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Research paper

Pliocene–Pleistocene boundary determination in hemipelagic sediment from the Ulleung Basin (East Sea, offshore Korea) inferred from terrigenous and marine palynofloras

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ABSTRACT

Palynofloral analysis was performed for the first time on sediment from the Ulleung Basin (East Sea, offshore Korea) to locate the Pliocene–Pleistocene boundary, which is very important in determining the depositional age of a stratigraphic unit that contains methane hydrate. Cores from the drill sites Ulleung Basin Gas Hydrate 1–9 (UBGH1–9) and Ulleung Basin Gas Hydrate 1–10 (UBGH1–10) in the Ulleung Basin produced abundant to common pollen grains and organic-walled dinoflagellate cysts. Age-diagnostic palynomorphs were present in certain intervals: 120–175 mbsf at site UBGH1–9 and 170–205 mbsf at site UBGH1–10. The biostratigraphically meaningful taxa were the pollen genera *Carya*, *Liquidambar*, and *Fagus* and the dinoflagellate cysts *Capillicysta fusca*, *Filisphaera filifera* subsp. *pilosa*, and *Selenopemphix quanta*. The latest stratigraphic occurrence of these pollen taxa in northeast Asia is the late Pliocene, and that of the dinoflagellate cysts is regarded as the late Pliocene in all aquatic areas, especially in the Pacific. The last appearance datum (LAD) of the age indicators in the two cores studied suggests that the Pliocene–Pleistocene boundary is at 120 mbsf at site UBGH1–9 and 170 mbsf at site UBGH1–10.

1. Introduction

The Ulleung Basin in the East Sea, offshore Korea, has been a target for gas hydrate exploration, and seismic data were acquired for the Ulleung Basin and Korea Plateau from 2000 to 2004. The analytical results of the seismic program led to deep drilling in the southwestern part of the Ulleung Basin (Fig. 1). A thick succession of methane-bearing strata was present at sites UBGH1–9 and UBGH1–10, but the chronostratigraphy of the cored interval was not clear, leading to exploration problems.

Although hemipelagic and pelagic strata in the mid-latitude western North Pacific generally contain low palynoflora concentrations (Kawahata and Oshima, 2002), several intervals of high palynoflora concentrations (pollen, spores, and dinoflagellate cysts) have been identified in strata spanning the last 2.4 million years at Ocean Drilling Program (ODP) Site 798 in the East Sea (Heusser, 1992) and at ODP Site 1179 in the western North Pacific (McCarthy et al., 2004). Cores from sites UBGH1–9 and UBGH1–10 contain common terrigenous pollen, embryophyte spores, and marine organic-walled dinoflagellate cysts in concentrations that vary with lithological composition. The acid-resistant palynomorphs are well-preserved in many sediment types and represent a useful biostratigraphic tool in both terrestrial and marine sediments (Traverse, 2008).

Analyses of physical properties (Bahk et al., 2011), sedimentary features (Chun et al., 2011), downhole logging data (Kim et al., 2011), and seismic data (Yi et al., 2011) suggested that methane hydrate in the southwestern Ulleung Basin is associated with a specific stratigraphic interval intersected by cores from sites UBGH1–9 and UBGH1–10. Seismic profiles show a distinct methane-bearing horizon elsewhere in the Ulleung Basin. Age-controlled seismic profiles acquired for the South Korea Plateau immediately north of the Ulleung Basin show four seismic units (US-1 to US-4) spanning the last 13 million years (KIGAM, 2008). The seismically distinctive horizon that is present in the area of sites UBGH1–9 and UBGH1–10 cannot be correlated with the four regional age-controlled seismic units because no age data are available for the cores. The depth of the Pliocene–Pleistocene boundary in the two cores is of particular interest. Analysis of pollen grains and dinoflagellate cysts in the two cores was undertaken to constrain the depositional age of the sediment and to locate the Pliocene–Pleistocene boundary.

2. Study area

The East Sea is a semi-closed marginal sea that is connected by narrow, shallow straits not only with the Pacific Ocean and the Sea

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of Okhotsk but also with the East China Sea. The East Sea consists of three basins: the southwestern Ulleung Basin, the southeastern Yamato Basin, and the northern Japan Basin (Fig. 1).

The Ulleung Basin was formed by continental crustal extension that accompanied southward migration of the Japanese Arc in the late Oligocene to early Miocene (Tamaki et al., 1992; Yoon and Chough, 1995). The southern margin of the Ulleung Basin has undergone compressive deformation since the late Miocene (Jolivet et al., 1995; Yoon and Chough, 1995). Distal turbidites and hemipelagites have been deposited in the deeper parts of the basin since the Pleistocene, as the basin's depocenter rapidly retreated to its southern margin (Lee and Suk, 1998; Lee et al., 2001; Bahk et al., 2011).

The Ulleung Basin is a deep, bowl-shaped, back-arc basin bounded by the steep continental slope of the eastern Korean Peninsula to the west and the Korea Plateau to the north (Fig. 1). The basin is bordered to the south by a gentle slope of 1–2° and to the east by a broad shelf

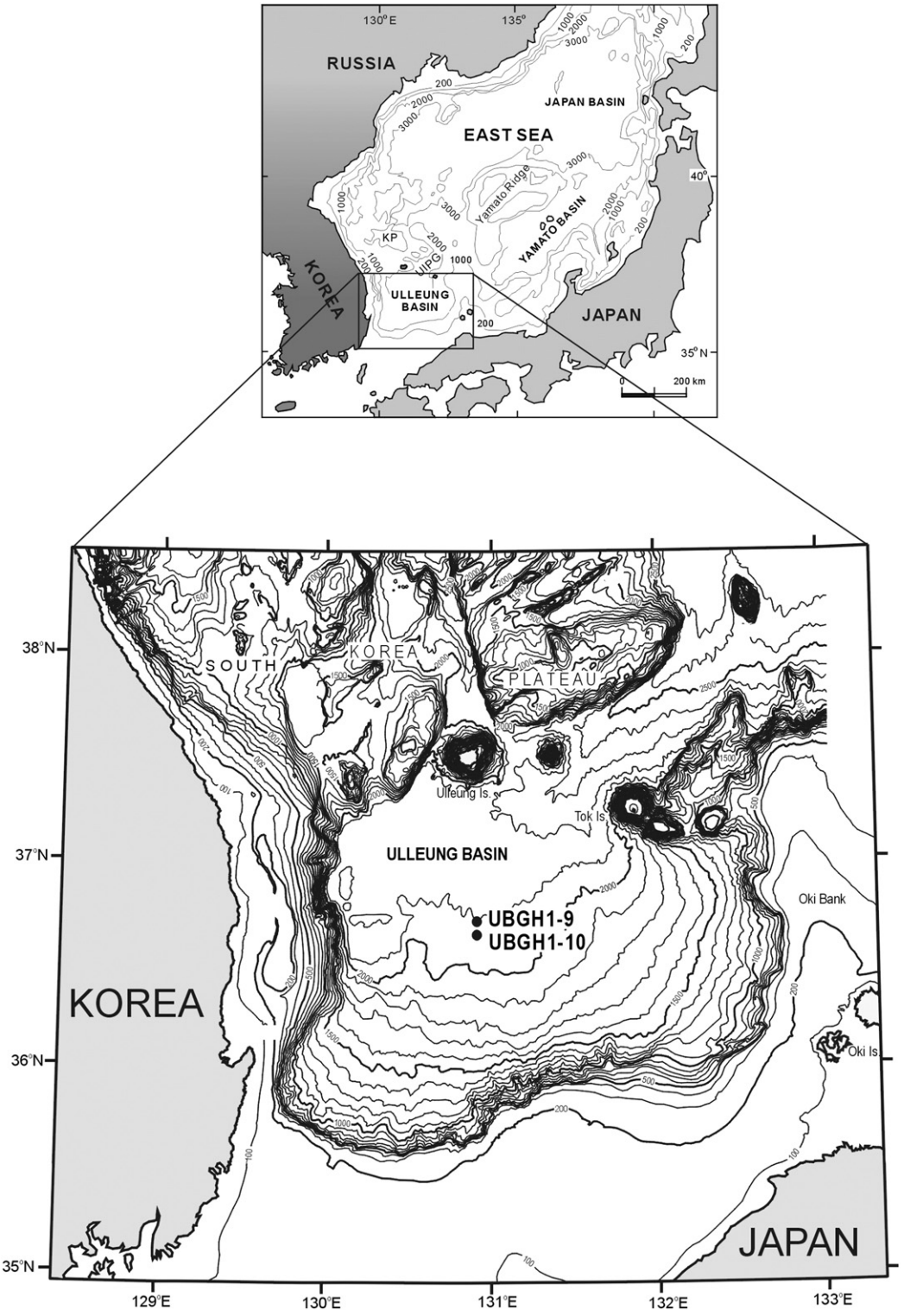

Fig. 1. Bathymetric map of the Ulleung Basin showing the location of drilling sites UBGH1–9 and UBGH1–10. KP: Korea Plateau, UIPG: Ulleung Interplain Gap. Modified from Lee et al. (2004).