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Diatoms, silicoflagellates, and ebridians at Site U1341 on the western slope of Bowers Ridge, IODP Expedition 323

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ABSTRACT

The biostratigraphy and datum levels of diatoms, silicoflagellates, and ebridians are presented at Site U1341 drilled by the IODP Expedition 323 on the western slope of Bowers Ridge in the Bering Sea. Identified biostratigraphic diatom zones were from the *Neodenticula seminae* Zone to the *Thalassiosira oestrupii* Subzone. Silicoflagellate and ebridian zones were from the *Distephanus octangulatus* Zone to the *Distephanus jimlingii* Zone. The bottom age in the deepest Hole U1341B is estimated between 4.1 Ma and 5.0 Ma. Based on the succession of microfossil assemblages throughout the studied holes, the changes in paleoceanographic conditions are outlined.

1. Introduction

Siliceous microfossils in the Bering Sea have been applied as important proxies for determining geological ages of marine sediments and reconstructing paleoceanographic conditions (Hanna, 1970; Bukry, 1973; Koizumi, 1973, 2010; Ling, 1973a,b; Baldauf, 1982; Sancetta, 1982; Katsuki and Takahashi, 2005; Gladenkov, 2006, 2008). The high wt% values of biogenic opal in the Bering Sea sediments (Okazaki et al., 2005) are mainly supported by high sinking fluxes of diatom frustules from the photic zone to the deep interior (Takahashi et al., 2000, 2002). The production and sinking of diatom particles and their accumulation in sediments play significant roles in biogeochemical cycles.

Previous studies around Bowers Ridge by Deep-Sea Drilling Project (DSDP) Leg 19 showed that sediments containing siliceous microfossils were of geological ages from the Pliocene and Pleistocene (Koizumi, 1973, Ling, 1973a,b), however recovery of sediments during DSDP drilling was poor. During July–September 2009, Integrated Ocean Drilling Program (IODP) Expedition 323 in the Bering Sea utilized new Advanced Piston Coring and Extended-Core Barrel Rotary Coring techniques that recovered continuous sections (Takahashi et al., 2011). However, the data collected onboard regarding diatoms, silicoflagellates, and ebridians at Site U1341 in IODP Exp. 323 were partially incomplete (Expedition 323 Scientists, 2011). Because the occurrence of carbonate microfossils in the Bering Sea are usually discontinuous (Expedition 323 Scientists, 2011), effective application of siliceous microfossils was needed for further development of micropaleontological and paleoceanographic studies of the Pliocene–Pleistocene Bering Sea. Here, we present revised biostratigraphic results on diatoms, silicoflagellates, and ebridians at Site U1341. In addition, the long-term trends in sea-surface paleoenvironmental conditions is also interpreted from the studied assemblages.

2. Oceanographic setting

The Bering Sea is the northern marginal sea of the North Pacific (Fig. 1). The Aleutian Island Arc geographically divides the Bering Sea and the North Pacific. The Alaskan Stream flows into the Bering Sea through the Aleutian Island passes. The advected Alaskan Stream water mixes with the Bering Sea waters and flows eastward along the north coast of the Aleutian Island arc (Aleutian North Slope Current), and then turns to northwest along the shelf break as the Bering Slope Current. Because of the cyclonic gyre of sea surface current, much of the inflow waters flow back out to the North Pacific mainly through the Kamchatka Strait (Stabeno et al., 1999) (Fig. 1). However, a limited amount of surface waters flows into the Arctic Ocean through the Bering Strait mainly due to the difference in sea-surface height between the North Pacific and the North Atlantic Ocean (Shaffer and Bendtsen, 1994). Flow through into and out of the Bering Sea may have changed in the past; for example, during the LGM the water depths of some of the eastern Aleutian passes and the Bering Strait were significantly shallower than that of the present because of the eustatic sea level drop (Hopkins, 1973; Bringham-Grette, 2001; Katsuki and Takahashi, 2005).

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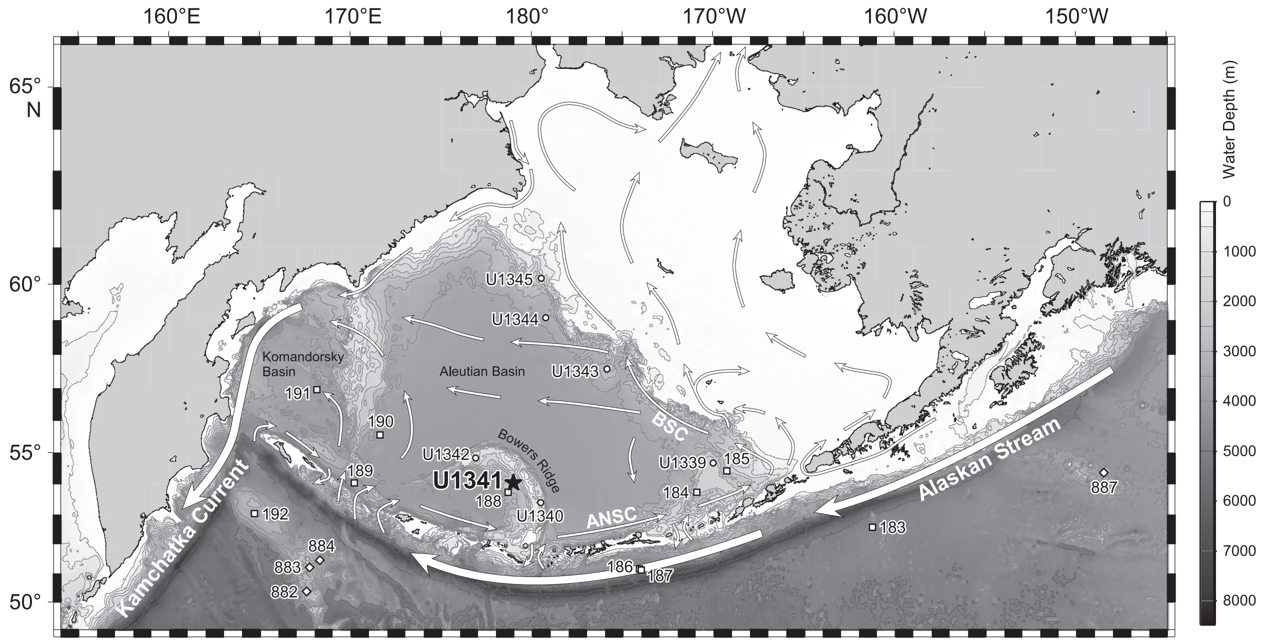

Fig. 1. Map for the study area. The locality of study site is represented by star shape symbol on the western slope of the Bowers Ridge. DSDP Leg 19 Sites 183–192, ODP Leg 145 Sites 882–884 and 887, and IODP Exp. 323 Sites U1339–U1345 are also plotted. Schematic sea-surface currents represented by arrows are based on Stabeno et al. (1999). The bold arrows represent the mean flow speed greater than 50 cm s^{-1}. ANSC and BSC are the abbreviation of the Aleutian North Slope Current, and the Bering Slope Current, respectively.

The studied IODP Site U1341 is located on the western flank of Bowers Ridge in the south central part of the Aleutian Basin (Fig. 1). Climatological data of sea surface temperature for 1971–2000 at this location ranges from 2.5 °C to 9.0 °C (Reynolds et al., 2002). Today's study area is far south of the annual maximum sea-ice extent. The nutrient conditions and summer shallow pychnoclines around Bowers Ridge appear to be suitable for high productivity of net phytoplankton including diatoms (Shiomoto, 1999).

3. Samples and methods

3.1. Samples

Studied core samples were obtained at Site U1341 on the western flank of Bowers Ridge in the Bering Sea (Fig. 1) by IODP Expedition 323 (Expedition 323 Scientists, 2011). The sediments at Site U1341 are mainly composed of diatom ooze (Expedition 323 Scientists, 2011). The upper soft sediments were drilled by Advanced Piston Cores (APC: Cores U1341B-1H to 53H) whereas deeper layers were retrieved by Extended Core Barrel (XCB: Cores U1341B-57X to 71X). Because the XCB drilling partially disturbed sediments, some contamination of sediments may occur during the drilling. At this site, two samples per core from Hole B were usually obtained for diatom and ebridian analysis. Higher resolution samples were applied for silicoflagellate analysis by using the samples from Holes A, B, and C. The age of each sample is estimated based on the age-model compiled by Takahashi et al. (2011) and Sakamoto et al. (pers. com., Sep. 2011).

3.2. Methods

For diatom assemblage analysis, a total of 123 samples were obtained from Hole U1341B. Freeze-dried samples weighing 10–11 mg (mean = 10.6 ± 0.3 SD) were cleaned using solutions of 15% hydrogen peroxide and sodium hexametaphosphate. After the chemical reaction, clay minerals were removed and the solution was rinsed out by repeated decantations. The volume of sample liquid was adjusted to 25 ml, and then 1 ml from the well mixed liquid was transferred onto a cover slip. The sample liquid on the cover slip was gently dried on a hot plate at 65 °C. The cover slip with sample on the surface was mounted on a microslide glass with Mountmedia® of Wako Pure Chemical Industries, Ltd. (refractive index > 1.5). Under a light microscope (LM) with × 1000 magnification with immersion oil, greater than 400 diatom valves in each prepared microslide were counted at species or genus levels. To identify species with rare abundances for datum determinations, a microslide for the coarse grain-size fraction (> 20 μm) was also checked.

For silicoflagellate assemblage analysis, a greater number of samples (total of 217) were analyzed than those used for diatom analyses because counting silicoflagellates is usually less time consuming than diatom counting. The dried samples of 5.4–14.1 mg were cleaned by two solutions of hydrogen peroxide and sodium hexametaphosphate. The clays were removed and the samples were rinsed by decantation several times. In order to remove the large and small specimens of diatoms and radiolarians, a sample liquid was sieved through a 63 μm mesh first and then through a 20 μm mesh. The remained coarse fraction particles on the 20 μm mesh was filtered through a membrane filter with 3 mm grid printed (0.45 μm pore size). The dried filter was mounted on a microslide glass with Canada balsam^R (refractive index = approx. 1.5). The specimens on the microslides were observed under a light microscope with × 200 and × 400 magnifications. The numbers of specimens encountered varied from sample to sample, but were usually greater than 50 skeletons.

In addition to the silicoflagellate counting in higher resolution samples, silicoflagellates and ebridians in the diatom microslides were also checked. The observation of their skeletons in the diatom microslide was conducted under an LM with × 200 magnifications. Because the content of silicoflagellate and ebridian specimens in the diatom microslides were usually rare, the results based on the diatom microslides are expressed as binary data of presence or absence for each taxon (Figs. 2 and 3).