論文の内容の要旨

Provenance changes and depositional process of the sediments in the Yangtze Delta during the late Holocene: Application to reconstruct spatial pattern of summer precipitation in South China

（後期完新世における揚子江河口部堆積物の供給源変動と堆積プロセス：南中国における夏季降水分布復元の可能性）

氏　名　　齋　藤　　京　太

The Asian summer monsoon (ASM) controls the climate over Asia and strongly influence the hydrological cycle there. The East Asian summer monsoon (EASM) is one of the important components of the ASM and characterized by a seasonally northwest-southeastward migrating precipitation front. It exerts a significant influence on the East China especially, because the most part of annual precipitation there is brought by the EASM.

Since it could bring the flood and drought hazards in addition to the annual precipitation, it is important to understand the behavior of the EASM, and reconstruction of the paleo-monsoon behavior is necessarily to understand the long-term variability of the EASM. According to the meteorological observation during the late 20th century, change in the intensity of the EASM, which represents the strength of atmospheric circulation over the East Asia, is accompanied by changes in the position of the rain front. So, it is effective to reconstruct changes in the distribution of paleo-precipitation, in order to reconstruct the pale-monsoon intensity

The Yangtze River drains a large part of the South China and is one of the largest river in the world in respect both of the water discharge and its drainage area. Precipitation in the Yangtze drainage basin is

significantly affected by the EASM and the changes in the EASM intensity are reflected in the distribution of the precipitation in its drainage basin. Namely, when the EASM becomes stronger, the precipitation front penetrates to the northwestern part of the Yangtze drainage basin, whereas when the EASM becomes weaker, the precipitation front remains in the southeastern part of its drainage basin. Since there are positive correlations among the precipitation, water discharge, and sediment discharge, respectively, the sediments derived from the heavy precipitation area in the Yangtze drainage basin should occupy a large part of the sediments discharged from the Yangtze rivermouth. Thus, the reconstruction of provenance of sediments at the Yangtze rivermouth should enable me to reconstruct the past changes in the heavy precipitation area in the Yangtze drainage basin.

In Part 1 of this study, I established proxies for distinguishing sediments from the different area of the Yangtze River basin, because proxies are necessary in order to reconstruct past changes in the provenance of sediments at the Yangtze rivermouth, The electron spin resonance (ESR) signal intensity and crystallinity index (CI) of quartz are used as proxies, because quartz is the most common mineral among detrital materials and is resistant to physical and chemical weathering. The ESR signal intensity of quartz increases with the age when the mineral was formed, whereas CI reflects the process of the mineral forming.

To reveal the characteristic of sediments discharged from individual area of the Yangtze drainage basin, riverbed sediments were collected at the site along the mainstream and major tributaries of the Yangtze River. The ESR signal intensity and CI of the riverbed sediments show distinct difference among the groups of major tributaries; the upper Jinshajiang, western tributaries, northern tributaries, and southeastern tributaries. Especially, the ESR signal intensity of the tributaries tend to increase southeastward, from 0 of the western tributaries to 20 of the southeastern tributaries.

The effectiveness of the ESR signal intensity as the proxy to distinguish the provenance of sediments within the Yangtze drainage basin was verified by two steps. First, the ESR signal intensity below the junction with specific tributary were predicted using the sediment budget and the analyzed ESR signal intensity of the mainstream and tributary above the junction. The predicted ESR signal intensity at the every junction with the major tributaries were consistent with the analyzed ESR signal intensity of riverbed sediments at the corresponding site, indicating that the ESR signal intensity properly reflect the mixing ratio of the sediments. Second, using the similar calculations, the change of the ESR signal intensity along the mainstream was

predicted using the sediment budget within the Yangtze drainage basin. Comparing the predicted and analyzed ESR signal intensity at the every junction with the major tributaries, the predicted values dropped within the error of the analyzed values, showing that it is possible to predict the ESR signal intensity at the rivermouth based on the sediment budget in the drainage basin.

In Part 2 of this study, I tried to reconstruct history of the provenance changes for the sediments at the Yangtze rivermouth during the middle to late Holocene. To attain this objective, drilling was conducted at the subaqueous Yangtze Delta, and cores were recovered at YD13 site in July 2013 at the depth around 35 m. YD13 cores are mainly composed of silt to sandy silt and many coarse¬-silt to sand layers are detected by the Soft-X ray radio photographs. These coarse-silt to sand layers are used for the definition of the lithological units. Correlation among the different holes of YD13 are established based on correlations of the lithological units and the occurrence of coarse-silt to sand layers ,which was supplemented by the vertical variation pattern of water content. The sediments of YD13 sediments during the last 6 ky were categorized into three sedimentary unit based on the frequency and structure of the coarse–silt to sand layers; namely, Unit 3 deposited before 5.1 ka, Unit 2 deposited during 5.1 to 2.3 ka, and Unit 1 deposited after 2.3 ka.

The age model of YD13 was established on the basis of the radiocarbon dating of shell fossils, which revealed that the top 10 m of YD13 cores corresponds to the last 5.1 ky. In addition, the radiocarbon dating of the benthic foraminifera was carried out and compared with the OSL dating of quartz in the fine¬–silt fraction by Sugisaki et al. (2015). Both in Unit 2 and 1, the foraminifera and OSL of quartz showed older ages compared to all of the shell fossils, indicating the contribution from the reworked sediments. In Unit 2, judging from the ages of foraminifera, the source of the reworked sediments were estimated to be the late transgressive system tract which were originally deposited during 1.2–0.7 ka during the continuous rise of sea level. The contribution ratio of the reworked sediments were estimated under the assumption that the radiocarbon ages of shell fossils, radiocarbon ages of foraminifera, and OSL ages of quartz in the fine–silt fraction represent the age of the riverine sediments, the reworked materials, and the mixture of the former two materials, respectively. The results revealed that 20–70 % of sediments in Unit 2 are the reworked materials. On the other hand, the source of the reworked materials in Unit 1 was estimated as either of the Jiangsu coastal sediments or the late transgression system tract same as Unit 2. In the same calculation as Unit 2, the contribution of the reworked materials in Unit1 was also estimated, and the results revealed that

up to 40 % of sediments in Unit 1 are the reworked materials.

In order to reveal the millennial changes in the provenance of sediments at the Yangtze rivermouth, the ESR signal intensity and CI of the background sediments, which exclude the coarse–silt and sand layers, were analyzed for the last 5.1 ka. The ESR signal intensity and CI effected by the reworked materials are corrected using the estimated contribution ratios. The temporal changes of the ESR signal intensity and CI values in the background sediments revealed that the contribution from the southeastern area was larger compared to that observed during the late 20th century during intervals from 5.1 to 4.1, 2.3 to 2.1, 1.2–1.0, and 0.7–0.2 ka, suggesting that the precipitation front remained within the southeastern area of the Yangtze basin during these intervals. On the other hand, the contribution from the northwestern area was comparable with that observed during the late 20th century intervals from 4.1 to 2.3 and 2.0 to 1.3 ka, indicating that the precipitation front penetrated into the northwestern area of the Yangtze basin during these intervals. These results indicate the millennial–scale fluctuations of monsoon intensity during the middle to late Holocene, under the assumption that the position of the precipitation front reflects the intensity of the EASM.

In addition to the background sediments, the ESR signal intensity, CI value, and frequency of the coarse-silt to sand layers, which were assumed to represent the occurrence of floods within the Yangtze basin, were also examined. The ESR signal intensity of the flood layers tend to be comparable with those of the background sediments except in the period from 2.0 to 1.3 ka.