

66. Holocene Raised Coral Reef on Senkaku Islands

An Active Remnant Arc

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Uotsuri-jima (Lat. 25°46'N; Long. 123°32'E; Fig. 1), the largest island of the Senkaku-retto, is situated at the southwestern end of a remnant arc ("Senkaku-gunto Ridge" of Konishi and Sudo, 1972) along the edge of the Eurasian Continent, which is being drifted behind the spreading Okinawa (=Ryukyu) Trough (back-arc basin), as the Ryukyu Island arc stays stationarily relative to the trench axis, where the Philippine Sea lithosphere is being subducted (Konishi, 1979; Uyeda and Kanamori, 1979). Together with marine geological and geophysical informations from the basin floor overlain with a thick pile of sediments (Wageman *et al.*, 1970; Honza *et al.*, 1976), neotectonic activity under this setting on the remnant arc is evidenced by occurrence of an intact coral reef raised up to 3.0 m above the present high tide level (=Uotsuri Limestone of Nohara, 1972).

Previous study has provided 1000±300 y.B.P. in ²³⁰Th and 2200±100 y.B.P. in ²³¹Pa date of a single coral sample from the reefy limestone at the eastern corner of the island (Konishi *et al.*, 1974) (Fig. 2). These dates, however, should be disputed critically, because of both ambiguity of the initial contents and inadequacy of the half-lives of these radionuclides, when applied to a Late Holocene sample. In this paper, we present five radiocarbon ages of hermatypic corals, which were collected from four new localities, and are proven to retain entirely original mineralogy of aragonite, with the implications for a remnant arc neotectonism behind the back-arc basin now actively spreading.

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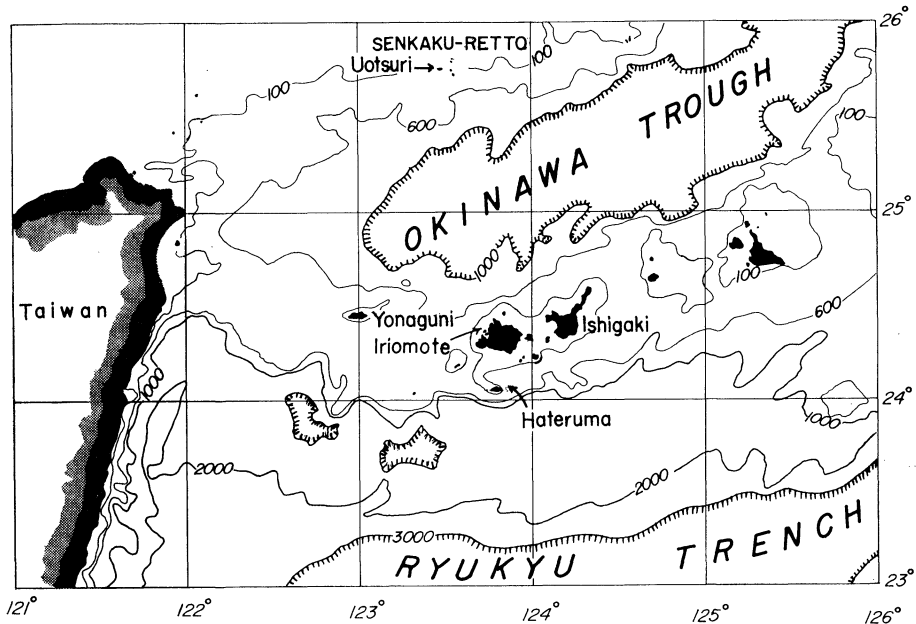


Fig. 1. Index map showing location of Utsuri-jima (Senkaku-retto) and adjacent islands, Southwest Ryukyus. Bathymetric contour interval 1,000 fathoms. Also added are isobath of 100 and 600 fathoms.

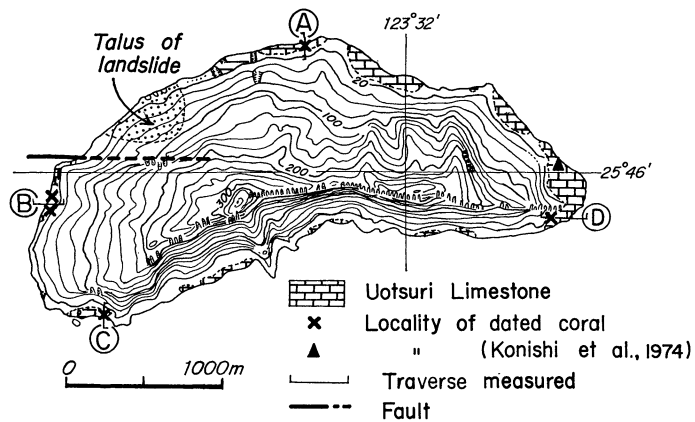


Fig. 2. Map indicating distribution of Holocene raised reef (=Utsuri Limestone), measured traverses and localities of dated corals on Utsuri-jima.

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The Utsuri Limestone fringes discontinuously the core of the island, which consists of Miocene coal-bearing clastics intruded by

hornblende-dioritic porphyrite sheets (Matsumoto and Tsuji, 1974) of later age (Fig. 2). A similar, if not the same, reefy limestone is known to crop out on Minami- and Kita-kojima nearby (Nohara, 1972).

All the fossil corals dated occur at growth position ("biolithites"). Their occurrence and other data including the radiocarbon measurements are summarized in Table I. The radiocarbon dates confirm not only the Postglacial age of the Uotsuri Limestone, but also uplift of 3 to 5 m relative to the present sea level in the last 5 ka (1×1000 years) or less.

Except Traverses A and B at the windward north and west coast, where two faintly separate levels, the upper 2.0 to 3.0 m and the lower 0 to 1.5 m, both above the high tide level, have been observed, the Holocene limestone forms a single-plane terrace dipping gently in uniform shorewards (Fig. 3). Two radiocarbon dates along Traverse B also indicate a time-regressive relation, hence a relative fall of sea level. At the northeastern coast, the width of the terrace attains as broad as 120 m to 150 m, and its upper landward 80 m are heavily vegetated by grass (*Zoisia tenuifolia*-sonaremugura and *Pemphis acidula*-koraishiba). Coupled with the youngest radiocarbon date (No. 7931401), the narrowness (30–40 m) and distinctly lower elevation of the limestone terrace along the leeward south coast, as compared with the rest (Fig. 3), suggest that a differential upheaval involving the relative drop of the southcoast occurred some time during the last 5 ka.

Extensional neotectonics related to the spreading Okinawa Trough can be corroborated with circumstantial evidences from land geology. The coal-bearing clastic rocks at Uotsuri and the lower Miocene Yaeyama Group at Iriomote and Yonaguni to the south present a paralic to shallow-marine basin associated with an old arc

Table I. Radiocarbon dates and other data of fossil corals from Uotsuri^{†)}

Sample no.	Taxa	Traverse	Elevation above high tide (m)	Net count/min./g. C ₆ H ₆	¹⁴ C*		¹⁴ C date (y.B.P.)	
					$\frac{A_{\text{sample}}}{A_{\text{std.}} \times 0.95^{**}}$	T _{1/2} (5730 y.)	T _{1/2} (5568 y.)	
7931105	<i>Goniastrea</i> sp.	A	2.5	3.993	0.5324	5210±80	5060±80	
7931108	<i>Goniastrea</i> sp.	B	2.5	4.744	0.6325	3790±80	3680±80	
7931109	<i>Montipora</i> sp.	B	2.5	5.294	0.7059	2880±80	2800±80	
7931401	<i>Montipora</i> sp.	C	1.0–1.5	5.628	0.7504	2370±80	2310±80	
7931502	<i>Montipora</i> sp.	D	2.0–2.5	5.131	0.6841	3140±100	3050±90	

^{†)} Analyzed by T. Tanaka. * The radiocarbon value shown is the average of three measurements. ** Standard: NBS-oxalic acid.

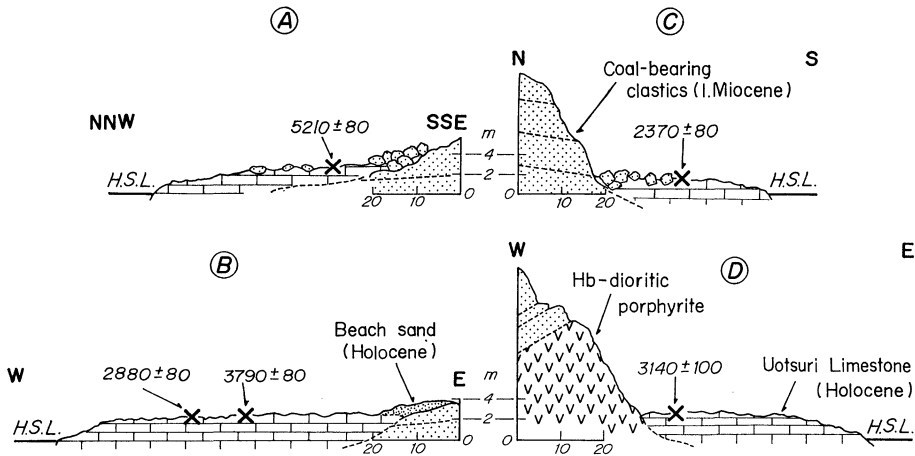


Fig. 3. Geologic cross sections of Holocene raised reef along Traverses (A, B, C and D as shown in Fig. 2). Localities of dated corals are added with radiocarbon ages.

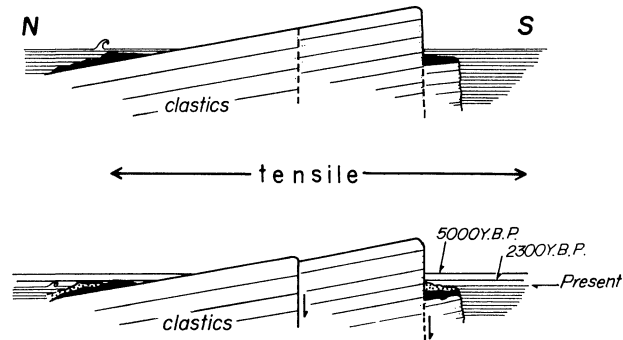


Fig. 4. Interpretative profile of Uotsuri-jima, implying southward tilting of Utsuri Limestone and relative fall of sea level during Late Holocene (not in scale). Porphyritic sheets are omitted from this figure.

system once bound, but now detached by spreading to have created the interposing Okinawa Trough since late Miocene (Konishi and Sudo, 1972). This interpretation was lately strengthened by seismic profiling survey tracing both the Yaeyama and succeeding Shimajiri (middle Miocene to Pliocene) Group across the heavily sedimented trough (Honza *et al.*, 1976).

From structural study of the Yaeyama Group and the overlying Ryukyu Group (Pleistocene) at Yonaguni, about 140 km south-southwest of Uotsuri (Fig. 1), Sakai *et al.* (1978) concluded that a com-

pressional stress field of N-S direction prevailed before development of antithetic fault system consisting of the E-W-trending extensional faults dipping to the north and faulted blocks tilting to the south. This change of the stress field yielding the new fault system is attributed to the crustal extension resulting in spreading of the Okinawa Trough.

Questa-topography by the north-dipping clastic basement rocks displaced by the parallel, E-W-trending normal faults at Uotsuri, may suggest a similarly, but oppositely dipping (i.e. to the south) fault system developed. As mentioned above, however, the Holocene raised coral reef here appears to indicate the opposite sense of tilting in the last 5 ka. In order to reconcile the two arguments, it is proposed that the south coast block has been downthrown along fault(s) dipping to the south, while sea level fell to the present position (Fig. 4). This relative change of sea level might be ascribed to crustal deformation due to the Postglacial isostatic rebound of this part of the Eurasian Continent (Walcott, 1972; Chappell, 1974).

It is highly recommended to resume a further detailed survey, preferably with the aid of subsurface coring, of the Holocene raised reef at this tectonically complex area, for testing, if the above interpretation can be tenable on a quantitative basis.

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