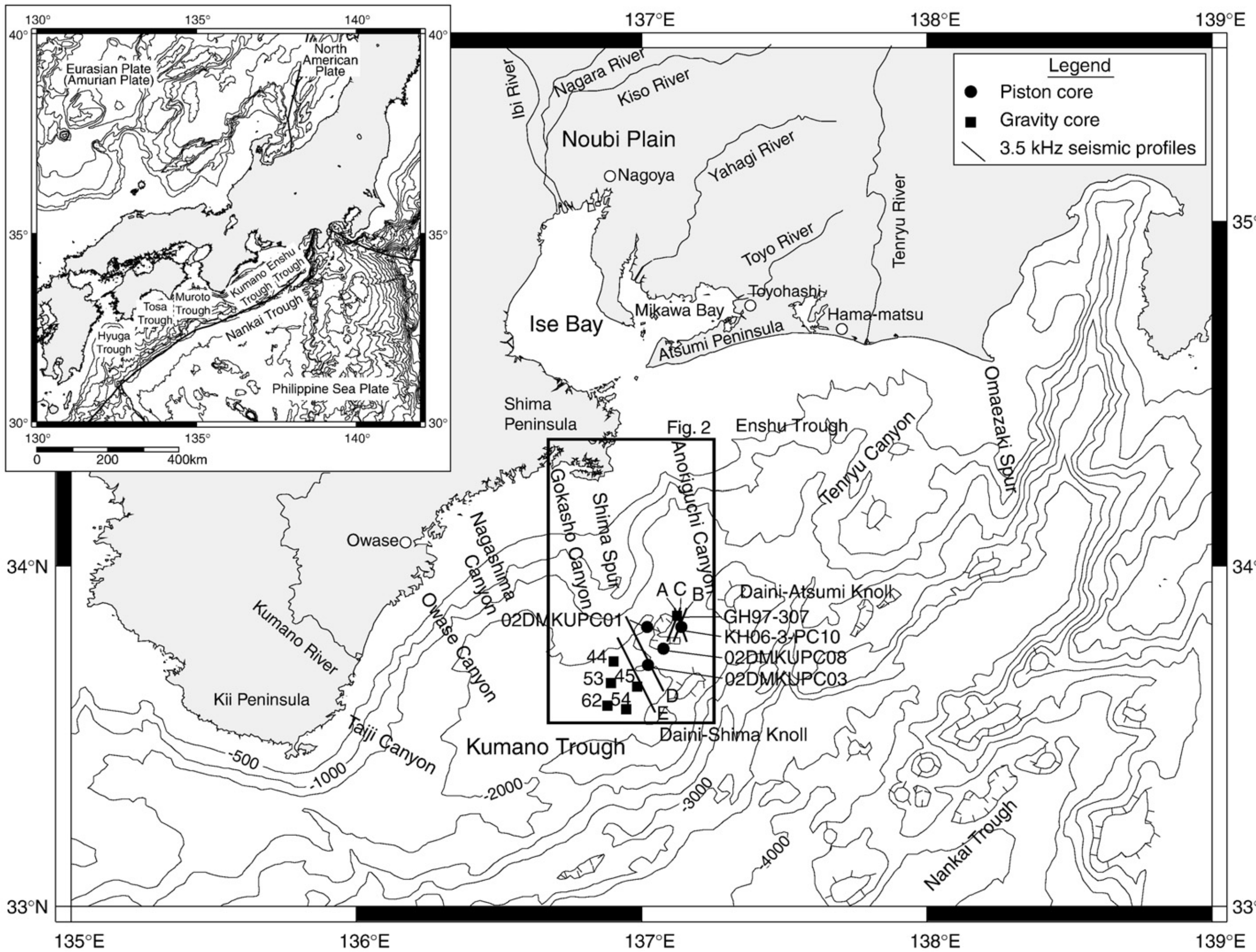

Fig. 1. Bathymetric maps showing the regional setting of the Kumano Trough (inset map) and the locations of cores and seismic profiles used in this study. Bathymetric contours are in meters.

forearc basin along the Nankai Trough, which has been formed by subduction of the Philippine Sea Plate beneath the Eurasian Plate (Fig. 1). The Kumano Trough has a wide basin floor at around 2000 m water depth below a steep continental slope and narrow shelf that is less than 10 km wide. The shelf edge is at about 150 m water depth (Fig. 2). Submarine canyons cut through the continental slope, but do not cut the shelf, with the exception of the Anoriguchi, Owase, and Taiji canyons (Figs. 1 and 2). The seaward boundary of the trough is marked by the Daini-Atsumi and Daini-Shima Knolls, which are respectively east and south of the Kumano Trough. No large rivers flow directly into the basin other than the Kumano River, which rises in the Kii Mountains (Fig. 1). Previous investigations (Arita and Kinoshita, 1988; Caddah et al., 1991; Ikehara et al., 1999) revealed that fine and very fine sands are distributed on the shelf and upper slope, and that they become finer toward the lower slope and basin floor. Silt is the main material deposited on the present-day basin floor. On the basis of numerous sediment core analyses, Arita and Kinoshita (1988) suggested that sandy sediments were transported via submarine canyons on the northern and western slopes to the basin floor, where they formed submarine fans.

This study concentrates on the eastern part of the Kumano Trough in an area close to and south of the Anoriguchi Canyon (Fig. 1). Three rivers (the Ibi, Nagara, and Kiso rivers) flow across the Nobi Plain into Ise Bay to form a present-day bay-head delta north of the Anoriguchi Canyon (Fig. 1). Omura and Ikehara (2006) considered that the frequency of turbidites and the composition of organic matter in submarine fan sediments in the trough suggest that the Anoriguchi Canyon was connected to a river mouth during the lowstand and early transgressive stages of the last deglaciation.

3. Materials and methods

3.1. Seismic reflection profiles

Five seismic reflection profiles used in this study were recorded using a 3.5 kHz sub-bottom profiler near the mouth of Anoriguchi Canyon (Figs. 1–4). Lines A, B, and C (Fig. 3) were recorded in the mouth of Anoriguchi Canyon during cruise KH06-3 of R/V *Hakuho-maru*. Line A crosses the canyon axis and lines B and C are approximately parallel to it (Fig. 2). Line B is close to the axis of the canyon. Lines D and E (Figs. 1, 2, and 4) were recorded across the submarine fan during cruise GH82-2 of R/V *Hakurei-maru* and are approximately perpendicular to the axis of the submarine fan.

3.2. Sediment cores

Details of sediment cores from the eastern part of Kumano Trough that we used in our analyses are provided in Figs 1 to 4 and Table 1. Cores GH97-307 and KH06-3-PC10 were acquired near the mouth of Anoriguchi Canyon. Cores 02DMKUPC03 and 02DMKUPC08 are from the central part of the submarine fan off the mouth of Anoriguchi