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Radiocarbon reservoir effect from shell and plant pairs in Holocene sediments around the Yeongsan River in Korea

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ABSTRACT

The marine reservoir effect was measured by comparing the radiocarbon ages of shell and plant pairs obtained from the same horizons of a sediment core around the Yeongsan River in the southwestern part of the Korean Peninsula. The Holocene sediment formed in five environments: tidal flat, inner bay, shallow marine, flood plain, and embankment from bottom to top. The tidal flat and shallow marine sediments should be good indicators of marine reservoir effect, as they formed in coastal environments where it was easy to access not only marine shells but also terrestrial plants. Some old detritus could be identified and removed, based on reliable accumulation curves and sedimentological interpretation. Hence, the age differences between the plants and shells could be successfully evaluated, and they indicated that the marine reservoir effect varied over time between 0 and 500 years. There was an increase of this effect at ca. 8000 cal year BP and a decrease at ca. 5000 cal year BP, possibly linked with coastal environment changes induced by sea level changes and by changes in the circulation of seawater.

1. Introduction

The calibration of radiocarbon ages of coastal calcareous samples presents difficult challenges because the marine reservoir effect is a complicated process that is associated with the upwelling of ^{14}C-depleted deep-sea water and the inflow of river water [1,2]. Previously reported marine reservoir ages were measured by pre-bomb and age-known shell samples around the Korean Peninsula (Fig. 1) [3–5], though this included only two results for Korea [5]. These results imply that relatively larger offsets would be recognized in the eastern parts of Korea than in the western parts. On the other hand, these few reports suggest that the collection of suitable samples for marine reservoir age measurement is a very difficult problem in Korea. Moreover, the results were based on samples obtained in the early 20th century, whereas a pre-historic time scale is essential for the suitable correction of old samples. In order to solve these problems, we studied the marine reservoir effect from the radiocarbon ages of shell and plant pairs from a sediment core acquired from a coastal area in the southwestern part of Korea.

2. Study site

A Holocene sediment (YAR-4) core with a length of approximately 20 m was collected from around the Yeongsan River in a southwestern area in Korea (N 34.82167, E 126.55357; 0.5 m below sea level) (Fig. 2). Many islands are scattered around this area, and the tide is principally semidiurnal with a mean spring range of 6 m. The freshwater discharges mainly occur during the summer monsoon season [6]. The length of the Holocene sediment collected for this study was from 5 to 20 m, and sediment at some points was thicker than the core lengths. This variety in the thickness implies that the paleogeography was as complicated as it is in the present landform of the western coastal area. The YAR-4 core was selected for our study from among more than 20 cores as it contained many shells and because the drilling site of this core was located around the axis of an incised valley, which had formed since the last glacial maximum. The MW-1 core was collected 6 km downstream of the coring site of the YAR-4 core (Fig. 2) [6]. The MW-1 core consisted of three sediments: a gravelly alternating sand-mud mix, yellowish brown mud, and greenish gray mud from bottom to top. These sediments were interpreted based on sedimentological, palynological, and organic geochemical analyses, with the conclusion that these units had formed in three paleoenvironments: fluvial, paleosol, and a Holocene estuary.

3. Methods

3.1. Sedimentological analysis

Lithological analysis of the YAR-4 core was conducted on an order of 1 cm and the grain size was analyzed at 0.5-m intervals. Plant and carbonate samples were collected for accelerator mass

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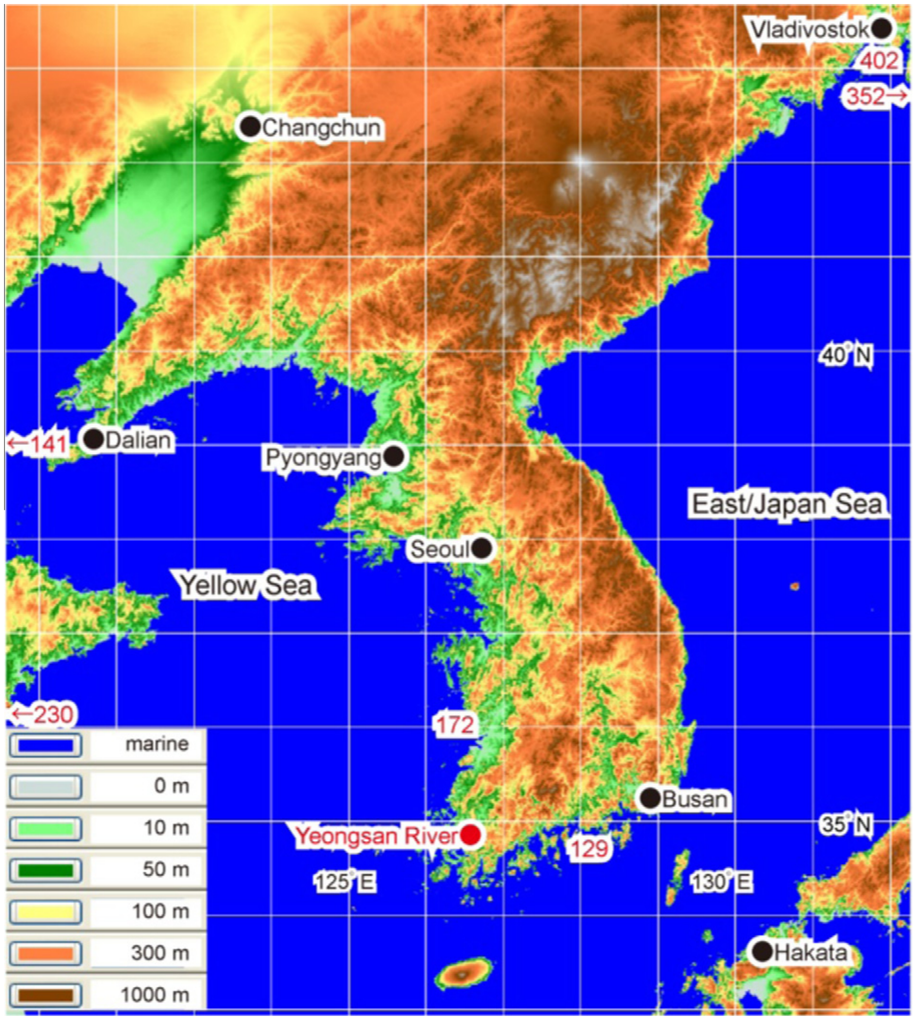

Fig. 1. Relief map around the Korean Peninsula and the modern values of marine reservoir ages reported by previous studies [2–4].

spectrometry (AMS) radiocarbon dating. The grain-size compositions of 29 samples were analyzed by the laser diffraction method with a Mastersizer 2000 (Malvern Instruments, Ltd., Worcestershire, UK) after treatment with a mixture of 35% H_2O_2 and 1 N HCl at 100 °C for 1 h to remove possible organic matter and carbonate minerals. The results are illustrated in Fig. 3 according to the grain size/depth contour map via the Kriging method using the Surfer 8 code (Golden Software Inc., Colorado, US). In order to understand the sedimentary environment, we identified mollusc assemblages based on the classification from an earlier work [7].

3.2. AMS ^{14}C dating

To establish a stratigraphically consistent chronology for the YAR-4 core and to evaluate the marine reservoir effects during the Holocene Epoch, we measured the ^{14}C ages of 33 terrestrial macrofossils and 38 marine calcareous samples by AMS. In total, 113 samples were collected from the sediment core, and samples in good condition were washed repeatedly with an ultrasonic cleaner. These samples were then cleaned chemically by acid-alkali-acid or acid treatments to remove secondary contamination. Samples of radiocarbon-free wood and IAEA C-1 were treated by the same procedure for blank measurement. The carbonate samples were milled. These samples, NIST OxII, IAEA C-7 and C-8, were combusted in an elemental analyzer, and the CO_2 gases were purified cryogenically in a high-vacuum automatic preparation system [8] and then converted to graphite by reducing on Fe-powder with hydrogen gas in a quartz tube. The ^{14}C ages of the samples were measured with the standard samples at the AMS facility at KIGAM (Korea Institute of Geoscience and Mineral Resources) [9]. We corrected the carbon isotopic fractionations by $\delta^{13}C$ measured at the AMS facility. The ^{14}C ages were calculated and converted into calendar dates using IntCal09 [10] and CALIB 6.0 [11].

4. Results

Based on our core analysis, six sedimentary facies were identified: a braided river channel, sand beach, tidal flat, inner bay, floodplain and artificial soil as illustrated in Fig. 3. These lithofacies along with remarks, depositional environments, and ages of the facies are described below. The radiocarbon ages are given in Table 1, and an age/depth diagram is illustrated in Fig. 4. The basement of these sediments, lower than a depth of 19.80 m, consisted of weathered granite. We identified the granite as the Daebo Granite of the Jurassic Period, as it is commonly found in this area [12].

4.1. Braided river facies: at a depth of 19.80–18.15 m

Description: This sediment consisted of alternating beds of sandy gravel layers and gravelly supported sand layers. Their gravels were semi-angular to semi-rounded, and the diameters were