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RADIOCARBON AGES OF MOLLUSCAN SHELL FOSSILS IN RAISED BEACH DEPOSITS ALONG THE EAST COAST OF LÜTZOW-HOLM BAY, ANTARCTICA, DETERMINED BY ACCELERATOR MASS-SPECTROMETRY

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Abstract: Radiocarbon ages of molluscan shell fossils embedded in raised beach deposits were measured by a Tandetron Accelerator Mass-Spectrometer at 12 locations in the Ongul Islands, Langhovde, and Skallen, all along the east coast of Lützow-Holm Bay, Antarctica. Radiocarbon ages determined by Tandem Accelerator Mass-Spectrometry are 34350±550, 35040±480, 36180±630, and 37420±720 years B.P. for the Ongul Islands, 3660±100, 33410±510, 34940±460, and 37200±910 years B.P. for Langhovde, and 3180±90, 3790±180, 4720±90, and 7810±130 years B.P. for Skallen, respectively.

1. Introduction

The precise knowledge of timing of peripheral recession and advance of sea areas is fundamental in order to reconstruct late Quaternary paleoceanographic changes in the eastern part of Lützow-Holm Bay, Antarctica. Age determination of marine sediments that crop out in the area as raised beach deposits can provide such chronological information because the preservation of beach deposits resulted from a process of ice sheet expansion and retreat.

A veneer of late Pleistocene to Holocene raised beach deposits occurs sporadically on Precambrian metamorphic rocks (HIROI and SHIRAISHI, 1986) that crop out at several ice-free areas along the Sôya Coast on the eastern shore of Lützow-Holm Bay. Previous workers attempted to determine ^{14}C ages of fossil marine organisms embedded in these deposits by applying traditional dating methods of β-ray counting such as gas counting technique or liquid scintillation technique (see KIGOSHI *et al.*, 1964; OMOTO, 1976).

In recent years, a new technique to establish ^{14}C ages, Tandem Accelerator

Mass-Spectrometry (TAMS) dating, has become available. This paper presents preliminarily re-examined ^{14}C dates at the Ongul Islands and Langhovde and reports the first ^{14}C dates from Skallen by TAMS dating method of molluscan shell fossils contained in the raised beach deposits. Further detailed discussion will be given in a separate paper.

2. Sampling Sites and Materials

Study areas are shown in Fig. 1. Samples of raised beach deposits were collected from four localities at the Ongul Islands, four at the northernmost coast of Langhovde, and four at Skallen during the 33rd Japanese Antarctic Research Expedition (JARE-33, 1991–1993). Materials used for dating are all molluscan shell fossils included in these deposits. Altitudes of these sampling sites, description of sediments and kinds of molluscan shell fossils recovered are listed in Table 1.

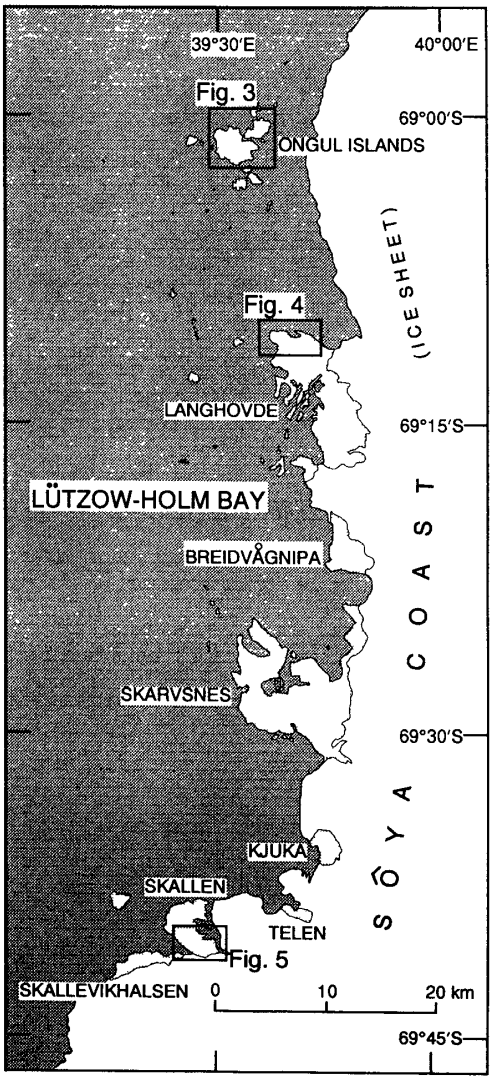

Fig. 1. Map of the east coast of Lützow-Holm Bay showing study areas.

Table 1. Description of sampling sites and results of radiocarbon dating.

Sample No.	Location	Altitude (m)	Sediments	Material	Age (yr. B. P.)
Nu-2	Northwestern part of East Ongul Island	10	Yellowish gray medium and fine-grained sand, containing pebbles and granules	Fragment of molluscan shell (*Laternula elliptica*)	37420±720
Ar-1	Aragane Dam, East Ongul Island	13	Brown coarse and medium-grained sand, containing pebbles and granules	Fragment of unidentified molluscan shell	36180±630
Wo-28	Northwestern part of West Ongul Island	18	Dark gray coarse and medium-grained sand, containing pebbles and granules	Fragment of unidentified molluscan shell	34350±550
Wo-48	Southeastern part of West Ongul Island	17	Dark gray fine-grained and silty sand, containing pebbles and granules	Fragment of molluscan shell (*Adamussium colbecki*)	35040±480
Ko-14	Lake Zakuro, Langhovde	−6	Yellowish gray coarse and medium-grained sand, containing pebbles and granules	Whole molluscan shell (*Laternula elliptica*)	33410±510
Ko-16	Lake Zakuro, Langhovde	6	Yellowish gray medium and fine-grained sand, containing granules	Fragment of molluscan shell (*Laternula elliptica*)	3660±100
Ko-20	Lake Zakuro, Langhovde	0	Gray fine-grained sand, containing pebbles and granules	Fragment of molluscan shell (*Laternula elliptica*)	37200±910
Ko-21	Kominato Inlet, Langhovde	8	Greenish gray medium and fine-grained sand	Whole molluscan shell (*Adamussium colbecki*)	34940±460
Mp-12	Magoke Point, Skallen	1	Greenish gray silt	Fragment of molluscan shell (*Laternula elliptica*)	3790±180
Mp-14	Magoke Point, Skallen	5	Greenish gray silty sand, containing granules	Fragment of molluscan shell (*Laternula elliptica*)	3180± 90
Ok-1	Lake Skallen Oike, Skallen	12	Gray coarse-grained sand, containing pebbles and granules	Fragment of molluscan shell (*Laternula elliptica*)	4720± 90
Ok-2	Lake Skallen Oike, Skallen	7	Gray fine-grained sand	Fragment of molluscan shell (*Adamussium colbecki*)	7810±130

3. Methods

Molluscan shell fragments were soaked in dilute hydrochloric acid for several hours and were cleaned ultrasonically. After drying, the fragments were ground into powder. About 15 mg each of carbonate sample was converted into CaO and CO_2 by combustion, and the CO_2 produced was reduced to graphite by reaction in H_2 with Fe as a catalyst. The graphite was used as the Cs beam target material of a tandem accelerator mass-spectrometer from which negative carbon ions were spattered into the vacuum system. The ^{12}C, ^{13}C, and ^{14}C contents of the graphites and the standard material were determined. Dating was performed by the Tandetron Accelerator Mass-Spectrometer at Nagoya University (see NAKAMURA and NAKAI, 1988).

4. Calculation

The ^{14}C ages "t" (years B.P.) were calculated by the following equation:

$$t = -8033 \ln \{As[1-(25+\delta^{13}C)/1000]/0.7459Anox[1-(25+\delta^{13}C')/1000]\}, \quad (1)$$

where As is the $^{14}C/^{13}C$ ratio of the sample, $Anox$ is the $^{14}C/^{13}C$ ratio of the NBS new oxalic acid standard, $\delta^{13}C$ is the per mil difference between the $^{13}C/^{12}C$ ratio of the sample and that of the PDB standard, and $\delta^{13}C'$ is the per mil difference between the $^{13}C/^{12}C$ ratio of the oxalic acid standard and that of the PDB standard (STUIVER and POLACH, 1977; STUIVER, 1983). In the equation, a Libby half life of 5570 years was used, and correction for isotopic fractionation effect on the $^{14}C/^{13}C$ ratios caused by exchange of CO_2 between the atmosphere and ocean was taken into account. The larger one of two errors was selected; either scatter error calculated with standard deviation of mean of the sample/standard ratios of $^{14}C/^{13}C$ or statistical error calculated using the total number of ^{14}C events for the standard and the sample. All dates are without correction for the reservoir effect that gives older than actual ^{14}C ages because of depletion of ^{14}C due to dilution with glacier melt water and upwelling of deep, old oceanic water (OMOTO, 1983; STUIVER *et al.*, 1986).

5. Results

The obtained ages are listed in Table 1 and are expressed as a diagram of the ages versus altitudes of sampling sites in Fig. 2.

At the Ongul Islands (Fig. 3), radiocarbon ages of the fossils ranged from 34350±550 years B.P. to 37420±720 years B.P. Altitudes of sampling sites stood rather high, ranging from 10 m to 18 m.

At the northernmost coast of Langhovde (Fig. 4), the fossil shells gave radiocarbon dates ranging from 33410±510 years B.P. to 37200±910 years B.P. except for one sample yielding a younger age of 3660±100 years B.P. Altitudes of sampling sites, ranging from −6 m to 8 m, were lower than those of the Ongul

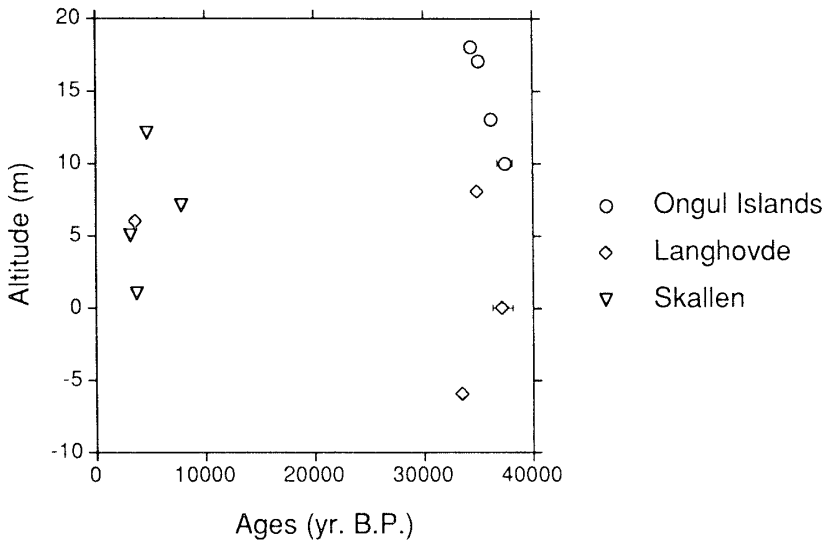

Fig. 2. Diagram showing ^{14}C ages versus altitude of this study.

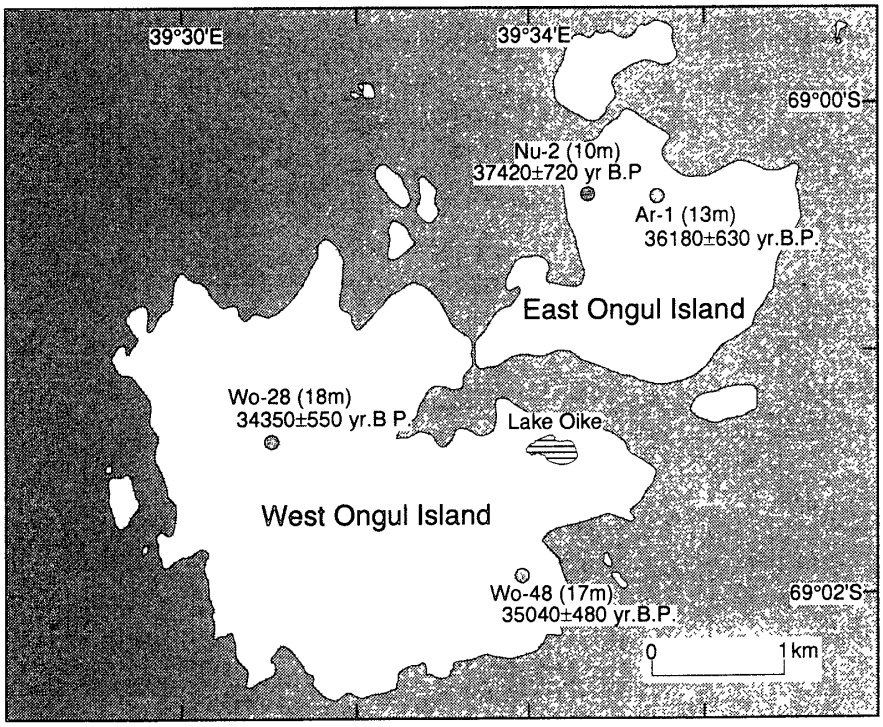

Fig. 3. Map of East and West Ongul Islands showing locations of samples, altitudes of the locations, and ^{14}C ages.

Islands.

At Skallen (Fig. 5), ages of the fossil shells ranged from 3180±90 years B.P. to 7810±130 years B.P. Altitudes of sampling sites ranged from 1 m to 12 m.

6. Remarks

There are some previous works on ^{14}C dates of fossil marine organisms

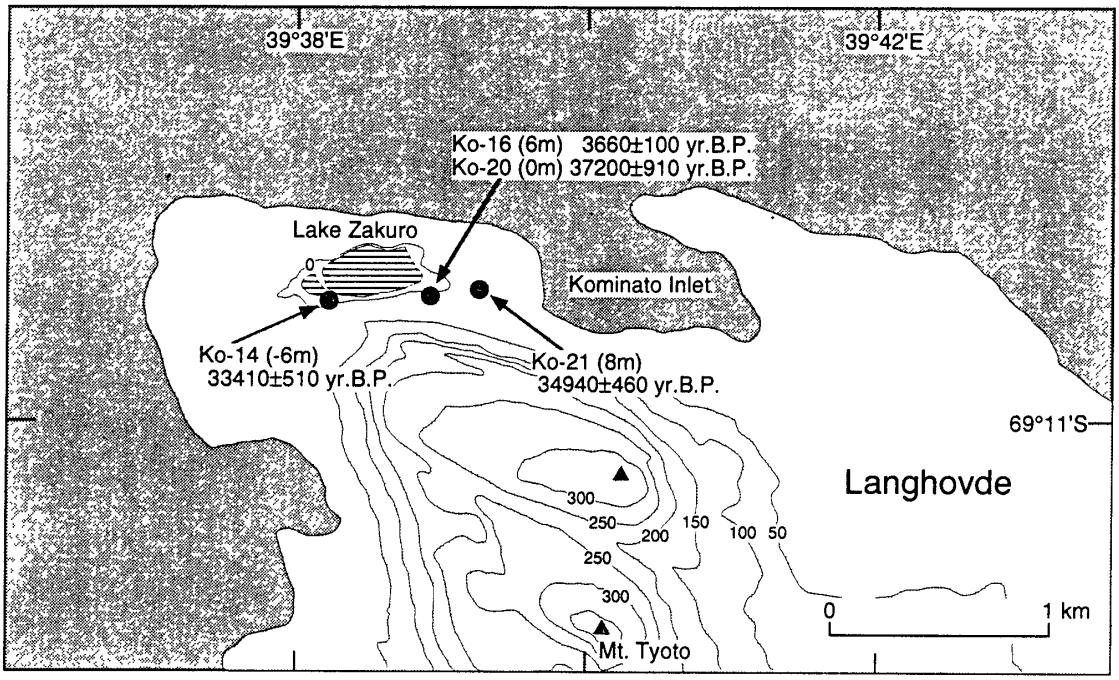

Fig. 4. Map of the northernmost coast of Langhovde showing locations of samples, altitudes of the locations, and ^{14}C ages. Contour interval 50 m.

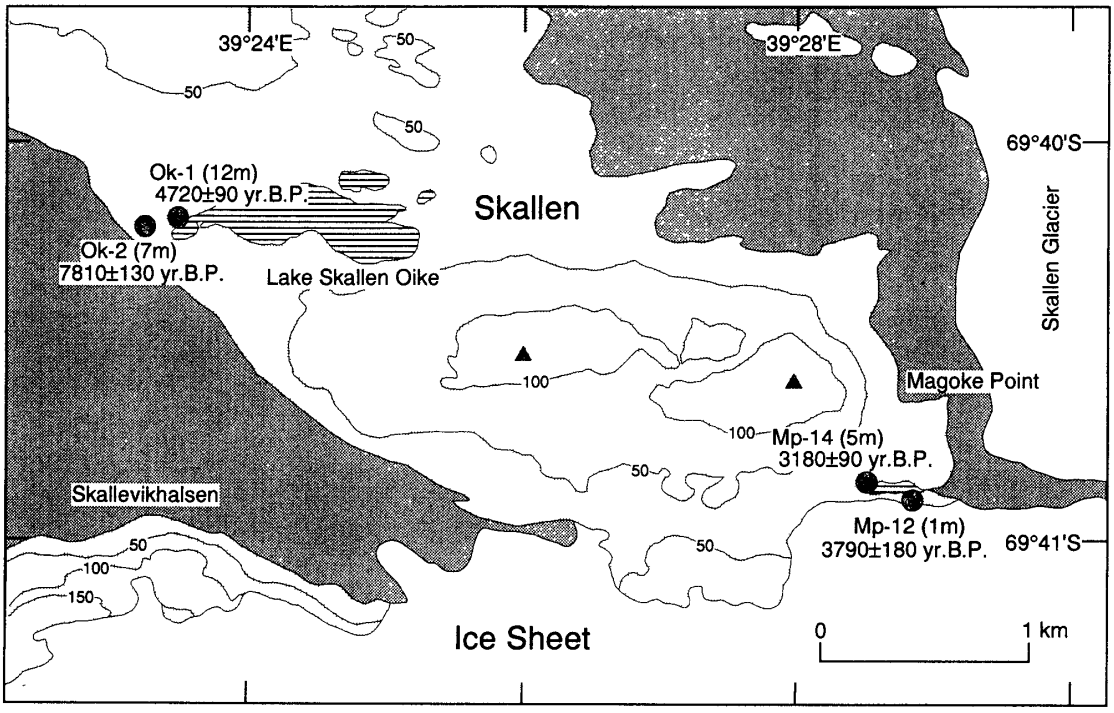

Fig. 5. Map of southern Skallen showing locations of samples, altitudes of the locations, and ^{14}C ages. Contour interval 50 m.

occurring in raised beach deposits on the Ongul Islands, Langhovde, and Skarvsnes (ISHIKAWA, 1974; MEGURO *et al.*, 1963; MORIWAKI, 1974, 1976; OMOTO, 1976, 1977, 1978; OMOTO *et al.*, 1974; YOSHIDA, 1970, 1973, 1983). These dates show a great range of variation over 20000 years B.P. (Figs. 6, 7). This variability might

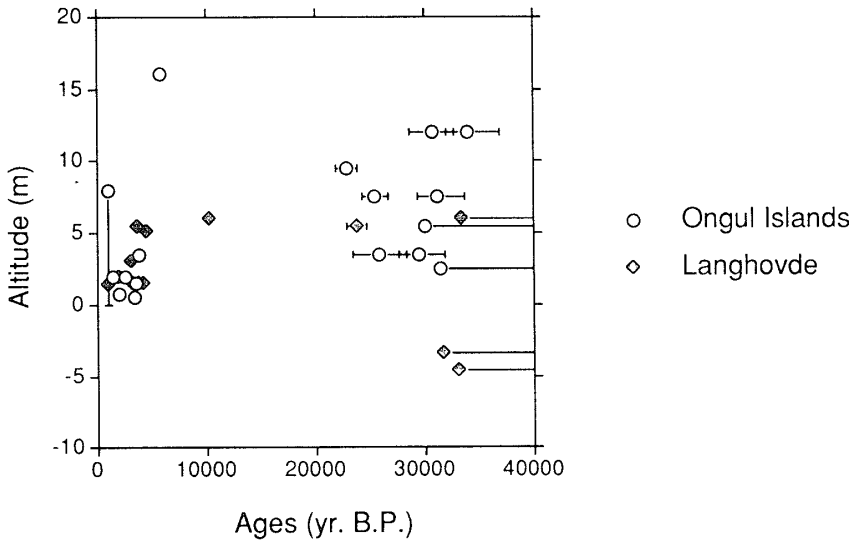

Fig. 6. Plots of ^{14}C ages versus altitude of raised beach deposits at the Ongul Islands and Langhovde. Data are quoted from ISHIKAWA *(1974),* MORIWAKI *(1974, 1976),* OMOTO *(1976, 1977, 1978),* OMOTO *et al. (1974), and* YOSHIDA *(1970, 1973, 1983).*

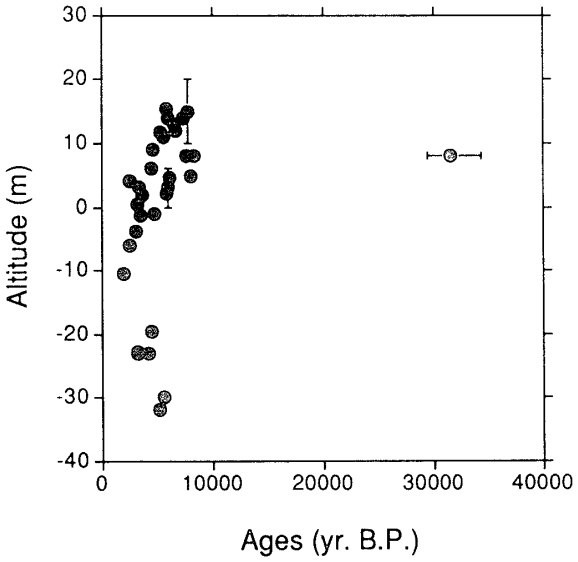

Fig. 7. Plots of ^{14}C ages versus altitude of raised beach deposits at Skarvsnes. Data are quoted from MORIWAKI *(1976),* OMOTO *(1976, 1977),* OMOTO *et al. (1974), and* YOSHIDA *(1970, 1983).*

be caused by mixing of old and young shell fossils in order to prepare about 100 g of calcium carbonate shells for dating. Furthermore, dates older than 20000 years B. P. have large error compared with those younger than 10000 years B.P. (Figs. 6, 7). This seems to reflect the limitation of the traditional ^{14}C dating method whose maximum measurable ages are thought to be about 40000 years B.P.

In the TAMS measurement adopted in this study, the amount of ^{14}C in graphite obtained from only about 15 mg of calcium carbonate sample can be counted precisely. Furthermore, the maximum age detection has been extended to about 60000 years B.P., and scatter or statistical errors have been smaller than those

obtained by the traditional dating method.

Based on this study and previous studies, raised beach deposits along the Sôya Coast distinctly cluster into two age groups: one falling between about 33000 and 38000 years B.P., and the other being less than about 10000 years B.P. In particular, almost all these ages at Skarvsnes and Skallen, that is, on the southern part of the Sôya Coast, range from about 2000 to 8000 years B.P., with the exception of one age showing 31600 (+2800, −2100) years B.P. at Skarvsnes (Figs. 2, 7). The present study clearly indicates that older raised beach deposits at Skarvsnes should be re-examined by the TAMS method.

The application of the TAMS dating method to shell fossils in raised beach deposits enables us to date precisely the timing of transgression in the Antarctic coastal region. Such knowledge will also assist our attempt at better understanding paleoenvironmental changes in the region.

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