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Physical property variations related to seismic units in the offshore sediments of the Heuksan Mud Belt, southeastern Yellow Sea, Korea

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A B S T R A C T

Sixteen piston core samples collected from the Heuksan Mud Belt on the southeastern inner shelf of Korea were analyzed to characterize sediment property and distribution in relation to interpreted seismic units. The results from seven of 16 cores are presented in this study using core locations along a seismic track line. Variations in physical properties with depth gradually increased and/or decreased, depending on the characteristics of the specific property. Property patterns are primarily the result of dewatering caused by compaction and/or consolidation. Significant variations in depth are due to differences in sediment texture. In particular, core P03 is largely composed of sandy sediments below 170 cm. All core data come from three specific seismic Units: I, IIa and IIb, in descending order. The seismic patterns that define these units are interpreted as related to the rate of sea-level change during transgressions and depositional processes during the Holocene. Regionally, the variation of physical properties along the seismic profile is likely to reflect the relative characteristics of the seismic units. Unit I is characterized by low shear strength/wet bulk density and high porosity. Unit IIa appears to have higher shear strength than Units I and IIb. Unit IIb shows high wet bulk density and velocity. These observations suggest that the physical properties are mainly controlled by depositional processes related to sea-level change. Clay fabric analysis that uses a scanning electron microscope for two core samples shows the change of particle arrangement due to compaction caused by overburden loading with burial depth. In the upper part of the core, edge-to-edge and edge-to-face contacts dominate. In contrast, face-to-face contact characterized by the well-oriented arrangement of clay particles frequently occurs in the lower parts of the cores, indicating sediment compaction or initial consolidation caused by overburden pressure.

1. Introduction

The physical and acoustic properties of marine sediments are important for understanding the geological history of marine environments (Hamilton, 1970; Hamilton and Bachman, 1982). Porosity in marine sediments is largely determined by composition, texture, and clay fabric (Stoll, 1977, 1989; Richardson et al., 1997). Bulk density, shear strength, and velocity increase as water content and porosity decrease as a result of overburden pressure after deposition. Sediment texture (mean grain size and clay content) is an important factor in the determination of the physical and acoustic properties of unconsolidated marine sediments (Kuster and Toksoz, 1974; Hamilton and Bachman, 1982; Kim et al., 2001a,b, 2007, 2011, 2012).

Knowledge of clay fabric structure is important for understanding the physical and mechanical properties of marine sediments (Bennett et al., 1981; Bryant et al., 1990; Kim et al., 1998, 2007, 1999a,b). In particular, shear wave velocity and shear strength are largely controlled by the orientation of clay particles with burial depth (Kim et al., 2007). The physical nature and consolidation behavior of clay-rich sediments can be understood through knowledge of the microstructure (Bennett et al., 1977; Bryant et al., 1990; Kim et al., 1998). Kim et al. (1998, 1999a,b) studied the relationship between mineralogy and changes in clay fabric to examine how they affected the petrophysical properties of sediments. They showed that most clay domains develop face-to-face contacts and become well-orientated with burial depth.

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The Yellow Sea including the Heuksan Mud Belt (Fig. 1) was completely exposed during the last glacial maximum (LGM), when the paleoshoreline was located about 120 m below the present sea level (Bloom and Park, 1985; Pirazzoli, 1991). Thus sea-level rise during the Holocene has significantly affected the formation of sedimentary units in the Yellow Sea (Jin and Chough, 1998; Jin et al., 2002; Shinn et al., 2007). The origin of sediments in the central Yellow Sea is well studied (Milliman et al., 1987; Alexander et al., 1991). This contrasts with the origin of sediments in the Heuksan Mud Belt, which is still poorly understood and the subject of debate (Park et al., 2000; Lee and Chu, 2001; Lim et al., 2013). Moreover, there is little information available on the physical properties and clay fabric of the Heuksan Mud Belt sediments (Kim et al., 2000).

The purposes of this study are: (a) to quantify variations in the physical properties and seismic velocity of sediments in the Heuksan Mud Belt with increasing sediment depth, and (b) to evaluate the relationships between physical properties based on seismically defined units. In addition, we investigated changes in grain orientation with burial depth, which highlights the changes in clay fabric caused by compaction from overburden pressure.

2. Geological setting

The Yellow Sea shelf, characterized by a low-gradient epicontinental sea, was completely exposed in a subaerial environment during the last glacial period. As the sea rapidly rose, late Pleistocene weathered deposits were unconformably overlain by transgressive deposits of variable thickness (Shinn et al., 2007). In the eastern part of the Yellow Sea, the transgressive deposits comprise retrograde tidal flat and channel facies, with overlying sand ridges and sheets above the ravinement surface (Lee and Yoon, 1997; Kim et al., 1999a,b; Shinn et al., 2007). The shelf ridges evolved from Pleistocene muddy tidal deposits to ridge surfaces covered by a Holocene sand veneer during the transgression (Jin et al., 2002; Shinn et al., 2007). Shinn et al. (2007) presented six transgressive depositional units in the southeastern Yellow Sea. The Heuksan Mud Belt, located at the southwestern tip of the Korean peninsula, consists mainly of fine-grained sediments. As to the origin of the sediments, there are two main hypotheses: one suggests that the sediments originate from the Geum River (Lee and Chu, 2001; Chough et al., 2004), whereas the other suggests that they were largely derived from the Changjiang or Huanghe rivers prior to about 7 ka, and have undergone significant erosion and reworking

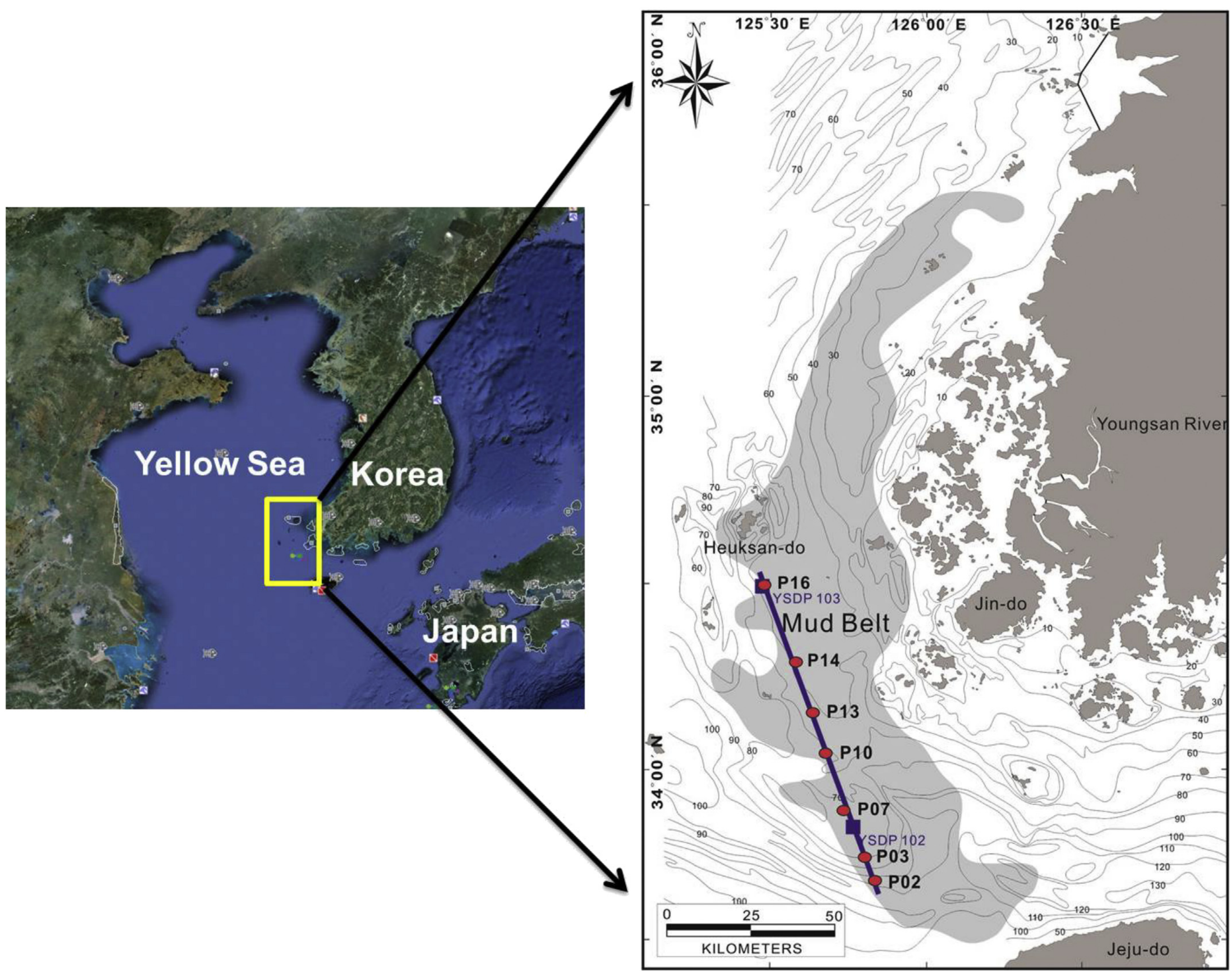

Fig. 1. Map showing bathymetry and core locations for the Heuksan Mud Belt study area. The seismic track line is marked along with core location. Note the location of deep cores (YSDP 102, 103) drilled by the Korea Institute of Geoscience and Mineral Resources (KIGAM). Bathymetry contours are in meters.