[PS]Geochemical Study on the Origin of Organic Matter and Depositional Environment of Late Quaternary Sediments in the Ulleung Basin of the East Sea*

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Abstract

According to radiocarbon dating of planktonic foraminifera samples from the Ulleung Basin of the East Sea, the cores cover the time interval from the middle stage of marine isotope stage (MIS) III through the last glacial maximum (LGM) to the Holocene. In the cores, hemipelagic muds (bioturbated and slightly laminated mud facies) were mainly deposited during interglacial periods (MIS I/III), whereas non-hemipelagic muds (laminated and homogenous mud facies) were formed during glacial period (MIS II). During the cold time, sedimentation rates clearly increased more than the other times. Such characteristic changes in sedimentary facies and sedimentation rate evidently reflect paleo-environmental variations on the Ulleung Basin during the Late Quaternary. Also, the cores contain several lapilli tephra layers, rhyolitic ash layers, and dark laminated muds. Among these, previously well-known tephra layers (Ulleung-Oki, Aira-Tanzawa, and Ulleung-Yamato) were identified and used to stratigraphically correlate the cores. Particularly, our sedimentary geochemical studies (Rock-Eval pyrolysis, elemental, and stable isotope analyses) allow us to discuss the origin of organic matter and the depositional environment of sediments. Down-core profiles of TOC (Total Organic Carbon), TN (Total Nitrogen) and $\delta^{13}C_{org}$ show the lowest values during MIS II and the highest during MIS I. The relationship between TOC/TN and $\delta^{13}C_{org}$ suggests that the organic matter was predominantly produced by a marine source rather than by a terrestrial source. However, redox-sensitive trace elements have not significantly varied during MIS II as well as during MIS I/III. The ratios of these trace elements also indicate a predominant oxic or suboxic environment, indicating that the Late Quaternary depositional condition of the Ulleung Basin was less dynamically changed than we expected before.

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Geochemical Study on the Origin of Organic Matter and Depositional Environment of Late Quaternary Sediments in the Ulleung Basin of the East Sea

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Abstract

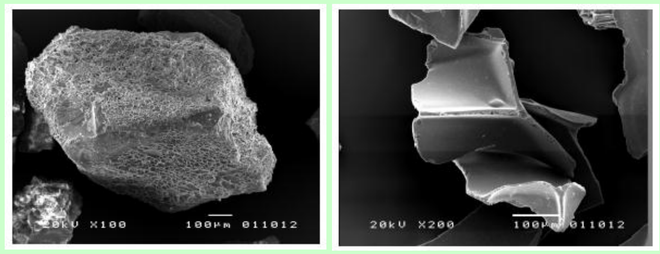
According to radiocarbon dating of planktonic foraminifera samples from the Ulleung Basin of the East Sea, the cores cover the time interval from the middle stage of marine isotope stage (MIS) 3 through last glacial maximum (LGM) to Holocene. In the cores, hemipelagic muds (bioturbated and slightly laminated mud facies) were mainly deposited during interglacial periods (MIS 1/3), whereas non-hemipelagic muds (laminated and homogenous mud facies) were formed during glacial period (MIS 2). During the cold time, sedimentation rates clearly increased more than the other times. Such characteristic changes in sedimentary facies and sedimentation rate evidently reflect paleo-environmental variations on the Ulleung Basin during Late Quaternary. Also, the cores contain several lapilli tephra layers, rhyolitic ash layers and dark laminated muds. Among these, previously well-known tephra layers (Ulleung-Oki, Aira-Tanzawa and Ulleung-Yamato) were identified and used to stratigraphically correlate the cores.

Particularly, our sedimentary geochemical studies (Rock-Eval pyrolysis, elemental and stable isotope analyses) allow us to discuss the origin of organic matter and the depositional environment of sediments. Down-core profiles of TOC (Total Organic Carbon), TN (Total Nitrogen) and $\delta^{13}C_{org}$ show the lowest values during MIS 2 and the highest during MIS 1. The relationship between TOC/TN and $\delta^{13}C_{org}$ suggests that the organic matter was predominantly produced by a marine source rather than by a terrestrial source. However, redox-sensitive trace elements have not significantly varied during MIS 2 as well as during MIS 1/3. The ratios of these trace elements also indicate a predominant oxic or suboxic environment, indicating that the Late Quaternary depositional condition of the Ulleung Basin was less dynamically changed than we expected before.

Type of Tephras

- ✓ Ulleung origin (U-Oki and U-Ym)
  - → Pumice-type glass shards
  - → K-rich glasses (R=K_2O/SiO_2>0.09) ranging from phonolitic to trachytic alkali compositions
- ✓ Japanese origin (AT)
  - → Plane-type and/or bubble-wall shards
  - → K-poor glasses (R=*ca.* 0.04) and rhyolitic composition

Ulleung origin (U-Oki & U-Ym) | Japanese origin (AT)



(Park *et al.*, 2003)

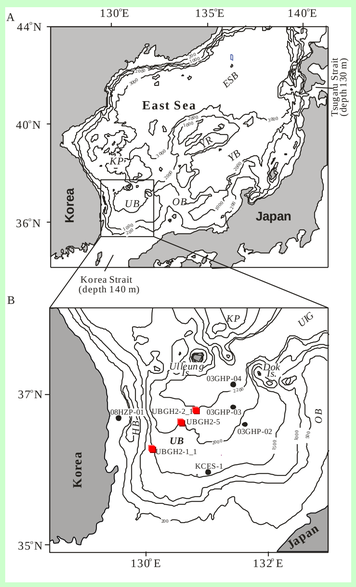
Purposes of Study and Materials

- ✓ To present the stratigraphic age dating and characteristic sedimentary facies of samples taken from the Ulleung Basin of the East Sea
- ✓ To identify the source of organic matter, and then, to reconstruct the depositional environment of sediment since Marine Isotope Stage (MIS) 3
- ✓ Piston cores were taken from the central Ulleung Basin part during the *R/V Tamhae II* cruise of KIGAM for the Gas Hydrate R&D Project

	Cal Age (ka BP)	Depth (mbsf)		
		03GHP-02	03GHP-03	03GHP-04
U-Oki	10.1	0.32	0.49	1.00
DLM	15.4	0.95	1.02	1.57
AT	23.0	2.34	2.45	2.66
U-Ym	30.9	-	4.78	5.79
Length (m)		5.22	5.44	7.34

* - : no observation

Depth of three tephras and DLM layers in the cores

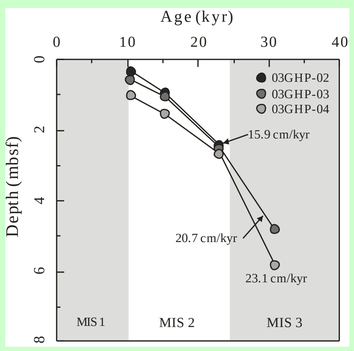


Ulleung Basin in the East Sea and core location

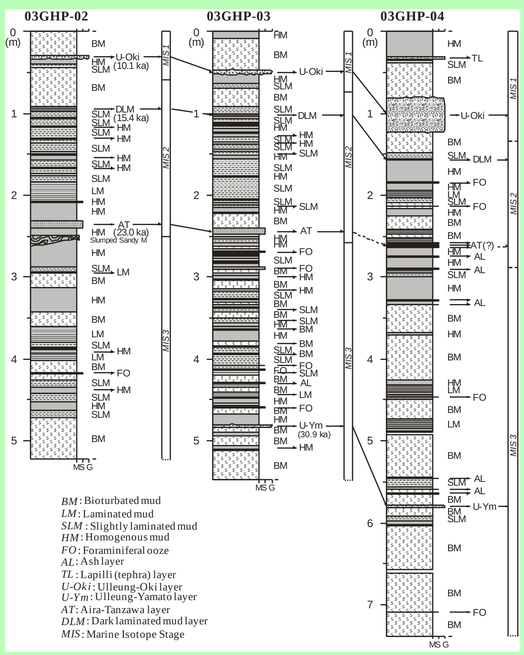
Age Dating and Model

- ✓ Selected samples were ^{14}C-dated by AMS at the lab. of Univ. Kiel, Germany
- ✓ After tephrostratigraphic studies, DLM, U-Oki, AT, and U-Ym represent 15.4, 10.1, 23.0 and 30.9 ka BP, respectively (*e.g.*, Park *et al.*, 2006; Kim *et al.*, 2007). They are useful tie points for the chronostratigraphic correlation, and were here used to construct the age model of the sediment cores
- ✓ According to this method, the U-Oki layer is roughly designated as the boundary between MIS 1/2 and the AT layer is between MIS 2/3

(DLM, Dark laminated mud; U-Oki, Ulleung-Oki layer; AT, Aira-Tanzawa layer; U-Ym, Ulleung-Yamato layer)



Relationship between the depths and calibrated ages



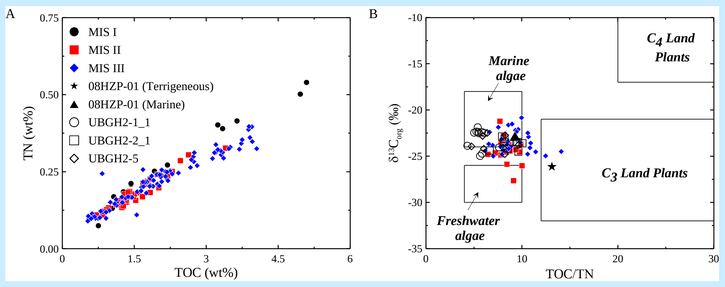
Characteristic Change in Sedimentary Facies

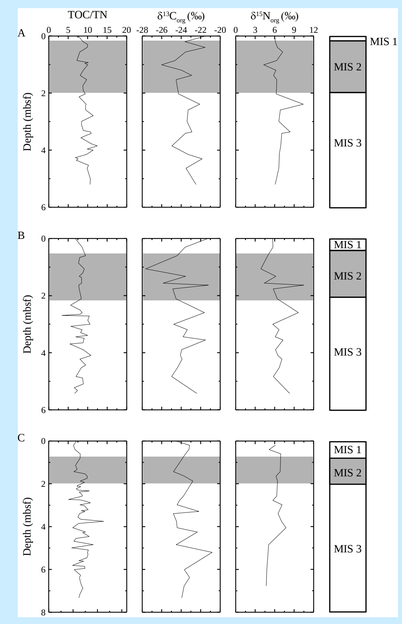
- ✓ In the cores, hemipelagic muds (bioturbated and slightly laminated mud facies) were mainly formed during interglacial periods (MIS 1 / MIS 3), whereas non-hemipelagic muds (laminated and homogenous mud facies) were deposited glacial period (MIS 2)
- ✓ Volcanic layers and grains are found in all cores. In particular, the U-Oki, AT and U-Ym layers are easily identified; the massive-type glass shards of the lapilli layers correspond to the U-Oki and U-Ym tephra layers, whereas the bubble-well and/or plane-type glass shards are the AT ash layer

Lithology of core sediment and inferred stratigraphy correlation based on tephra and DLM layers (*mbsf*, meters below sea floor)

Origin and Diagenesis of Organic Matter

- ✓ TOC/TN ratios : 6 ~ 10 and $\delta^{13}C_{org}$: -21 ~ -28 ‰
  - → Organic matter is predominantly generated by marine algae rather than by terrestrial plants
  - → and has not significantly changed since MIS 3 in the basin
- ✓ Correlation between TN and TOC and between $\delta^{13}C_{org}$ and TOC/TN
  - → Most organic matter has been located in or near the region of marine algae since MIS 3



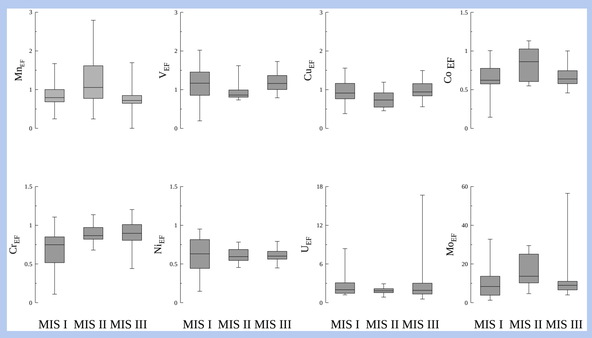


Downcore profiles of TOC/TN, $\delta^{13}C_{org}$ and $\delta^{15}N_{org}$

- ✓ $\delta^{15}N_{org}$: 4 ~ 11 ‰
  - → Originated from marine algae
- ✓ Enriched $\delta^{15}N_{org}$: Usually caused by the denitrification process in the water column under suboxic condition
- ✓ The decreasing downcore profile of nitrate concentration, the increasing downcore profile of phosphate concentration, and lower N/P ratio (<12.4) in the water column: Evidence of the occurrence of denitrification via micro-reducing environment or aerobic denitrification in the sea

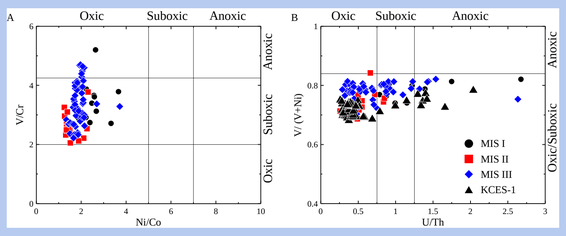
Depositional Condition : Influence of Tephra and Biodetritus

- ✓ Abundance of redox-sensitive trace elements (e.g., Mn, V, U, and Mo) : Not varied from MIS 3 to MIS 1
- ✓ Ratios of redox-sensitive trace elements indicate a predominately oxic or suboxic environment during times of sediment deposition since the Late Quaternary
- ✓ Tephra and foraminiferal shell fragments display abnormal element/Al ratios : Biodetritus and tephra obviously affect the variation of sedimentary facies and the geochemistry in the Ulleung Basin



Box plots for EF values of Mn, V, Cu, Co, Cr, Ni, U, and Mo

※ Enrichment Factors (EFs), $X_{EF} = (X/Al)_{sample}/(X/Al)_{AS}$



Correlation (A) between V/Cr and Ni/Co and (B) between V/(V+Ni) and U/Th

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