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Pollen and Phytolith Analyses of Ancient Paddy Fields at Chuodun Site, the Yangtze River Delta*[1]

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ABSTRACT

A number of paddy fields pertaining to the Majiabang Cultures (5500–3800 years BC) were discovered during the archaeological excavations that were carried out since 1998 at the Chuodun site in the Yangtze River Delta. The pollen and phytolith analyses of two soil profiles from the northeastern part of this site were carried out to trace the agricultural practices of the Neolithic period. The phytolith results showed that rice domestication in the Yangtze River Delta could be traced back to as early as the Majiabang Culture. The pollen assemblage also revealed low levels of aquatic species, similar to that in modern paddy fields. This finding suggested that humans might have removed weeds for rice cultivation during the Neolithic period. Thus, pollen analysis in association with phytolith analysis was a promising method for identifying ancient paddy fields.

Key Words: ancient paddy fields, Neolithic period, pollen analysis, phytolith analysis, Yangtze River Delta

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INTRODUCTION

The lower Yangtze River area has for long been thought of as an important center of early rice domestication (Crawford and Shen, 1998; Malone, 1998; Zhao, 1998; Mannion, 1999). Although fossil rice phytoliths preserved in the late glacial sediments of Poyang Lake, southern China (Jiang and Piperno, 1999) and the East China Sea (Lu *et al.*, 2002) suggest that rice cultivation in this area might have started as early as about 14000 years BP, direct evidence of a very early origin of rice agriculture is scarce.

During archaeological excavations that had been carried out since 1998 at the Chuodun site in the Yangtze River Delta, the Nanjing Museum, the Suzhou Museum, and the Institute of Soil Science, Chinese Academy of Sciences, discovered a number of paddy field remnants dating back to 4500 years BC. During the sixth excavation in November 2003, a total of 22 paddy fields, numbered S2–46, were found in Unit VI of this site within an area of 300 m^2. These small fields with areas of 1–10 m^2 were reclaimed in the lowland during the Majiabang Cultures (5500–3800 years BC). To facilitate irrigation, these fields were usually connected to each other with channels, ponds, and wells where living utensils, such as pottery vessels, pots, and jars, were found. In addition, a wealth of charred rice grains were

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washed and sorted from ash layers. According to the latest archaeological reports, the shape of these rice grain remnants was very different from that of the wild rice (Tang, 2003).

Studies on the ancient paddy fields at the Chuodun site are of great importance for unraveling the history of rice domestication in East Asia. This study aimed to investigate the pollen and phytolith assemblages of two soil profiles from the ancient paddy fields of the Chuodun site.

MATERIALS AND METHODS

The Chuodun site (31° 24′ 12″ N, 120° 50′ 1.5″ E) is in the lowland area of Yangcheng Lake and the Taihu Lake watershed, East China, with an elevation of about 3 m above the present sea level. There are a considerable number of small lakes around Yangcheng Lake. Some are still its lagoons and some have been isolated because of lake aggradation (Chen *et al.*, 1988). The Chuodun site is situated between Yangcheng Lake and Kuilei Lake, to the north of Zhengyi, Kunshan County, Jiangsu Province, China.

Northern subtropical mixed forests with broadleaf deciduous and evergreen trees characterize the natural vegetation of the Taihu Lake watershed. Hardwood and evergreen broadleaf species are *Cyclobalanopsis spp.*, *Castanopsis spp.*, *Quercus spp.* (including the deciduous species), *Castanea spp.*, and *Liquidambar formosana*. *Pinus massoniana* Lamb. is also common in this area. Hydrophytes are abundant with high species diversity including *Nelumba nucifera*, *Zizania caduciflora*, *Sagittaria sagittifolia* var. *sinensis*, *Nymphea tetragona*, *Trapa bispinosa*, *Euryale ferox*, *Pistia stratiotes*, *Eichhornia spp.*, *Azolla imbricata*, *Salvinia natans*, *Spirodela polyrrhiza*, and *Lemna minor* (Wu, 1980). Long-term human activities have considerably modified the pristine vegetation, and most of the natural forests in the densely populated areas have been cleared.

The northern part of the Chuodun site was low and therefore was reclaimed for rice fields. A primary school and a village occupied the southern part. Two soil profiles of the ancient paddy fields, P01 from the northeastern part of Unit VI of this site and P03 30 m southeast of the P01 profile, were sampled. Detailed geological characteristics including the origin, composition, distribution, and vertical succession of stratigraphy of the P01 and P03 profiles are given in Table I. Because it was difficult to obtain the accurate ages of the soil organic matter using radiocarbon dating (Wang, Y. *et al.*, 1996; Stanley and Chen, 2000), the age-depth model based on archaeological chronology was used.

In the corresponding archaeological layers, eight pollen samples from the P01 profile and five samples from the P03 profile (Table I) were collected and processed according to the procedures of Fægri and Iversen (1989). One tablet of *Lycopodium* spores (12 540 grains) was added as a marker to each sample (10 g) at the beginning of the chemical treatment to allow the calculation of pollen concentration. Four modern soil samples from modern paddy fields and three lacustrine sediment samples from the Taihu Lake watershed were also analyzed. Because the focus was on the local vegetation of this site, the results were expressed as percentages based on the sum of all the pollens and spores. Phytolith samples (10 g) were taken continuously from the cultural layers (Table I). The counting method of Fujiwara (1976, 1982) was used to calculate the concentration.

Pollen and phytolith assemblages of the ancient paddy soil were compared with that of a modern paddy soil to validate the method of pollen analysis as a possible approach toward the identification of the ancient paddy fields.

RESULTS

The phytolith analysis of the P01 profile (Table II) showed that each layer contained different quantities of phytoliths except for the parent soil material and the concentrations of phytoliths were generally higher in both ancient and modern paddy soils than the parent soil material (Table I). The average concentration of the *Oryza* phytoliths at the 75–100 cm depth (the late Majiabang Culture) was only 3 542 grains g^{-1}. In the P03 profile, the average concentration of the *Oryza* phytoliths between 60 and 88 cm was low. No *Oryza* phytolith was found below 88 cm (Table II), which suggested that no