^{14}C AGE CORRECTIONS BASED ON ISOTOPE FRACTIONATIONS FOR BEACHROCK SAMPLES FROM THE NANSEI ISLANDS, SW JAPAN

Kunio Omoto

Department of Geography, College of Humanities and Sciences, Nihon University, 24-40, 3 Chome, Sakurajosui, Setagaya-ku, Tokyo 156-8550, Japan. Email: omoto@chs.nihon-u.ac.jp.

ABSTRACT. The purpose of this paper is to determine an average age correction for fossil shells, fossil coral, and calcarenite samples from the Nansei Islands, SW Japan. Isotope fractionations of 414 beachrock samples were analyzed, and age corrections for the different materials comprising the beachrocks ranged between 573 and 311 yr, with an average age of 446 yr. The averages for fossil shells, fossil coral, and calcarenite samples were 464, 438, and 441 yr, respectively. These figures are useful for correcting ^{14}C ages that were determined previously without isotope corrections.

INTRODUCTION

The islands comprising Japan are located on the Eurasian and North American plates where the Pacific Plate and the Philippine Sea Plate subduct under those 2 plates. Along their subduction zones, huge earthquakes occurred during periods of recorded history as well as during prehistoric times. They occurred frequently along the 2 plate boundaries and formed numerous marine terraces along the coasts. Many Japanese geomorphologists have reported relationships between seismic crustal movements and uplifted marine terraces (e.g. Konishi 1965; Nakata et al. 1978, 1980; Ota et al. 1978; Ota 1980; Koba 1980, 1983; Kawana 1985, 1989; Ota and Omura 1992). Natata et al. (1979) investigated Holocene marine terraces develop on Kikai Island of Nansei Islands and the coast of Boso Peninsula located near Tokyo. They concluded that Holocene marine terraces in seismically active regions are good recorders for the history of major earthquakes originating along active submarine faults. Their detailed investigations on these terraces enable us to clarify the ages of earthquakes and the frequency of major earthquakes.

As for the Nansei Islands (Figure 1), a number of Japanese geoscientists have reported on the sea-level changes and tectonic movements during the Holocene and Late Pleistocene. These reports are based on radiocarbon ages and elevations of uplifted fossil corals and beachrock. However, almost all of the ^{14}C dates determined before 1990 were uncorrected for isotope fractionation.

Isotope fractionation is essential for obtaining correct ^{14}C ages as recommended by Stuiver and Polach (1977). Therefore, we use isotope fractionation to determine the recurrence of huge earthquakes in order to save many lives and property. In this region, it is necessary to obtain accurate and reliable ages in order to estimate precisely when the next major earthquake may occur in the future.

This paper proposes age corrections for marine samples from the Nansei Islands based on calculations of their isotope fractionations. Using these figures, we will be able to estimate correct recurrent times of huge earthquakes that will undoubtedly occur in the future.

DATA SOURCES

Ginsburg (1953) defined beachrock as a friable to well-cemented rock consisting of calcareous skeletal debris cemented by calcium carbonate. While mineral grains and rock fragments are common in beach deposits, they also occur in the beachrock. Beachrock occurs in thin beds dipping seaward at <15°. Moreover, beachrock forms only in the intertidal zone. Beachrock commonly forms on tropical and subtropical sandy beaches where it represents small-scale *cuesta* topography with thin slabs (strata) that dip seaward (Higgins 1968).

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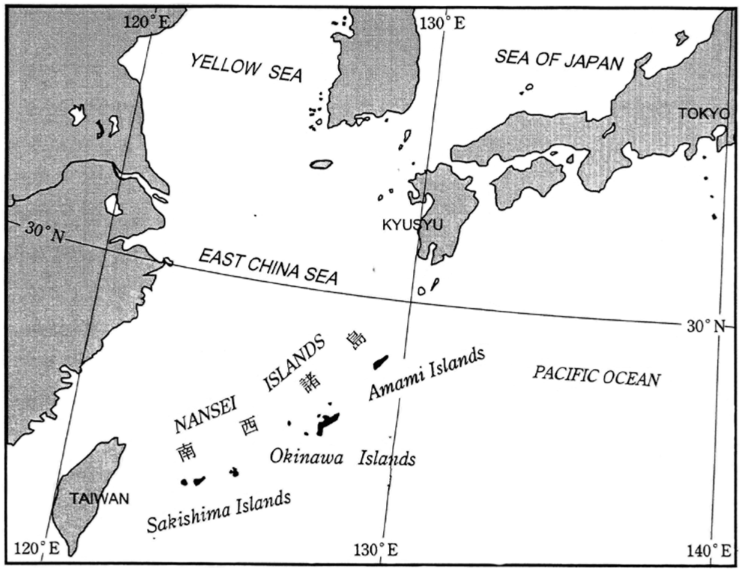

Figure 1 Map of the surveyed islands

Most authorities believe beachrock formed within the range of the intertidal zone, where beach sediments, including fragments of shells, corals, foraminifers, and other marine biocarbonates were cemented by calcium carbonate and magnesian calcite (Figure 2). Therefore, beachrock not only provides good sample material for ^{14}C dating but also provides good indications of past sea levels (Omoto 2005b).


Figure 2 Photo of beachrock, including fragments of fossil shells (mostly *Tridacna sqamosa*) and fossil corals (*Acropora*, *Polites*, *Goniastrea* sp., etc.).

Omoto (2004, 2005a) compiled ^{14}C ages and isotope fractionations of 414 beach rock samples collected from 158 sites on 29 of the Nansei Islands. The samples consisted of 146 calcarenite samples, 116 fossil corals, and 152 fossil shells. The data for this paper is based on the above reports. Figures for age corrections were calculated and based on the individual $\delta^{13}C$ values (Figure 3) for each sample material reported by Omoto (2005a). The results are shown in Table 1.

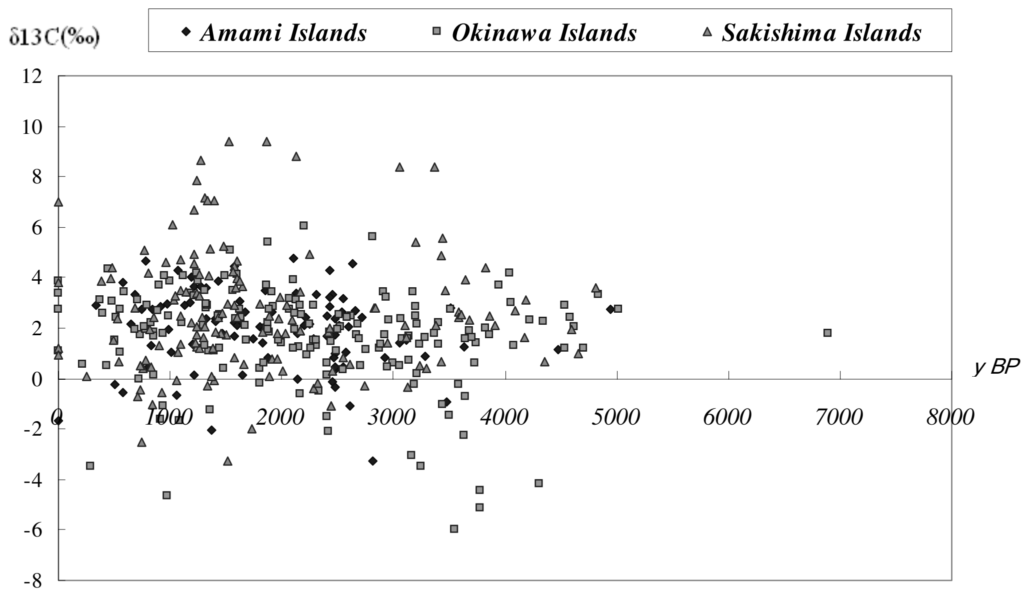

Figure 3 $\delta^{13}C$ values and ^{14}C ages of beachrock samples collected from the Nansei Islands (Omoto 2005b)

DISCUSSIONS AND SUMMARY

The age correction figures of marine samples ranged between 573 and 311 yr; the average figure for all samples collected from the 29 Nansei Islands was 446 yr (Table 1). The maximum and minimum figures of age corrections for calcarenite samples were 573 and 361 yr, respectively, while the average was 441 yr (Table 1). The maximum and minimum figures of age corrections for coral samples were 531 and 311 yr, respectively, while the average was 438 yr. The maximum, minimum, and average figures of age corrections for fossil shells were 573, 328, and 464 yr, respectively (Table 1). Different figures of age corrections indicate different values of isotope fractionations of the sample materials, which might have been environmentally influenced when the organisms were alive or by their position within food-chains (Omoto 2005b).

The maximum age correction was applied to 1 shell sample (*Tridacna squamosa*) and 1 calcarenite sample collected from Ishigaki Island, while the minimum age correction was applied to 1 shell sample (*Tridacna squamosa*) collected from Okinawa Island.

The maximum, minimum, and average age corrections for Amami Islands samples were 493, 356, and 445 yr, respectively. The maximum, minimum, and average age corrections for Okinawa Island samples were 515, 311, and 438 yr, respectively. The maximum, minimum, and average age corrections obtained for the Sakishima Island samples were 573, 356, and 456 yr, respectively. Different age correction figures seem to be caused by the influence of the island's geology (composed of the Ryukyu Limestone) and an obviously different origin of calcium carbonate in meteoric water (Omoto 2005b).

Table 1 ^{14}C age corrections for beachrock samples from the Nansei Islands (calculated using data sets of Omoto [2005a]).

Island	Calcarenite				Coral				Shell				Total			
	nr	max	min	avg	nr	max	min	avg	nr	max	min	avg	nr	max	min	avg
Amami Islands																
Amami Oshima	12	447	377	419	7	442	393	420	7	469	412	433	26	469	377	423
Kakeroma	2	449	445	447	0	—	—	—	0	—	—	—	2	449	445	447
Yoro	0	—	—	—	1	383	383	383	0	—	—	—	1	383	383	383
Tokuno	6	456	356	432	4	441	356	434	6	491	459	474	16	491	356	449
Okinoerabu	11	466	415	452	10	485	397	448	5	493	469	480	26	493	397	456
Yoron	13	477	439	457	4	464	435	451	4	485	459	470	21	485	435	458
Subtotal	*44*	*477*	*356*	*441*	*26*	*485*	*356*	*436*	*22*	*493*	*412*	*462*	*92*	*493*	*356*	*445*
Okinawa Islands																
Iheiya	4	449	373	429	6	478	445	461	9	420	412	417	19	478	373	451
Izena	3	436	421	429	1	353	353	353	3	432	328	393	7	436	328	421
Okinawa	10	508	422	449	23	454	311	413	27	482	333	429	60	508	311	429
Ie	13	461	415	444	2	472	423	447	11	515	428	462	26	515	415	452
Aguni	3	439	432	434	1	409	409	409	2	470	458	464	6	470	409	440
Kume	5	470	432	445	7	451	377	417	7	455	421	446	19	470	377	435
Oha	0	—	—	—	0	—	—	—	3	464	450	459	3	464	450	459
Oh	7	461	415	441	2	435	423	429	3	469	431	447	12	469	415	440
Hatenohama	7	481	433	461	1	431	431	431	1	431	431	431	9	481	431	2.5
Zamami	2	465	451	458	1	459	459	459	10	498	432	468	13	498	432	466
Tokashiki	0	—	—	—	1	402	402	402	1	461	461	461	2	461	402	432
Aka	0	—	—	—	1	412	412	412	1	468	468	468	2	468	412	440
Geruma	0	—	—	—	1	392	392	392	0	—	—	—	1	392	392	392
Subtotal	*54*	*508*	*373*	*445*	*47*	*478*	*311*	*421*	*77*	*514*	*328*	*444*	*178*	*515*	*311*	*438*
Sakishima Islands																
Miyako	16	453	370	427	15	457	378	420	16	531	435	476	47	531	370	441
Tarama	5	452	409	439	1	407	407	407	2	466	454	460	8	466	407	440
Ishigaki	7	573	471	527	18	532	356	438	16	573	414	474	41	573	356	467
Hatoma	0	—	—	—	0	—	—	—	2	496	470	483	2	496	470	483
Yonaguni	3	452	423	434	2	473	414	443	2	526	451	489	7	526	414	452
Iriomote	5	555	405	468	3	453	421	441	4	555	471	505	12	555	405	473
Kohama	1	443	443	443	0	—	—	—	1	455	455	455	2	455	443	449
Taketomi	3	482	462	469	2	482	442	461	1	500	500	500	6	500	442	471
Kuro	5	445	429	438	0	—	—	—	1	461	461	461	6	461	429	442
Hateruma	3	468	454	460	2	443	436	439	8	488	447	471	13	488	429	464
Subtotal	*48*	*573*	*361*	*454*	*43*	*531*	*361*	*432*	*53*	*573*	*414*	*477*	*144*	*573*	*356*	*456*
Total	**146**	**573**	**361**	**441**	**117**	**531**	**311**	**438**	**152**	**573**	**328**	**464**	**414**	**573**	**311**	**446**

It is clear that figures of age corrections differ with the island surveyed and with the date of the materials. Therefore, corrections based on the isotope fractionations are significant and indispensable for obtaining correct ^{14}C ages. Omoto (1976, 2001) previously reported a figure of 450 yr for the ocean reservoir effect of Okinawa Island, while Stuiver and Braziunas (1993) proposed an average figure of 400 yr to reservoir correction for world's oceans. The former figure offset 446 yr given to the average age correction over 29 of the Nansei Islands.

Using the figures shown in Table 1, we obtain ages that are more accurate by correcting the previously determined uncorrected ^{14}C ages without the isotope corrections. Based on these results, we are now able to make a more accurate estimate of recurrent times of the next huge earthquakes, and we can provide countermeasures for natural calamities that are triggered by huge earthquakes.

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