940. FOSSIL NONARTICULATED CORALLINE ALGAE AS DEPTH INDICATORS FOR THE RYUKYU GROUP*

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Abstract. Fossils of nonarticulated coralline algae occur in the coral limestone of the Pleistocene Ryukyu Group distributed in Yoron, Okierabu, Toku and Kikai Islands. Four fossil nonarticulated coralline algal assemblages are compared with their Recent coralline algal depth distribution in the Ryukyu Islands. Each assemblage represents a particular depth range. Depositional environments inferred from the Pleistocene coralline assemblages accord well with those based on hermatypic corals and benthic foraminifera.

Key words. Nonarticulated coralline algae, depth indicator, species assemblage, Pleistocene, Ryukyu Group.

Introduction

Nonarticulated coralline algae (Corallinaceae, Rhodophyta) play an important framework-building role, together with hermatypic corals, in Tertiary to Recent reef formations. For example, they may cover more than 30% of the reef surface in some modern reefs (Littler, 1973a, 1973b; Iryu and Matsuda, 1988). Intensive ecologic studies on the nonarticulated corallines in the modern tropical reef environment have been conducted since the 1960's. This enables us to make use of these organisms for paleoenvironmental interpretation. Studencki (1979) and Bosence and Pedley (1982) analyzed depositional environments of algal-related biofacies mainly based on the coralline morphology, while Mankiewicz (1988) and Jones and Hunter (1991) used the coralline assemblages as a depth indicator.

The Pleistocene Ryukyu Group, reef complex deposits, consists of limestones and related terrigenous sediments. The fossil corallines occur abundantly as crusts in the coral limestone or as an aggregated form of foraminiferal-algal nodules (rhodoliths) forming a distinct lithofacies called the rhodolith limestone. Heydrich (1900) first studied these fossil corallines in the Ryukyu Group and described Lithothamnium na-haense, an important constituent of the flora. However, taxonomic works were undertaken later by Ishijima (1938, 1942a, 1942b, 1944, 1954), who described 16 nonarticulated and 27 articulated coralline algal species. Minoura (1979a, 1979b) and Minoura and Nakamori (1982) investigated a sedimentological aspect of the rhodolith limestone and Iryu (1984, 1985) revised these results based on a study of Recent rhodoliths. Since paleoenvironmental significance of the fossil corallines in the coral limestone has not been examined, however, they have not widely been used as paleoenvironmental indicators. In contrast, Noda (1976) and Nakamori (1986) used benthic foraminifers and hermatypic corals as paleoenvironmental indicators, and mapped the distribution of biota and various sediment types in the reef-

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complex facies at the time of deposition of the Ryukyu Group.

This paper aims at establishing the usefulness of fossil nonarticulated coralline algae in a coral limestone facies as depth indicators for the Ryukyu Group; that is to establish a "coralline bathymeter," in the following manner. The distribution of living corallines in the reefs around the Ryukyu Islands is reviewed. These data, coupled with those from Guam (Gordon et al., 1976) and Hawaii (Adey et al., 1982), form a basis to select depth-indicative species from the fossil corallines occurring in the Ryukyu Group. This in turn enables to circumscribe discrete species assemblages, each of which represents a particular depth range. Paleobathymetric accuracy based on the coralline assemblages will then be tested against those derived from the coral communities (Nakamori, 1986) and benthic foraminiferal assemblages (Noda, 1976).

The taxonomy used for identifying corallines coming under the subfamilies Lithophyloideae and Melobesioideae is that of Woelkerling (1988), with some later nomenclatural modifications, such as disposition of Titanoderma proposed by Campbell and Woelkerling (1990). However, the extended generic concept of Spongies (subfamily Mastophoroideae), which encompasses the genera Porolithon, Hydrolithon, and Pseudolithophyllum sensu Adey (1970) as heterotypic synonyms of Spongies (Penrose and Woelkerling, 1988), is not adopted and the latter three genera are conserved.

**Living nonarticulated coralline algae**

The reef complexes around the Ryukyu Islands are divided into three basic topographic zones: reef flat, reef slope, and island shelf. Nonarticulated coralline algae are distributed in all three zones (Figure 2).

**Reef Flat**

No quantitative investigation on the coraline algae inhabiting the reef flat has been conducted. The following evidence is avail-
able on the distribution of coralline algae at a qualitative level.

(1) Eighteen species coming under nine genera of the nonarticulated coralline algae are identified (Iryu, 1991a, 1991b). They are Neogoniolithon conicum (Dawsen) Gordon, Masaki et Akioka, N. foslei sensu Matsuda (1989), N. frutescens (Foslie) Setchell et Mason, Spongia sp. A (= Spongia sp. A in Iryu and Matsuda (1988)), Porolithon onkodes (Heydrich) Foslie, Porolithon sp. A (= Porolithon sp. A in Iryu and Matsuda (1988)), Hydro lithon reinboldii (Weber van Bosse and Foslie, Mastophora pacifica (Heydrich) Foslie, M. rosea (C. Agardh) Setchell, Fosliella farinosa (Lamx) Howe, Pneophyllum sargassii (Foslie) Chamberlain, Lithophyllum insipidum Adey, Townsend et Boykins, L. kotschyanum Adey, L. moluccense (Foslie) Foslie, L. pallescens (Foslie) Foslie (= L. okamurai Foslie), Mesophyllum erubescens (Foslie) Lemoine, M. mosemor-
Reef Slope


Iryu and Matsuda (1988) measured the standing crop of the nonarticulated coralline algae on well-illuminated flat rocky substrata in the forereef environment down to 30 m depth and their results are summarized as follows (Figure 3). The mean total coverage and density are 33.0% and 5.6 thalli/100 cm², respectively, throughout the investigated depth range. The dominant species are *N. conicum*, *Sponges* sp. A, *P. onkodes* and *L. insipidum*. *Neogoniolithon conicum* is distributed throughout the observed depth range, not showing a regular pattern in its standing crop distribution, and its mean density ranks first of all the species. *Sponges* sp. A has the greatest mean coverage and its standing crop is highest at 15 m depth. *Porolithon onkodes* and *L. insipidum* are most abundant at 1 m depth, but they decrease markedly with increasing depth and are entirely absent below 20 m.

Based on such a depth distribution, three nonarticulated coralline algal assemblages are discriminated; Assemblage I, II and III. Assemblage I is distinguished by abundant *P. onkodes* and *L. insipidum* and its depth ranges 0–15 m. Assemblage II is characterized by the common to abundant occurrence of *Sponges* sp. A. Depth range of Assemblage II is between 15 and 25 m, where *P. onkodes* and *L. insipidum* are scarce down to 20 m and are entirely absent below that. Assemblage III, observed deeper than 25 m, is delineated by the common growth of *N. conicum*. *Sponges* sp. A is seldom found, whereas *M. purpurascens* with extensive thalli is sporadically distributed in this depth range.

The coralline-algal flora has not been inves-
tigated at depths from 30 to 50 m.

Island Shelf

Extensive investigations of biota and sediments by such authors as Nohara et al. (1979), Iryu (1984, 1985), Iryu and Hayasaka (1985), Matsuda and Tomiyama (1988), and Tsuji et al. (1989) have revealed that the rhodoliths, nodules composed predominantly of nonarticulated coralline algae, are distributed commonly on the deep forereef to island shelf in waters from 50 to 200 m deep around the Ryukyu Islands. Recently, Matsuda et al. (1992) showed the distribution, abundance, and composition of rhodoliths based on 119 grab samples taken around Okinawa-jima at depths from 50 to 200 m. The rhodoliths are found from 70 sites in depths from 50 m to 135 m. The mean coverage of the rhodoliths is about 45% in that area. These rhodoliths are spheroidal, ellipsoidal, or rarely a disclike shape, 5-10 cm (up to 15 cm) in mean diameter, and consist mainly of thin crustose forms of nonarticulated coralline algae and the encrusting foraminifer *Gypsina plana* (Carter), both of which are closely superposed to form a more or less concentric or irregular internal structure. Twenty-eight species of the nonarticulated coralline algae have been identified, coming under the genera *Spongytes*, *Hydrolithon*, *Lithoporella*, *Lithophyllum*, *Mesophyllum*, and *Lithothamnion*. Of these, *Lithothamnion* is the most dominant and diverse, comprising 11 species. The nonarticulated coralline algae grow commonly, covering 40 to 50% of the surface of the rhodoliths at depths less than 120 m, whereas *G. plana* predominates in depths exceeding 120 m.

Fossil nonarticulated coralline algae

Field Setting

Fossil nonarticulated coralline algae were studied from the Yoron-jima, Shimohirakawa and Kamishiro, Sakibaru, and Takigawa Formations on Yoron-jima, Okierabu-jima, Toku-no-shima, and Kikai-jima, respectively. There were 14 localities in Yoron-jima, 11 in Okierabu-jima, 10 in Toku-no-shima and 9 in Kikai-jima (Figures 4, 5, 6 and 7). Okierabu-jima and Kikai-jima were selected for

![Figure 4. Map showing localities of sampling sites and their coralline-algal assemblages (white letter in solid circle) in Yoron-jima. Lines drawn in the map are roads.](image-url)

![Figure 5. Map showing localities of sampling sites and their coralline-algal assemblages (white letter in solid circle) in Okierabu-jima. Lines drawn in the map are roads.](image-url)
comparison of paleoenvironments inferred from fossil corallines with those based on fossil corals by Nakamori (1986), and some specimens were collected from the same outcrops where he examined fossil corals. Yoron-jima was also investigated for comparison with benthic foraminifers by Noda (1976). Toku-no-shima was chosen because fossil corallines occur in the best state of preservation among the Ryukyu Islands. The stratigraphy of these islands has been discussed by previous works (Yoron-jima, Noda (1976), Iryu (1986); Okierabu-jima, Iryu et al. (1992); Toku-no-shima, Iryu and Yamada (1991); and Kikai-jima, Nakamori (1986)).
Floristic Characteristics
Some 955 thin sections were examined in this study. Eighteen species coming under 11 genera of fossil nonarticulated coralline algae whose thalli appear to be in situ were counted and listed (Table 1). This list does not include the corallines which seem to have grown in a cryptic, shaded environment as judged from their growth directions; such cryptic flora is beyond the scope of my investigation of the modern coralline-algal distribution and thus is of no use for establishing a “coralline bathymeter”. Fragments of 2 branched (*N. frutescens* and *L. moluccense*) and 1 leafy (*N. collis*) species are also recognized, although not counted and listed. Among those species known from the Ryukyu Group, the following have been reported from reefs in the present-day Indo-Pacific region: *Neogoniolithon colli, N. foslei, Porolithon onkodes, Hydrolithon reinboldii, Lithoporella melobesioides* (Foslie) Foslie, *Mastophora pacifica, Lithophyllum insipidum, L. moluccense, L. tesellatum* Lemoine, *Mesophyllum erubescens, M. purpurascens, Lithothamnion australis* Foslie, *L. funafutiense* (Foslie) Foslie, and *Archaeolithothamnium erythraele* (Rothpletz) Foslie. It can be concluded that the coralline-algal floral composition of the Ryukyu Group is almost the same as that of modern Indo-Pacific reef regions. There are some differences in the coralline-algal species composition between Recent and Pleistocene floras in the Ryukyu Islands. *Neogoniolithon conicum*, for example, is very abundant in the present-day Ryukyu Islands, whereas it is not found from the Pleistocene Ryukyu Group. On the other hand, *N. foslei*, which has a very low level of standing crop in the modern reefs, is rather common in the Pleistocene.

*Hydrolithon* sp. A and *Lithophyllum* sp. B are new to science and will be described elsewhere. *Hydrolithon improcerum* (Foslie) Foslie has been reported only from the Atlantic Ocean, and this is the first discovery of

![Figure 8](image_url)

**Figure 8.** Sketch of a typical example of Assemblage A in E6 (Okierabu-jima). a: *Neogoniolithon foslei*; b: *Spongiites* sp. A; C: *Porolithon onkodes*; d: *Porolithon* ? sp.; e: *Hydrolithon* sp. A; f: *Pseudolithothamnium* sp.; g: *Lithophyllum tesellatum*; h: *Lithophyllum* spp. (branched form); i: *Mesophyllum erubescens*; j: *Lithothamnion funafutiense*; k and l: other nonarticulated coralline algal species; m: corals.
it from the Pacific region. The use of thin sections for coralline identification rendered it impossible to distinguish some branched forms of *Lithophyllum* such as *L. kotschyanum* and *L. pallescens* and they are indicated as "*Lithophyllum* spp. (branched form)" in the list.

**Fossil Assemblages**

*Porolithon onkodes*, *Neogoniolithon foslei*, *Spongites* sp. A, and *Lithothamnion australi* are chosen as depth-indicative species, because they occur from the Ryukyu Group commonly to abundantly and their distribution is very limited in the modern reef environment not only in the Ryukyu Islands but also in Guam (Gordon *et al.*, 1976) and Hawaii (Adley *et al.*, 1982). Based on the presence or absence of these species, four fossil coralline species assemblages are delineated (Assemblages A, B, C and D) and their depth ranges are given as follows.

Assemblage A is characterized by the presence of *P. onkodes* (Figure 8). This species is widely distributed in shallow waters of the tropical Pacific Ocean (Adley *et al.*, 1982;
Table 2. Delineation of the nonarticulated coralline algal species assemblages and their depth ranges.

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth Range (m)</th>
<th>Ass. A</th>
<th>Ass. B</th>
<th>Ass. C</th>
<th>Ass. D</th>
</tr>
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<tbody>
<tr>
<td>Neogoniolithon foslei</td>
<td>0-20</td>
<td>•</td>
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<tr>
<td>N. foslei sensu Matsuda (1989)</td>
<td>20-35</td>
<td>•</td>
<td>•</td>
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<td>•</td>
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<tr>
<td>Spongites sp. A</td>
<td>35-50</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<tr>
<td>Porolithon onkodes</td>
<td>50+</td>
<td>•</td>
<td>•</td>
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<tr>
<td>Lithophyllum insipidum</td>
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<td>L. texellatum</td>
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<td>L. spp. (branched form)</td>
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<tr>
<td>Lithothamnion australis</td>
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<td>L. funafutitense</td>
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<td>L. sp. A</td>
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<td>Rhodolith</td>
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Table 3. Comparison of depth indicated by the nonarticulated coralline algal species assemblages with that by coral communities by Nakamori (1986). The upper and lower bars in each column show the depth ranges determined by the nonarticulated corallines and by the corals, respectively.

Foslie, 1929; Gordon et al., 1976; Iryu and Matsuda, 1987, 1988; Lee, 1967; Lemoine, 1911; etc.). Most of its occurrence is restricted to depths shallower than 20 m. The extent of areal coverage and abundance of *Lithophyllum insipidum* are very similar to that of *P. onkodes* in the Recent Ryukyu Islands (Iryu and Matsuda, 1988). Later observation reveals, however, that this species grows rarely at depths from 20 to 30 m in the Ryukyu Islands. In Hawaii, a few specimens of this species were found from a 15 to 35 m depth range, although it is principally a shallow-water species (Adey et al., 1982). Consequently, it seems that *L. insipidum* is not a suitable species to use as a depth indicator for the Ryukyu Group. Assemblage A is thought to have been distributed in depths down to 20 m. The assemblage, which is indicative of the moat environment, was expected to be distinguishable from the Assemblage A on the basis of occurrence of *Neogoniolithon frutescens* which grows abundantly and whose habitat is restricted within the moat area of the present-day Ryukyu Islands. This has not been realized because an *in situ* thallus of *N. frutescens* has not been found from the Ryukyu Group.

In Assemblage B, *P. onkodes* is totally lacking and *Neogoniolithon foslei* or *Spongites* sp. A is found instead (Figure 9). *Spongites* sp. A is abundant at depths from 0 to 25 m and is rarely observed to a depth of 30 m in the Recent Ryukyu Islands. This is synonymous with at least a part of *N. foslei* sensu Adey et al. (1982) which is restricted to depths less than 25 m in Hawaiian reefs. However, this species is not so abundant in the Pleistocene as in the Recent Ryukyu Islands. *N. foslei*, which occurs abundantly in the Ryukyu Group, is also selected as a depth indicator. Gordon et al. (1976) recorded it to depths of 35 m in Guam. Assemblage B is considered to have existed at depths from 20 to 35 m.

Assemblage C is composed of species having a wide depth range, such as *Lithophyllum*
tesellatum, Lithothamnion funafutiense and branched forms of Lithophyllum spp. (Figure 10). The absence of P. okodes, N. foslei, and Spongites sp. A characterizes Assemblage C and indicates that this assemblage was distributed at depths greater than 35 m. Rhodoliths are not found from the outcrop where Assemblage C is observed. In the modern Ryukyu Islands, rhodoliths are found from deep fore reef regions exceeding 50 m in depth, where they are distributed sporadically. It is highly probable that this assemblage existed in the depth range from 35 to 50 m or deeper.

Assemblage D is also composed of wide-depth-range species and lacks P. okodes, N. foslei, and Spongites sp. A. It is distinguished from Assemblage C in that Lithothamnion australie occurs in association with Lithothamnion sp. A. In the stratigraphic section characterized by Assemblage D, rhodoliths are sporadically scattered in outcrop. Lithothamnion australie is distributed at depths greater than 30 m and occurs very frequently at depths greater than 60 m in Hawaii (Ady et al., 1982). It is thought that Assemblage D existed in the deep fore reef environment, exceeding 50 m depth, where hermatypic corals were highly reduced in number and abundance was replaced by rhodoliths (Table 2).

Comparison with Coral communities

Nakamori (1986) recognized five fossil coral communities (Communities A, B, C, D and E) in the coral limestone of the Ryukyu Group based on generic comparison and sedimentological features. Community A was thought to have been distributed in the moat to the reef crest of the fringing reef or in the protected shallow water of patch reefs. Community B was considered to have existed in the reef edge which stood at almost sea level. The Communities C, D, and E were interpreted as inhabiting water depths from 0 to 15 m, from 10 to 30 m, and from 30 to 100 m on the reef slope, respectively. In order to compare the bathymetric interpretations derived from coralline algae and corals, fossil coralline algae were collected from nine outcrops on Okierabu-jima and nine on Kikai-jima from which Nakamori (1986) examined fossil corals. The depositional environments determined by the algae accord well with those based on corals at 13 localities (Table 3), but there are disagreements amongst the remaining five outcrops. This is because the algal Assemblage C indicates environments deeper than those suggested by the corals (E10, K2, K3 and K8). Assemblage C is discriminated by negative evidence; namely three shallow (P. okodes, Spongites sp. A, and N. foslei) and two deep (L. australie and Lithothamnion sp. A) water algal species are not observed. Because the 35 to 50 m depth range, where Assemblage C is considered to have been situated, is beyond the safety limit of conventional SCUBA diving, ecologic information available on living corallines may not necessarily be sufficient to provide accurate distributional data. The coralline bathymeter should be improved in this respect. It is concluded that the depositional environments indicated by algae generally agree with those based on corals and that the fossil corallines can be as excellent depth indicators as corals.

Comparison with Foraminiferal assemblages

Noda (1976) discriminated three benthic foraminiferal assemblages (Assemblages A, B and C) in the Ryukyu Group on Yoron-jima. He stated that the Assemblage A characterized an “off-reef floor facies” and the Assemblages B and C a “reef facies”. But no quantitative bathymetric data were given for each assemblage. This makes it difficult to compare quantitatively bathymetric interpretations derived from foraminifera and coralline algae. However, the fact that their interpretations agree can be verified qualitatively by comparing the distributional patterns of the flora and fauna. The foraminiferal assemblages are distributed nearly concentrically: Assemblage C occurs in an area around Ritcho where the basement rocks are exposed.
at present; areas of Assemblages B and A surround the Assemblage C area successively. The distribution of the coralline-algal assemblages is highly concordant with that of foraminifera. In other words, these floral assemblages are also distributed more or less concentrically. Assemblages B and C are distributed around the area of Assemblage A. Therefore, paleoenvironments determined by the nonarticulated coralline algal assemblage do not contradict those suggested by benthic foraminifera.

Discussion

Although nonarticulated coralline algae are distributed from tropical to boreal latitudes and from intertidal to more than 200 m depths in the modern marine environment, many geoscientists considered them to be tropical shallow-water organisms. Adey and MacIntyre (1973) pointed out such misunderstandings and gave principles for paleoecologic interpretation based on the coralline algae. An increasing number of studies since the 1960's on the coralline population and zonation, coupled with works on systematics, in northern waters (Adey, 1966; Adey et al., 1976) and in the tropics (Lee, 1967; Littler, 1973a, 1973b; Littler and Doty, 1975; Gordon et al., 1976; Adey et al., 1982; Minnery, 1990) have shown that the ecologic specificity of many coralline taxa and morphological groups. This indicates the great potential of the coralline algae as paleoenvironmental indicators. In particular, paleontologists have paid attention to ecologic specificity in such things as morphology of coralline crusts and branches and generic floral composition.

The coralline growth form, in particular, is thought to be indicative of paleoenvironment, especially hydraulic energy, based on the following two relationships observed in the present-day marine environment: (1) The branching of the thallus increases with increasing turbulence, namely, densely branched forms are found in turbulent areas and open-branched forms in quiet areas. In such cases, the apices of the branches of dense forms grow laterally, in response to abrasion, and fuse with adjacent branches to form an algal nodule called a rhodolith (Bosellini and Ginsburg, 1971; Bosence, 1976, 1983; 1985a). (2) The high-energy coralline-algal frameworks are constructed from closely superposed thick crusts and mutually fused thickly branched thalli, whereas those from sheltered environments are more delicate and open in their construction, being composed of thinner branches and crusts (Bosence, 1985b). The subtidal zonation according to coralline morphologies growing on stable substrata in tropical and nontropical regions made by Steneck (1986) indicates that thick forms predominate over thin ones at shallower depths while the reverse relationship is observed in deeper waters. These relationships were used to determine hydraulic conditions of coralline algal bioherms and biostromes by Studencki (1979) and Bosence and Pedley (1982). However, these observations are not adopted in this study. The relationship (1) is considered adequate to adopt because of the following two reasons. Firstly, this relationship is applicable to algal-related sediments containing many in-situ thalli of branched species of nonarticulated coralline algae. Such autochthonous thalli occur less abundantly in the Ryukyu Group and thus the relationship is of little use for this group. Secondly, it is still uncertain whether the branching species found from the Ryukyu Group, such as Porolithon sp. A, Lithophyllum spp., and Meso-phyllum erubescens, show a similar relationship between branch morphology and hydraulic conditions such as exists in the modern marine environment. My observation of living corallines in the reefs of the Ryukyu Islands shows that the branch morphology of Porolithon sp. A and Lithophyllum pallescens is highly stable. This means
that the relationship (1) does not hold well in all the branched coralline species. The relationship (2) seems to show a general and rough relationship between the morphology of corallines forming frameworks and hydraulic conditions or depth and to have many exceptions. I can give the following example as disproof. In the reefs of the modern Ryukyu Islands, it is common that the thick-crustose species, such as *Neogoniolithon foslei* and *Spongites* sp. A, are closely superposed to form thick robust frameworks at around 15 m depth on the reef slope, whereas thin and leafy corallines inhabit the basal dead portion of the dendroidal hermatypic corals to form a delicate and open framework on the more turbulent outer and inner reef flats. This evidence does conflict with the relationship (2). Consequently, the relationship (2) also can not be used for establishing the kind of paleoenvironmental interpretation attempted in this study.

The floral composition at generic level has been used for delineating paleobathymetry of algal-related deposits (Jones and Hunter, 1991). A schematic chart given by Adey (1979) and Adey *et al.* (1982) representing the relative abundance of coralline genera with respect to depth given has been used as a working standard for paleobathymetry in such studies. However, Adey (*op. cit.*) defined neither assemblages nor zones relative to specific depth ranges. Workers, therefore, had to interpret the paleobathymetry of algal-related deposits, the object of their own studies, by comparing their floral composition with Adey's scheme. This will possibly lead the workers to more or less arbitrary interpretations. Actually, Mankiewicz (1988) pointed out the occurrence of the *in-situ* branching *Mesophyllum* as one of the important documentation for the determination of water depth at the time of *Halimeda* accumulation; she stated that "Adey *et al.* (1982) showed that in modern (Atlantic) reef environments, *Mesophyllum* typically occurs in water depths greater than 50 to 60 m."

This figure ignores the fact that the branching *Mesophyllum* species, such as *M. erubescens* and *M. canariense*, are distributed at shallower depths in the Atlantic and thus seems to be arbitrary. Therefore, I have presented a stricter delineation of fossil assemblages and their specific depth ranges to avoid such vagueness.

The coralline bathymeter proposed in this paper is likely to be applicable to the Pleistocene reef limestones in the broader Indo-Pacific region, because most of the species used for the delineation of the assemblages, such as *Porolithon onkodes*, *Neogoniolithon foslei* and *Lithothamnion australis*, have a wide geographic distribution in modern marine environment and are thought to have a similar distribution in Pleistocene time. In summary, my study indicates that the fossil coralline-algal assemblages provide a reasonable paleobathymetric information on the depths of deposition of the Pleistocene reef-limestone complex.

**Conclusions**

Four fossil nonarticulated coralline algal species assemblages were discriminated from the coral limestone sequence of the Pleistocene Ryukyu Group. Each assemblage indicates a specific depth range.

Paleoenvironments inferred from these algal assemblages accord well with those derived from coral communities and benthic foraminifera. It is considered that the nonarticulated coralline algae are excellent depth indicators, and we can reconstruct detailed paleoenvironments by applying the coralline bathymeter.

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琉球層群の古水深指標としての無節サンゴモ: 琉球列島の与論島、沖永良部島、徳之島、喜界島に分布する第四系琉球層群中の無節サンゴモ化石を検討した。現在の琉球列島周辺海域における無節サンゴモとの比較から、同層群中に4つの化石無節サンゴモ群落を識別し、それぞれの化石群落の分布深度を推定した。化石無節サンゴモ群落の示す古水深は、化石サンゴ群集による推定古水深とはほぼ調和的であり、化石無節サンゴモが古環境、特に古水深の指標として有用であることが判明した。