

## 712. RELATIVE FALL OF SEA LEVEL WITHIN THE PAST 3000 YEARS

KENJI KONISHI and SHINYA MATSUDA

Department of Earth Sciences, Faculty of Science, Kanazawa University,  
Marunouchi, Kanazawa 920

**Abstract.** Radiocarbon dating of two crustose coralline algae (*Porolithon onkodes*) and six hermatypic corals (species of *Porites*, *Acropora* and *Goniastrea*) from a windward fringing reef complex off Kabira Bay, Ishigaki-jima (Southwest Ryukyus) reveals that the present-day reef crest exposing 60 cm above the mean level of low tide does not represent a growing algal ridge system, but relics of a salient ridge grown between 1500 and 3000 years ago, when sea level stood at least 1.5 m higher than the present. A later fall of the sea level has planed off the top of the ridge down to the present configuration where the erosion predominates over upward "sedimentation".

The classic concept of Postglacial hydro and glacio-isostatic readjustment of lithosphere (DALY, 1934) has been vitalized to reconcile discrepancies among the curves of relative sea level change during the Holocene, which have been documented from various areas in the world (e.g. WALCOTT, 1972). In order to refine a numerically predicted curve modeled after this concept (CLARK *et al.*, 1978), however, we are still short of field studies controlled through time both in local and regional extent. Surficial geology of contemporary coral reef can provide information pertinent to this purpose, especially when supported by radiocarbon dating (e.g. TRACEY and LADD, 1974; BUDDEMEIER *et al.*, 1975).

In the fringing and barrier reefs of the Ryukyu Islands, the windward reef crest exposing above the mean low water level is ubiquitously characterized by the lack of algal ridge system and is actually

barren of the present-day reef-building organisms including crustose coralline algae. As a typical example of this situation, we selected the windward fringing reef complex (24°27'N; 124°09'E) off Kabira Bay, northwestern Ishigaki-jima, Southwest Ryukyus, where a topographic zonation from forereef slope to coastal beach, *via* low tide bench, reef crest and moat, has been recognized (Fig. 1). Severe neotectonic uplift related to the plate convergence has not been deduced here from our studies of raised coral reefs (KONISHI *et al.*, 1974).

Our dated materials came from the following four environments (Table 1; Fig. 1).

(1) Reef crest exposing 60cm above low tide level consists of coral-algal reefrock composed of dead colonies of huge thick-stalked tabular *Acropora* (*A. cfr. humilis*) and crust (one 5 cm and the other more than 20 cm in thickness) of *Porolithon onkodes* with subordinate massive *Goniastrea*, while the forereef slope and low

Received August 30, 1979.

Table 1. Radiocarbon dates of corals and coralline algae from windward fringing reef, off Kabira Bay, north-northwestern Ishigaki

Sample No.	Taxa	Elevation above mean sea level	$^{14}\text{C}$ age ( $T_{1/2}$ ; 5568y.)
<b>Corals:</b>			
N-3248(KM-02)	<i>Acropora</i> sp. cfr. <i>humilis</i>	m 0 (reef crest)	2980+80
N-3247(KM-01)	<i>Acropora</i> sp. cfr. <i>humilis</i>	-0.1 (reef crest)	2350±80
N-3249(KM-03)	<i>Goniastrea</i> sp.	-0.2 (reef crest)	1980±75
Gak-5859(KK74111904)	<i>Porites</i> sp.	1.5 (abandoned bench)	3030±95
Gak-5960(KK74112102)	<i>Goniastrea</i> sp.	1.0 (emerged beachrock)	1440±90
Gak-5858(KK74111506)	<i>Porites</i> sp.	0 (dead microatoll)	1060±90
<b>Coralline Algae:</b>			
N-3251(KM-05)	<i>Porolithon onkodes</i>	-0.2 (reef crest)	2270±75
N-3250(KM-04)	<i>Porolithon onkodes</i>	-0.2 (reef crest)	1600±85

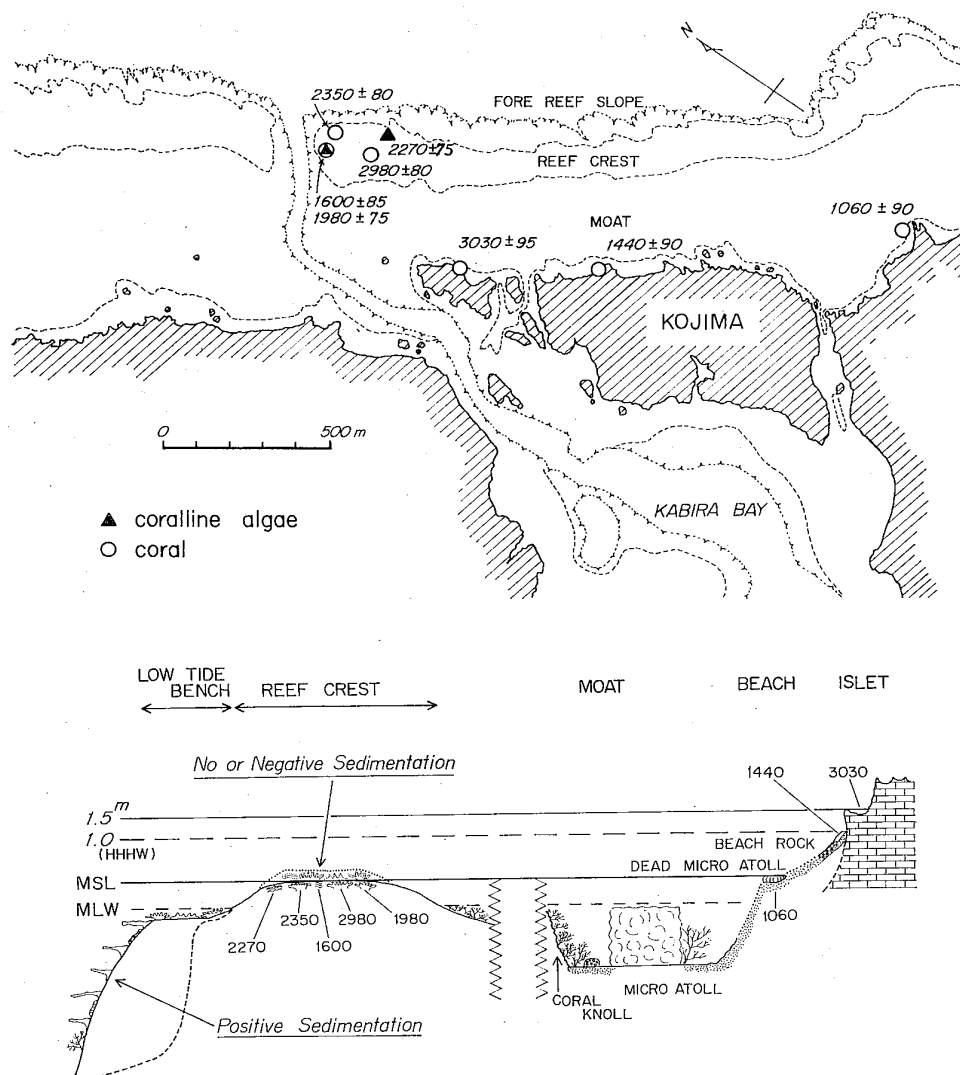


Fig. 1. Map and schematized cross-section across windward fringing reef off Kabira Bay, north-northwestern Ishigaki. Localities and radiocarbon ages of dated fossils are indicated.

tide bench are the site of vigorous growth of tabular species of *Acropora*. A veneer of living crustose corallines starts to occur only from the upper forereef slope below the low tide bench. Radiocarbon ages were determined for three corals and two algae from the reef crest, which were recovered in a shallow excavation (20 cm in depth).

(2) Back-reef moat, 2 to 3 m deep, holds microatolls of *Porites* both living and dead. The outermost layer of a dead microatoll about 1.0 m in diameter has been collected for radiocarbon dating from a very shallow landward part of the moat off Yoshihara. In contrast to the living colonies, it exposes above the mean low water.

(3) At the northeastern beach of Kojima, emergent beachrocks crop out 1.0 m above the present mean high water level. A small autochthonous colony of *Porites* attached to the top of the beachrock was collected for dating.

(4) A thick, but partly eroded, colony of *Goniastrea* was sampled from a dried tide pool on an abandoned abrasion bench cutting the Pleistocene Riukiu Limestone, 1.5 m above the present mean sea level.

Our radiocarbon dates indicate that the sea level here (1) attained the present position by 4000 y. B. P. or even earlier, (2) stood at least 1.5 m higher than the present during the period between 1500 and 3000 y. B. P., and (3) subsequently fell to the present, resulting in diminishing a ridge covered with algal crust into the non-accreting reef crest, within the past 1000 years. Abandoned bench of several tens cm above the highest high water spring which occurs sporadically at pocket beach may record the same event of the sea level drop. A similar magnitude of relative fall of sea level for the last 2000

years was lately documented at the Senkaku Islands about 150 km northwest of Ishigaki across Okinawa (=Ryukyu) Trough (KONISHI *et al.*, 1979).

A study of growth rate and succession of crustose coralline algae on artificial substrate (glass and polyvinyl chloride plates) confirmed that practically not a single thallus of the coralline algae has settled on the top of the reef crest during one year experiment (MATSUDA, 1979). Together with this conclusion, field observation about activities of reef-building organisms suggest that the reef crest represents an unstable substrate, where erosion accompanied with urchin boring (*Echinometra mathaen* (BLAINVILLE)) prevails to accretional sedimentation at present. Like other parts of the Ryukyu Islands, the sea level maximum referred to the "Climatic Optimum" of 5000 to 6000 y. B. P. could not be verified here. Much deeper structure of this windward fringing reef off Kabira should be thoroughly examined, with the aid of subsurface coring, in order to trace back the history of sea level changes prior to 3000 y. B. P.

The present work is an outgrowth of the interdisciplinary research project financed by the Grant-in-Aid for Scientific Research (No. 910313) from the Ministry of Education, Science and Culture. We thank Prof. M. HORIKOSHI, the project representative. Radiocarbon dates were supplied from Dr. K. KIGOSHI (Gakushuin University) and Mr. T. HAMADA (Japan Radioisotope Association).

#### References cited

- BUDDEMEIER, R. W., SMITH, S. V. and KINZIE, R. A. (1975) : Holocene windward reef-flat history, Enewetak atoll. *Geol. Soc. Amer. Bull.*, vol. 86, p. 1581-84.
- CLARK, J., FARRELL, W. E. and PELTIER,

- W.R. (1978) : Global changes in Postglacial sea level: a numerical calculation. *Quat. Res.*, vol. 9, p. 265-87.
- DALY, R.A. (1934) : The changing world of Ice Age. p. 1-277. *Yale Univ. Press.*
- KONISHI, K., OMURA, A. and NAKAMICHI, O. (1974) : Radiometric coral ages and sea level records from the Late Quaternary reef complexes of the Ryukyu Islands. *Proc. 2nd Intern'l Coral Reef Symp.*, no. 2, p. 595-613.
- KONISHI, K., OSHIRO, I. and TANAKA, T. (1979) : Holocene raised coral reef on Senkaku Islands: an active remnant arc. *Proc. Japan Acad.*, vol. 55, ser. B, no. 7, p. 335-340.
- MATSUDA, S. (1979MS) : Succession, growth rates and sedimentation of encrusting crustose coralline algae in upper forereef environment on Ishigaki Island, Ryukyu Islands. (in Japanese with English abstract). *M. Sc. Thesis, 1979-No. 52, Fac. Sci., Kanazawa Univ.* p. 1-113.
- TRACEY, J.I. Jr. and LADD, H.S., (1974) : Quaternary history of Eniwetok and Bikini atolls, Marshall Islands. *Proc. 2nd Intern'l Coral Reef Symp.*, no. 2, p. 537-550.
- WALCOTT, R.I. (1972) : Past sea levels, eustasy and deformation of the Earth. *Quat. Res.*, vol. 2, p. 1-15.

過去3000年間の相対的海水準降下:

琉球列島石垣島の川平湾外にある風上側裾礁には平均低潮位よりも約 60 cm 高く造礁サンゴ、サンゴモの生育していない平坦礁頂 (reef crest) がみられる。この裾礁複合体から採取されたサンゴモ (*Porolithon onkodes*) 2 試料, 造礁性サンゴ 6 試料 (*Acropora*, *Goniastrea*, *Porites* 属) の放射炭素年令は, この平坦礁頂が石灰藻嶺系ではなく 1500~3000 年前の礁突出部の残存地形であり, 当時は現在よりも少なくとも 1.5 m 海水準が高かったことを示している。その後の相対的海水準降下によりその突出部は侵食をうけ現在の地形にまで平坦化された。

小西健二・松田伸也