SOME CONSIDERATION ON ELEVATED COASTAL FEATURES AND THEIR DATES AROUND SYOWA STATION, ANTARCTICA

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Abstract: Near Syowa Station, Antarctica, elevated beaches develop in many of the ice-free coastal areas up to 35 m above sea level. These elevated beaches contain many marine organic remains. Their radiocarbon dates can be divided into younger (2000–8000 years B.P.) and older (20000–35000 or more years B.P.) groups. From the former dates the rate of a relative uplift is estimated as 2.5 mm/year on the average, possible maximum being 5 to 6 mm/year. On the other hand, radiocarbon datings on several kinds of living marine organisms yielded a mean value of 1120 years B.P. This value may be used as a correction factor for radiocarbon dates of marine organic remains in this area.

1. Introduction

Antarctic ice-free coastal landforms are essential for the elucidation of the geomorphic development of the Antarctic Continent, especially for clarifying the crustal movement relative to the sea level. Many descriptions and discussions have been made on elevated beaches and have brought fruitful results on the explanation of coastal development of the Antarctic (for example, NICHOLS, 1966; JOHN, 1972). It seems, however, that more field data should be accumulated for detailed discussion of the problems. In this connection, the Dry Valley Drilling Project (DVDP) provided invaluable information on the late Cenozoic history of the Antarctic. The present authors present here a progress report on the age of elevated beaches around Syowa Station, which may contribute, though limitedly, to the future development of DVDP.

2. Elevated Beaches and Their Dates

2.1. Topography

Well-developed elevated beaches occur in the coastal ice-free areas near Syowa Station, East Antarctica, often as pocket beaches. Well-defined maximum heights of these beaches and marine terraces are 20 to 25 m along the eastern coast of Lützow-Holm Bay and 30 to 35 m above sea level along the Prince Olav Coast.

The elevated beaches in some places have many steps which appear to have been formed successively as the relative lowering of sea level progressed.

Some steps seem to have been shaped by solifluction due to soaking of sea water close to the sea level. However, the existence of a few incomplete beach ridges indicates that the influence of weak wave action contributed to the formation of steps to some extent. Marine boulder pavement also develops on the Prince Olav Coast much better than on the east coast of Lützow-Holm Bay. This fact may reflect the difference in the magnitude of wave action between the Prince Olav Coast and Lützow-Holm Bay. In any case, it is almost indisputable that the topography of elevated beaches was formed under the circumstances close to the sea level.

2.2. Age

Beach deposits contain abundant organic remains such as fragments of shells, tests of Foraminifera, worm tubes, etc. Well-preserved *Adamussium colbecki* SMITH, *Laternula elliptica* and some worm tubes occur as *in situ* fossils. Adhesion of coralline algae to bedrock is also an indication of uplift of the ground.

Many radiocarbon datings were made on these organic remains. Most of datings were carried out by Dr. KIGOSHI, Gakushuin University. The dates, the kind of organisms and the altitude of sampling sites are plotted on the diagram (Fig. 2). It is obvious that the altitudes of occurrence of organic remains do not directly indicate the former levels of sea, because the habitat of these marine organisms is not always close to the sea level. The altitudes of their occurrence give only the mini-

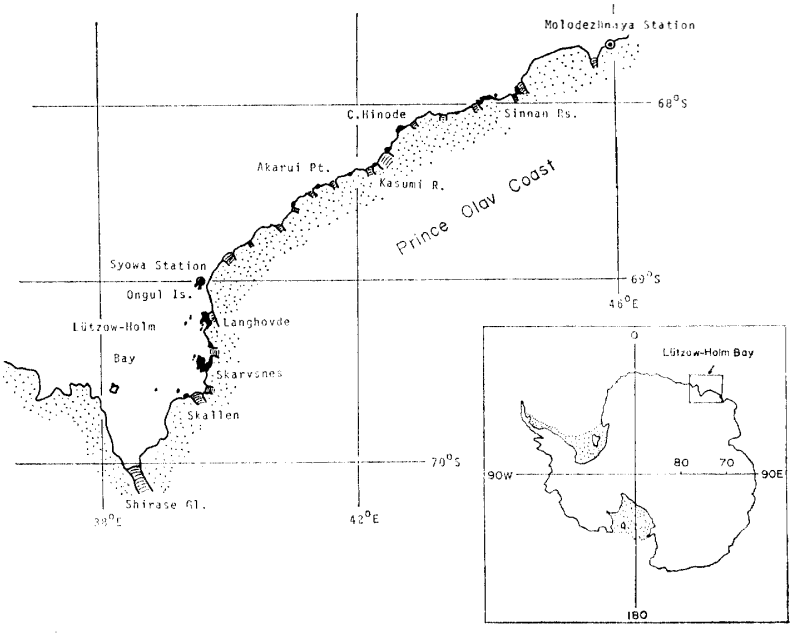

Fig. 1. Location map.

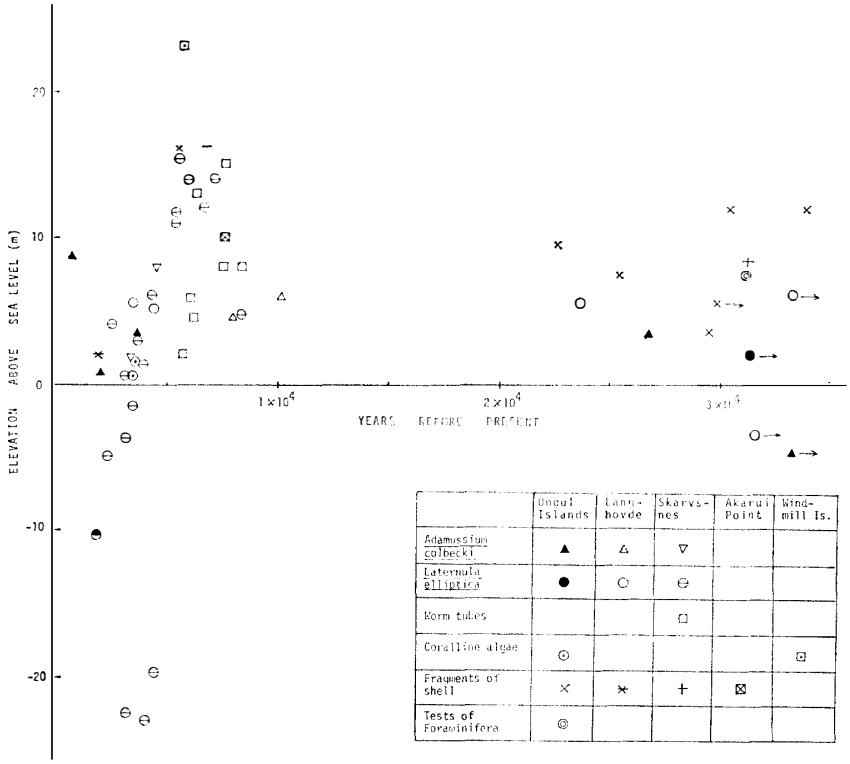

Fig. 2. Relationship between the radiocarbon dates of marine organic remains and the elevations of their occurrence, according to sampling areas and kinds of organisms. Data by Dr. M. NOGAMI, Tokyo Metropolitan University, are included. For the uniformity of chemical analysis, most of data by Dr. K. OMOTO are excluded (which does not mean Dr. OMOTO'S data are doubtful).

mum heights of the former sea levels. However, the outline of the relative uplift of coastal ice-free areas can be deduced from even such incomplete data. Many more dating data will make up for the imperfection of data.

From Fig. 2 the radiocarbon dates can be divided roughly into two groups. The one is so-called "Post-glacial" in age, the dates falling between about 2000 and 8000 years B.P. The other belongs to ages between about 20000 and 35000 years B.P.

The following conclusions can be drawn from the dates of the younger group.

i) The rate of the uplift of the submerged ice-free areas relative to the sea level seems to be at least 2.5 mm/year on the average during the last 6000 years. OMOTO (1977), in his detailed study, estimated the rate as 0.6 to 2.7 mm/year. If 30 to 35 m high elevated beaches and marine terraces on the Prince Olav Coast where no positive chronological evidence is available are assumed to have been formed around 6000 years B.P., the rate of the relative uplift would amount to 5 to 6 mm/year. The result from Windmill Islands in Wilkes Land (CAMERON and GOLDTHWAIT, 1961) suggests that the rate of the relative uplift reached 4 mm/year. It is noteworthy

that these rates of crustal uplift are comparable with those in the Circum-Pacific orogenic regions where the active up-lift is taking place.

ii) Organic remains occurring at higher sites were dated as around 6000 years B.P. In the McMurdo Sound region, the highest elevated beach is thought to have been formed 7000 years B.P. (NICHOLS, 1966). A 6000 years old terrace was found on Windmill Islands (CAMERON and GOLDTHWAIT, 1961). These facts indicate that after deglaciation of inland ice starting from coastal areas, the rate of rise of the sea level had been greater than or at least equal to the rate of crustal uplift prior to 6000 years B.P. OMOTO (1977) speculated that both the rates had been almost equal.

It is difficult to explain clearly the dates of the older age group, ranging 20000 to 35000 years old. HENDY *et al.* (1969) postulated that 30000 years old elevated marine sediment on Ross Island in the McMurdo Sound region had been deposited during the mid-Wisconsin Interstadial. In a region where the crustal uplift is active during the late Quaternary epoch, a marine terrace of about 30000 years old can be found (OKA, 1970). However, evidence for the mid-Wisconsin sea level is very scarce in the Antarctic. MIAGKOV *et al.* (1976) discussed sea level changes in the last 50000 years in the McMurdo Sound region. On the other hand, BRADY (1977) postulated that 30000 to 50000 years old shorelines discussed in the above-mentioned papers were incorrect from the viewpoint of diatom analysis.

FUJIWARA (1973) examined elevated beaches on East Ongul Island in Lützow-Holm Bay, and concluded that the relative sea level lowered gradually during the last 30000 years. However, the result of radiocarbon datings is not always coincident with this conclusion.

Above all, it seems to the present authors that the data are still insufficient for detailed discussion about the older elevated beach deposits, and that a hasty conclusion should not be drawn at the present state of knowledge. It can be safely said that at least before 30000 years deglaciation of the ice sheet took place in the coastal area of Lützow-Holm Bay and Prince Olav Coast. Comparison of degree of weathering of bedrocks between these areas and the coasts of the Antarctic Peninsula where rather fresh bedrocks are exposed, though based on only visual observation, seems to support this conclusion.

3. Radiocarbon Datings of Living Marine Organisms

Previous considerations are based mainly on radiocarbon datings of fossil marine organisms. Radiocarbon dates of these organic remains, however, are often said to be problematical, especially in the Antarctic regions. OMOTO (1977), who discussed geomorphic development of the Lützow-Holm Bay region during the last 50000 years, had some doubt about the validity of radiocarbon dates older than 20000 years.

Apart from the older ages, the present authors would deal with the question of the younger ages and present a preliminary result. Living marine organisms often give ages of several hundreds to about one thousand years. SIEGEL and DORT, Jr. (1969) used a correction value of 650±100 years for the date on a mummified seal from the McMurdo Sound region. The problem of deficiency of ^{14}C in the Antarctic marine living organisms arouses scientific interest, because it may be related to i) interference by ice against exchange of carbon dioxide between atmosphere and sea, ii) supply of older air by melting of the ice sheet and icebergs, iii) ecosystem, such as a possible simple food chain, etc. OMOTO (1972) obtained the result that the sea water near Syowa Station included 2860 years and 880 years old carbon, and concluded that the meltwater from the ice sheet was the main cause of deficiency of ^{14}C in marine organisms.

As one step to approach these problems and the obtain a reasonable correction value for radiocarbon datings, analysis of living marine organisms was attempted. Dr. HOSHIAI, National Institute of Polar Research, collected suitable samples from Lützow-Holm Bay. Datings were made by Dr. KIGOSHI, Gakushuin University. The result is shown in Table 1. Samples were fish, sea urchin, sea snail, and starfish. The values are considerably uniform, the average being 1120 years old. STUIVER

Table 1. Radiocarbon dates of living marine organisms.

Code No.	Sample	Sampling depth	Years before 1950
GaK-6789a	*Neoliuccinum eatoni.* Dated on flesh.	17~35 m	1.190±90* ($\Delta^{14}=-137.9\pm9.2‰$, $\delta^{13}C=-19.1‰$)
GaK-6789b	Sample is same as GaK-6789a. Dated on shell.	〃	1.300±90
GaK-6790a	*Ophionotus victoriae.* Dated on flesh.	92 m	1.070±90* ($\Delta^{14}=-124.6\pm9.7‰$, $\delta^{13}C=-12.9‰$)
GaK-6790b	Sample is same as GaK-6790a. Dated on shell.	〃	1.210±100
GaK-6791a	*Sterechinus neumayeri.* Dated on flesh.	17 m	1.160±110* ($\Delta^{14}=-134.4\pm12.2‰$, $\delta^{13}C=-10.47‰$)
GaK-6791b	Sample is same as GaK-6790a. Dated on shell.	〃	860±110
GaK-6792	*Trematomus berunacchii*	15 m	1.160±110* ($\Delta^{14}=-148.4\pm8.8‰$, $\delta^{13}C=-19.4‰$)
GaK-6793	*Zoarcidae* sp.	500 m	1.010±110* ($\Delta^{14}=-118.2\pm12.5‰$, $\delta^{13}C=-21.6‰$)

Samples were collected by Dr. T. HOSHIAI from the sea around Syowa Station during October and December of 1975. Datings were conducted by Dr. K. KIGOSHI. Isotope fractionation correction was made on the dates with asterisks.

et al. (1976) suggested that the correction factor for radiocarbon dates of *Adamussium colbecki* collected from New Harbor, McMurdo Sound region, would fall between 850 and 1400 years. It is noteworthy that these values are fairly coincident with those obtained from Lützow-Holm Bay in spite of the difference in kind of organisms. For the present the mean value of 1120 years may be used as a correction factor in this area. If this is applied to the above-mentioned dates of organic remains, the rate of relative uplift will somewhat increase.

4. Concluding Remarks

In the present paper, the authors briefly discussed the elevated coastal landforms and their dates near Syowa Station, Antarctica, and presented a result of radiocarbon dating of living marine organisms as a basis for future discussion on the deficiency of radiocarbon in the Antarctic seas and on the correction factor for dating the remains of marine organisms. Elevated beaches of the Antarctic coast is one of the clues to elucidate the geomorphic development of the Antarctic, and many works have been done. However, ambiguity remains on the mode of uplift, the relationship between sea level change and uplift, and the relationship between emerged and submerged (*i.e.* drowned glacial topography) landforms. A study on deficiency of radiocarbon in sea water will provide some basis for the dating of elevated landform, as well as information on the behavior of sea water and on ecosystem.

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