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801. NEW DATA ON URANIUM-SERIES AGES OF HERMATYPIC CORALS FROM THE PLEISTOCENE LIMESTONE ON KIKAI, RYUKYU ISLANDS*

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Abstract. Twenty-one Pleistocene corals newly collected at fourteen localities on the island of Kikai were dated by the uranium-series $^{230}Th/^{234}U$ method. One of the most salient observations is that a part of the Pleistocene limestone on the island was dated to be Middle Pleistocene in age, which may be correlative with two stages of the high sea stand. The one is corresponding to the stage 7 of the marine oxygen isotopic record (Emiliani and Shackleton, 1974), approximately 200,000 years B.P., and the other may be correlative to the stage 9 (or older one), 250,000 years or more B.P. From the distribution of corals assigned to more than 250,000 years and the lithology of limestone including those corals, the very shallow environment where hermatypic corals could grow up is inferred to have spread at that time over the area having a diameter of at least 6.5 km. Namely, the initial coral reef settled directly onto the Pliocene basement (Somachi Formation; Nakagawa, 1969) might be a fairly extensive table reef and the limestone deposited as such a reef is nowadays composed the basal part of Late Pleistocene limestone. The other new uranium-series dates also are shown in the present paper.

We point out, based on these new $^{230}Th/^{234}U$ dates, that the geologic history itemized by Konishi *et al.* (1970) should be modified, although it is not necessarily required to change principally the articles concerning the history since the past 130,000 years.

Introduction

The Pleistocene limestone (Riukiu Limestone of Hanzawa, 1935) on the island of Kikai has been chronologically studied in some detail mainly by employing the uranium-series dating technique (Komura and Sakanoue, 1967; Konishi *et al.*, 1970, 1974; Omura, 1983). So far, the $^{230}Th/^{234}U$ and $^{231}Pa/^{235}U$ coral dates number between forty and fifty. In addition to them, the ESR (electron spin resonance) dating also has been applied to some corals on this island (*e.g.*, Ikeya and Ohmura, 1983). The number of radiometric dates, however, is not necessarily

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enough to discuss exhaustively the geologic history of the island and to correlate the Pleistocene limestone on Kikai with the counterparts in other areas.

The present paper deals with $^{230}Th/^{234}U$ ages for hermatypic corals collected at new localities, from most of which no radiometric date has been reported. In this study, we try to examine the following two problems which remain still equivocal. (1) Since when has the coral reef been settled in the place where Kikai is at present? How was the scale of such an initial reef? It is the chief concern of ours to examine whether the dates assigned to 200,000 years or more can be obtained for corals from the Pleistocene limestone on Kikai. Although they were verified from two islands in the Ryukyu Islands, Hateruma (Konishi, 1980; Omura, 1984) and Toku (Omura, 1982), yet no uranium-series dates indicative of Middle Pleistocene have been reported from this island. (2) When and how was the uppermost terrace formed? Konishi *et al.* (1970, 1974) inferred that the oldest part of the Pleistocene limestone distributing in the highest area of the island was deposited at the time of the highest sea stand through the last interglacial from three uranium-series ages (122,000 ± 2,000 to 128,000 ± 3,000 years) of corals collected at the height of 170 m. They defined such a stratigraphic unit of reefy limestone as the Older Member of Riukiu Limestone. The height of the shoreline at that time of formation of the Older Member was thought to be more than 200 m in present altitude. In order to inspect their estimation, we devoted special attention to collect the datable coral samples from the localities of the height of 200 m or more.

Samples

Radiochemical analyses were carried out on twenty-one hermatypic coral samples including seven genera of *Favia*, *Goniastrea*, *Porites*, *Montipora*, *Favites*, *Galaxea* and *Montastrea*. Among them, five genera except *Galaxea* and *Montastrea* are most representative of corals occurred in the Pleistocene limestone on Kikai. Table 1 lists numbers, taxonomy and elevation for all samples examined. The localities of them are plotted in Text-fig. 1 together with those of both hermatypic and ahermatypic solitary corals dated previously to be Late Pleistocene in age (see the papers of Konish *et al.*, 1974, and Omura, 1983, for details).

Fossil corals found at the outcrops of Pleistocene limestone were examined very carefully on their mode of occurrence and mineralogy. The samples for dating purpose were selected during the field survey owing to their original position of growth and to nature of neither pore-filling nor recrystallization. Three samples (OA053, AO089 and AO152) listed in Table 1 were apparently not in situ.

Prior to the isotopic analysis, the X-ray powder diffraction method of Davies and Hooper (1963) was used for each sample in order to check the existence of the secondary calcite and the calcite/aragonite ratio. As the results, more than 5% of calcite were detected in four samples (AO091, AO173, AO085 and AO175). Particularly, AO085 and AO175 samples were composed of the high percent (25 and 40%, respectively) of the secondary calcite. The other seventeen samples were free from calcite or consisted of more than 95% of the original aragonite.

Results and discussion

Table 2 summarizes analytical results and $^{230}Th/^{234}U$ ages calculated from the following equation;

$$^{230}Th = {}^{238}U[1-\exp(-\lambda_0 t)] + ({}^{234}U - {}^{238}U)[\lambda_0/(\lambda_0 - \lambda_4)][1-\exp(\lambda_4 t - \lambda_0 t)]$$

where λ_0 and λ_4 are decay constant of ^{230}Th and ^{234}U, respectively.

Known quantities of ^{232}U and ^{228}Th were used as yield tracers in the analyses of the radioisotopes listed in the table. The quoted errors (one standard deviation) are based on the counting statistical fluctionations only. In calculation of the ages, we assumed that ^{230}Th was initially absent or present in negligible amounts and

Table 1. List of the dated coral samples from the Pleistocene limestone on the island of Kikai.

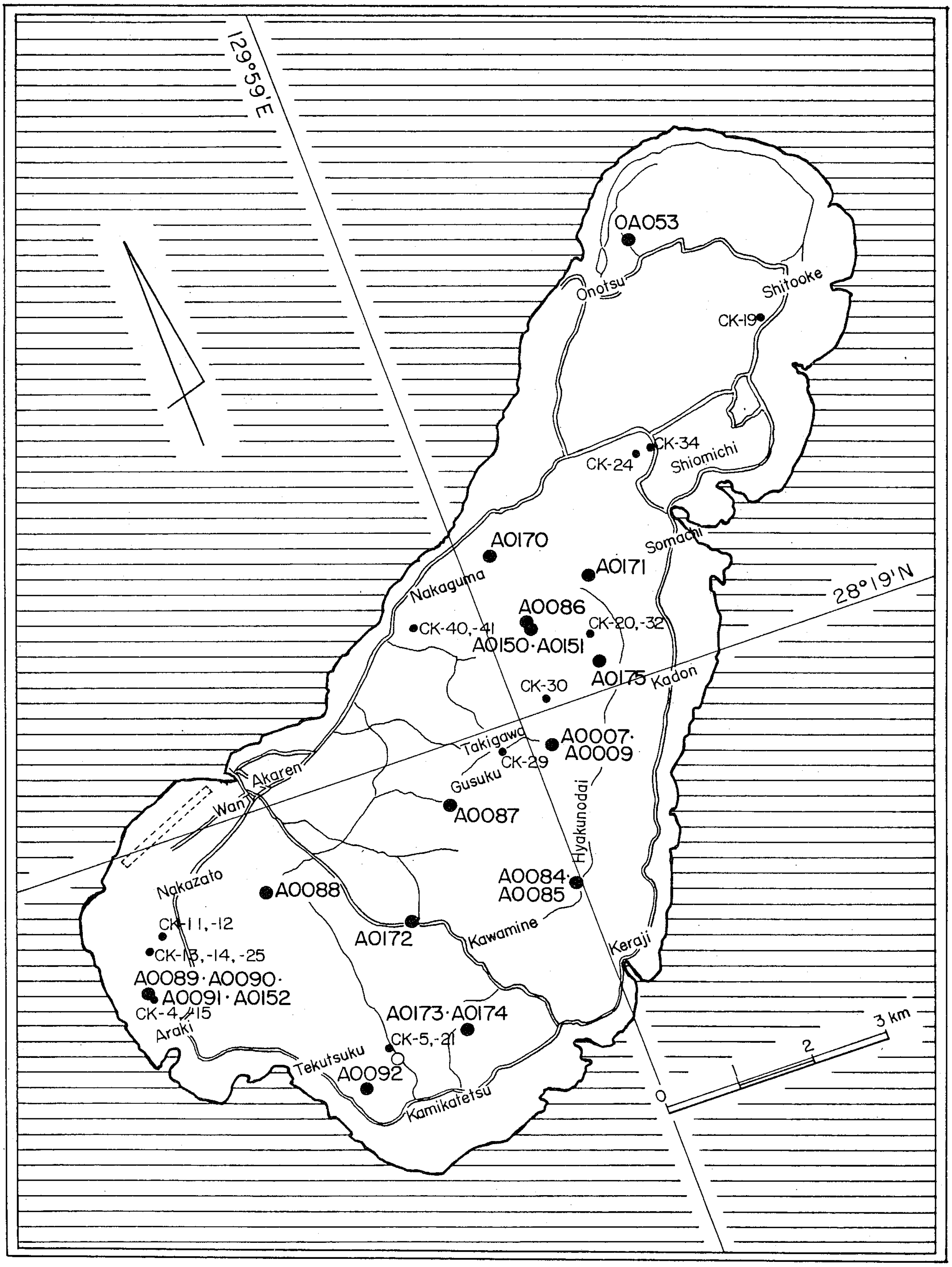
Code Number	Sample Number	Genera	Elevation	Calcite / Aragonite
OA053	CK-23	*Favites*	40 m	< 0.05
AO007	75-4-1-3A	*Goniastrea*	170	0
AO009	75-4-1-3B	*Goniastrea*	170	0
AO084	K-C-11	*Porites*	210	< 0.01
AO085	K-C-4	*Porites*	210	0.25
AO086	K-C-10	*Montipora*	120	< 0.01
AO087	K-C-5	*Favites*	110	< 0.02
AO088	K-C-3	*Montipora*	25	< 0.01
AO089	K-C-12	*Porites*	25	< 0.01
AO090	K-C-13	*Montipora*	25	0
AO091	K-C-14	*Goniastrea*	25	0.08
AO092	K-C-18	*Galaxea*	20	< 0.05
AO150	K-C-26	*Porites*	140	0
AO151	K-C-27	*Porites*	140	0
AO152	K-C-28	*Montastrea*	25	< 0.01
AO170	K-C-29	*Favia*	33	< 0.05
AO171	K-C-30	*Favia*	135	< 0.05
AO172	K-C-31	*Montipora*	62	0
AO173	K-C-32	*Montipora*	72	0.08
AO174	K-C-33	*Montipora*	72	< 0.05
AO175	K-C-34	*Favites*	175	0.40

that samples acted as a closed system after incorporation of the radioisotopes. The half-life values used for ^{230}Th and ^{234}U are 75,200 years and 248,000 years, respectively.

Uranium content in AO175 sample, in which the high percentage (40%) of calcite was detected, differs significantly from those in the contemporary corals in the same area (Omura, 1976). This fact is thought to be dependent either on the scantiness of uranium in the calcite crystallized secondarily or the elution of uranium from the original aragonitic skeleton during the time of recrystallization, and/or on the joint effect of both factors. In any case, the reliable uranium-series age cannot be expected from a sample, of which uranium has been reduced the quantity through the diagenetic history.

In the case of AO085, the another sample composed of the high percentage (25%) of calcite, it cannot be asserted from the apparent isotopic composition that the sample has not been preserved as a closed system. Because uranium content is almost equal to those in the present-day corals and $^{230}Th/^{232}Th$ activity ratio is very much higher (156 ± 11) than those (1 to 3) in natural waters or sediments. The existence of the secondary calcite, however, means that this sample does not fulfill one of the most important criteria for reliable age determination (Veeh and Burnett, 1982). For these reasons, the dates of both AO175 and AO085 samples are rejected from the following discussion.

The others, seventeen samples except AO091 and AO173, can be interpreted to satisfy all of the criteria for reliable dating from both the



Text-fig. 1. Map showing the localities of dated corals from the Pleistocene limestone on the island of Kikai.
(Bigger and smaller black circles show the localities of hermatypic coral samples dated in this study and reported by Konishi *et al.*, 1974, respectively: open small circle, the locality of ahermatypic solitary corals by Omura, 1983).

Table 2. Uranium and thorium isotopic composition and estimated $^{230}Th/^{234}U$ ages of fossil corals from the Pleistocene limestone on the island of Kikai.

Code Number	Isotope Concentration				Activity Ratio			Estimated Age (ka)
	^{238}U (ppm)	^{234}U (dpm/g)	^{232}Th (ppm)	^{230}Th (dpm/g)	$^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	
AO092	3.26 ± 0.04	2.73 ± 0.04	< 0.02	0.866 ± 0.016	1.12 ± 0.01		0.317 ± 0.022	41 ± 4
AO090	4.16 ± 0.07	3.47 ± 0.06	< 0.02	1.20 ± 0.03	1.12 ± 0.02		0.346 ± 0.032	46 ± 5
AO088	4.17 ± 0.03	3.53 ± 0.03	< 0.02	1.33 ± 0.02	1.13 ± 0.01		0.376 ± 0.020	51 ± 3
AO091	3.24 ± 0.05	2.70 ± 0.04	< 0.02	1.02 ± 0.02	1.12 ± 0.01		0.376 ± 0.023	51 ± 4
AO152	3.32 ± 0.03	2.73 ± 0.03	0.0544±0.0063	1.09 ± 0.02	1.10 ± 0.01	83.9 ± 9.7	0.401 ± 0.007	55 ± 2
AO007	3.19 ± 0.10	2.66 ± 0.08	0.0245±0.0068	1.60 ± 0.04	1.12 ± 0.03	273 ± 76	0.602 ± 0.039	99 ± 9
AO009	3.23 ± 0.07	2.61 ± 0.06	< 0.02	1.62 ± 0.05	1.08 ± 0.02		0.621 ± 0.038	104 +11 -10
OA053	3.10 ± 0.09	2.38 ± 0.07	0.0361±0.0021	2.03 ± 0.04	1.03 ± 0.04	234 ± 14	0.853 ± 0.030	204 +23 -19
AO086	3.80 ± 0.04	2.86 ± 0.03	< 0.02	2.61 ± 0.03	1.01 ± 0.01		0.911 ± 0.015	259 +19 -17
AO089	2.71 ± 0.03	2.08 ± 0.03	< 0.02	2.02 ± 0.02	1.03 ± 0.01		0.973 ± 0.017	360 +64 -40
AO170	3.44 ± 0.04	2.62 ± 0.03	0.162±0.011	2.54 ± 0.03	1.02 ± 0.01	65.6 ± 4.4	0.973 ± 0.016	369 +69 -42
AO084	2.71 ± 0.03	2.05 ± 0.03	< 0.02	2.01 ± 0.02	1.01 ± 0.01		0.981 ± 0.016	409 +120 -55
AO151	3.13 ± 0.03	2.39 ± 0.03	0.0242±0.0044	2.42 ± 0.03	1.02 ± 0.01	417 ± 76	1.01 ± 0.02	> 450
AO172	4.66 ± 0.05	3.53 ± 0.04	0.0233±0.0041	3.55 ± 0.04	1.02 ± 0.01	634 ± 111	1.01 ± 0.02	> 450
AO173	4.16 ± 0.05	3.11 ± 0.04	0.0210±0.0038	3.13 ± 0.04	1.00 ± 0.01	620 ± 112	1.01 ± 0.02	> 450
AO171	3.02 ± 0.04	2.32 ± 0.03	0.0284±0.0038	2.37 ± 0.02	1.03 ± 0.01	348 ± 46	1.02 ± 0.02	∞
AO087	3.08 ± 0.03	2.36 ± 0.02	< 0.02	2.42 ± 0.02	1.03 ± 0.01		1.03 ± 0.01	∞
AO174	3.75 ± 0.05	2.83 ± 0.04	0.0304±0.0049	2.93 ± 0.04	1.01 ± 0.01	401 ± 65	1.04 ± 0.02	∞
AO150	2.87 ± 0.03	2.23 ± 0.03	0.0278±0.0040	2.37 ± 0.03	1.04 ± 0.01	354 ± 51	1.06 ± 0.02	∞
AO085	4.55 ± 0.05	3.47 ± 0.04	0.0235±0.0016	3.66 ± 0.03	1.02 ± 0.01	156 ± 11	1.05 ± 0.01	(∞)
AO175	1.41 ± 0.02	1.08 ± 0.02	0.0636±0.0082	1.08 ± 0.02	1.03 ± 0.02	71.1 ± 9.2	1.00 ± 0.03	(> 450)

mineralogical nature and the isotopic composition of each sample. In other words, the assumptions used in calculating the ages are certainly supported in these samples by the observations listed in Tables 1 and 2 (see the paper of Veeh and Burnett, 1982, for detail and concrete discussion).

The $^{230}Th/^{234}U$ dates reported here involve some useful pieces of information to understand the geologic history of Kikai. They are as the followings:

The estimated ages of twelve samples, from OA053 through AO150 in Table 2, are 200,000 years or more, and moreover the ESR dates of 403,000 ± 21,000 to 536,000 ± 37,000 years have been obtained from ten samples except OA053 and AO170. We may, therefore, reasonably say that a part of the Pleistocene limestone on Kikai is Middle Pleistocene in age. Such $^{230}Th/^{234}U$ dates are likely to be divided into two groups. The one is approximately 200,000 years from one sample (OA053) and the other is more than 250,000 years. The former is almost equivalent to the age of the penultimate interglacial which is corresponding to the stage 7 of the marine oxygen isotope record (Emiliani and Shackleton, 1974). In the Ryukyu Islands, the same dates have been previously reported from the island of Hateruma by Konishi (1980) and Omura (1984). Namely, a part of the Pleistocene limestone on this island may be correlative with the Hateruma I of Ota *et al.* (1982). The extent of distribution and the litho- and biofacies of the limestone deposited at this stage, however, are not clear on Kikai as of now.

The value of the latter is thought to be near or beyond the limitation of the $^{230}Th/^{234}U$ method for dating, although the ages can be numerically calculated as shown in Table 2. It can be conclusively said from the $^{234}U/^{238}U$ ratios close to the unity that these corals are too old for the uranium-series method to be applicable. The value of the $^{234}U/^{238}U$ activity ratios of the samples averages $1.01_9 \pm 0.01_1$. Assuming that the initial $^{234}U/^{238}U$ ratio was 1.14 (Ku *et al.*, 1977), the mean age is estimated from such an average value of $^{234}U/^{238}U$ ratio to be $645{,}000^{+284{,}000}_{-103{,}000}$ years. These facts suggest that the oldest limestone on Kikai may be correlative to the deep-sea core stage 9 or the preceding warm stage. So far, in the Ryukyu Islands the same extent of $^{230}Th/^{234}U$ age has been obtained from the Kametsu Formation (Nakagawa, 1967), a part of the Riukiu Limestone of Hanzawa (1935), on the island of Toku (Omura, 1982).

The localities of the samples assigned to more than 250,000 years are scattered in a extensive area on the island (Text-fig. 1). Such an area is likely to cover the distribution area of the Younger, Middle and Older Members of Riukiu Limestone of Konishi *et al.* (1974). The distance in a straight line between the localities of AO170 and AO174 samples is about 6.5 km. Tsuji (1979) mapped geologically the southwestern part of Kikai and concluded that the oldest limestone on this island occurs fairly extensively in this area and is unconformably overlain even with the Araki Limestone which is thought to be the uppermost unit of the Pleistocene limestone on this island and to have been deposited 35,000 — 45,000 years ago by Konish (1967) and Konish *et al.* (1970, 1974). The very shallow environment where hermatypic corals could grow up is thus inferred to have spread at that time over the area having a diameter of at least 6.5 km. On the whole, the limestone including corals indicative of the age of Middle Pleistocene is not typical bindstone or framestone of Embry and Klovan (1971). However, it is sure that a considerable number of hermatypic corals are preserved in the state of their original position of growth and that the binding structure made of flat-shaped colonies of hermatypic corals and crustose coralline algea is observed in some places. These facts suggest that the initial coral reef developed directly onto the Pliocene basement (Somachi Formation; Nakagawa, 1969) might be a fairly extensive table reef. And then, the limestone deposited as such a reef is considered to constitute the basal part of the Pleistocene limestone on the island.

Two (AO007 and AO009) samples were dated to be approximately 100,000 years, which fits in the time of an interstadial phase and almost equals the age of the Barbados II terrace of Mesolella *et al.* (1969) on Barbados, West Indies, and the age of the Reef Complex VI on the Huon Peninsula in New Guinea (Bloom *et al.*, 1974). Both $^{230}Th/^{234}U$ and $^{231}Pa/^{235}U$ ages of about 100,000 years have been previously reported for a coral sample (CK-30) collected on the island by Konish *et al.* (1974). This date corresponds with the age of the Hateruma IV (Omura, 1984).

As shown in Table 1, the elevation of both AO007 and AO009 samples is 170 m and is 30 m higher than that of CK-30 sample of Konish *et al.* (1974). Based on the elevation and the mode of occurrence of these samples, there is very little doubt that the sea level of about 100,000 years ago was 170 m or more in present altitude. It is generally known that the sea level, through the period of the last interglacial, has attained to the maximum (say 6 m higher than present) 120,000 to 130,000 years before. Comparing with it, the sea level during the interstadial of about 100,000 years ago seems to have been roughly 20 m lower, from the data for the uplifted coral reefs on the island of Barbados and the Huon Peninsula (Broecker *et al.*, 1968; Bloom *et al.*, 1974).

Supposing the depositional depth ("Ld" value of Konishi, 1967) of 0 — 10 m, we can infer from the present elevation (as a first approximation, regarded as "Le" value) of the sample dated that the sea level was 170 — 180 m in present altitude. The limestone, from which both AO007 and AO009 were sampled, consists of large hermatypic coral heads in growth position and of encrusting coralline algae and foraminifera. For this observation, we suppose that this limestone was formed as the reef-wall facies and that its depth was 0 to 10 m. Because the differences ("ΔSL" value) between sea level at the time of deposition and sea level at present is —14 m, the amount of vertical displacement ("ΔV" value) due to tectonic uplift is calculated to be 184 — 194 m by the equation of Konish (1967). If the displacement is continuous rather than episodic, the rate of displacement ("ΔV/ΔT" value) is estimated to be 1.84 — 1.94 mm/y. This ΔV/ΔT value is consistent with that estimated for the Araki Limestone and the Younger Member of Riukiu Limestone by Konish *et al.* (1970). By assuming that such a value of ΔV/ΔT is also valied for the limestone deposited at the time of 120,000 — 130,000 years ago, then we can calculate that the sea level at that time reaches to the present elevation of 227 — 239 m to 245 — 258 m. This means that the highest point of 224 m in Hyakunodai has been submerged during the time of last interglacial as pointed out by Konish *et al.* (1970, 1974).

In order to vindicate the inference as stated above, it is the best way to date the appropriate coral samples occurred in the limestone unit which makes of the terrace deposit of Hyakunodai, attaining a height of more than 200 m. Among the samples treated in this study, only two samples (AO084 and AO085) are collected at the locality of higher than 200 m. The apparent date of AO085 sample, however, cannot be used here for above-mentioned reason. Thus, for the present, we can hardly avoid the conclusion that the limestone of the highest terrace is Middle Pleistocene in age. It is necessary in the further study to search and date the coral samples occurred in the portion close to the surface of the terrace.

The date of a coral sample (AO092) was 41,000 ± 4,000 years (Table 2), which is corresponding to the age of the Araki Limestone of Konish *et al.* (1970, 1974). This limestone unit was originally divided as an independent lithostratigraphic unit from the Riukiu Limestone of Hanzawa (1935) by Schlanger and Konishi (1966) who remained the name of "Riukiu Limestone" adopted by Hanzawa (1935) and divided the other part into two, Younger and Older Members of Riukiu Limestone. The Araki Limestone is composed mainly of well-sorted and slightly cemented calcarenite. Main components of this unit are tests of *Calcarina*, *Amphistegina*, *Marginopora* and *Baculogypsina*, and disarticulated fragments of *Amphiroa*, *Corallina* and *Halimeda* (Konishi *et al.*, 1970). A few hermatypic corals in growth position are present at the basal part of the formation. The age of the Araki Limestone is thought based on $^{230}Th/^{234}U$ and $^{231}Pa/^{235}U$ dates of total numbers of fifteen to be 35,000 — 45,000 years B.P. (Konishi *et al.*, 1974). Tsuji (1979) who examined the litho- and bio-facies in more detail made clear that this limestone unit is sporadically distributed in the southwestern part of the island. The locality of AO092 sample is situated approximately 800 m northwest of Kamikatetsu at a height of 20 m, and is included in the area of the Araki Limestone seen in the geologic map of Tsuji (1979). These facts support, therefore, his conclusion as to the distribution of the Araki Limestone.

A date of 55,000 ± 2,000 years was obtained for a coral (AO152) collected at the type locality of the Araki Limestone. This date is correlative to the age of the Younger Member of Riukiu Limestone of Konishi *et al.* (1974). It may, therefore, be said that some corals in the Araki Limestone are detrital in origin, even though they appeared to be kept in their original position of growth. An another sample (AO091) from the same location also may be of detrital origin, depending on its date (51,000 ± 4,000 years) close to the age of the Younger Member of Riukiu Limestone.

As stated above, we reported in this paper some additional uranium-series dates of corals from the Pleistocene limestone on the island of Kikai. Such dates do not require to change largely the geologic history since the last interglacial of this island, which was itemized by Konishi *et al.* (1970), although the dates assigned to probably two stages during the time of Middle Pleistocene were newly obtained. In order to generalize the geologic history of Kikai, we propose here to add at least two articles described below between the first (A) and the second (B) among the seven items seen in the paper of Konishi *et al.* (1970).

(i) Development of a fairly extensive coral reef (probably, table reef) onto the basement, Pliocene Somachi Formation (Nakagawa, 1969), more than 250,000 years B.P.

(ii) Formation of a small-sized reef (fringing reef?), during the time of the penultimate interglacial stage, approximately 200,000 years B.P.

Summary

(1) A part of the Pleistocene limestone on the island of Kikai is Middle Pleistocene in age and is thought to have been deposited during two stages of high sea stand. The one is approximately 200,000 years B.P. and the other is more than 250,000 years B.P.

(2) The former can be correlative with the Hateruma I on Hateruma Island (Omura, 1984). The latter is almost near or beyond the limitation of the $^{230}Th/^{234}U$ dating method but is thought from the $^{234}U/^{238}U$ activity ratio to be correlative with the Kametsu Formation (Nakagawa, 1967) on the island of Toku.

(3) The distribution of corals assigned to more than 250,000 years denotes that the very shallow environment where hermatypic corals could grow up has spread at that time over the area having a diameter of at least 6.5 km. The initial coral reef settled directly onto the Pliocene basement (Somachi Formation; Nakagawa, 1969) might be a fairly extensive table reef.

(4) The limestone deposited approximately 100,000 years ago is traced up to a height of 170 m. Assuming that the displacement is continuous, the amount and the rate of vertical displacement since the past 100,000 years are estimated to be 184 — 194 m and 1.84 — 1.94 mm/y, respectively. Moreover, it is very strong possibility that the most elevated point of 224 m on this island has been submerged at the time of the last interglacial, 120,000 — 130,000 years ago.

(5) The date correlative to the age of the Araki Limestone (Konishi *et al.*, 1974) was obtained for a coral which was sampled at the other spot than the type locality of it. This fact supports the conclusion of Tsuji (1979) that the Araki Limestone is sporadically distributed in the southwestern part of the island.

(6) Some corals in the Araki Limestone may be detrital in origin, even though they are ap-

parently in their original position of growth.

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喜界島に分布する更新統石灰岩産サンゴのウラン系列年代に関する新資料：琉球列島喜界島に分布する更新統石灰岩 (Hanzawa, 1935, の Riukiu Limestone) から，新しく $^{230}Th/^{234}U$ 法によって放射年代を求めた。ここで報告する年代値は，ほとんどが，これまで放射年代が知られていない地点で採集した７属 (*Favia, Goniastrea, Porites, Montipora, Favites, Galaxea, Montastrea*)・合計21個の礁性サンゴ化石から得たものである。その結果として，喜界島の更新統の一部は，更新世中期における２回の高海水準期に形成されたことが明らかになった。一つは，おおよそ20万年前の Emiliani and Shackleton (1974) の oxygen isotopic stage 7 にあたり，他の一つは，25万年以上前の stage 9（あるいは，より以前の温暖期）に相当する。後者の年代値は，島の各所で採集した試料から得られたが，それら採集地点の広がりとそれらサンゴ化石を含む石灰岩の岩相などから，当時，礁性サンゴの生育が可能な極浅海環境が，一つの直径が少なくとも6.5 km ある範囲に広がっていたと思われる。すなわち，基盤（上部鮮新統早町層；中川，1969）上に，はじめて形成されたサンゴ礁は，かなりの広がりをもった卓礁であった可能性もあり，当時の礁を形成していた石灰岩は，現在，Konishi *et al.* (1974) ほかの琉球石灰岩古・中および新期部層の基底部を構成していると考えられる。

今回新たに得られた $^{230}Th/^{234}U$ サンゴ年代から，以前 Konishi *et al.* (1970) によって箇条書きにして述べられた本島の地史を，過去13万年間の部分は基本的に変更の必要はないものの，一部修正しなければならないことを指摘する。

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