

## Discovery of Late Triassic ammonoid *Arcestes* in the Kochigatani Group, Sakawa Town, Kochi Prefecture, Japan

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**Abstract** : A well preserved specimen of Triassic ammonoid *Arcestes* sp. is described from the middle part of the Kochigatani Group in the Ootogo area of Sakawa Town in Kochi Prefecture, Japan. The shell, measuring 68.8 mm in diameter, shows some mature modifications such as coiling change and contraction of the last quarter whorl, development of an apertural constriction, and formation of a ventrolateral salient at the apertural margin. *Arcestes* is the cosmopolitan genus of the Late Triassic period. The occurrence of the specimen and bivalves such as *Halobia* and *Tosapekten* leads to the conclusion that the middle part of the Kochigatani Group in the Ootogo area is that of Carnian-Norian interval.

**Key words** : Carnian-Norian, *Halobia*, Ootogo area, *Proarcestes* aff. *bicarinatus*, *Tosapekten*

### Introduction

Mesozoic deposits are widely distributed in Sakawa Town, Kochi Prefecture, Japan and have attracted the attention of many scientists since the pioneering work of Edmund Naumann (Naumann, 1885; Naumann and Neumayr, 1890; Yehara, 1927 etc.). The Kochigatani Group in the region yields numerous marine Upper Triassic fossils, and many bivalves and ammonoids have been described (Shimizu, 1927, 1930, 1931; Kobayashi and Ichikawa, 1950a, 1950b, 1950c; Bando, 1964 etc.).

Although most fossils from the Kochigatani Group are fragments, steinkerns, or flattened ones by compaction, coauthor Kenji Minato recently discovered an exceptionally well preserved *Arcestes* specimen together with bivalves, gastropods and crinoids from an outcrop in the Ootogo area of Sakawa Town (Figs. 1, 2; Mimoto, 2001). We describe the specimen hereafter and discuss the significance of the finding.

### Note on stratigraphy

Kobayashi *et al.* (1940) divided the Kochigatani Group into three lithologic units: lower, middle, and upper parts, and recognized four biostratigraphic units based on bivalve fauna, in ascending order: *Oxytoma-Mytilus*, *Halobia-Tosapekten*, *Myoconcha* and *Entomonotis* beds.

Katto *et al.* (1956) subdivided the group into two subgroups: the Lower and Upper Kochigatani subgroups. The lower part of the Lower Kochigatani Subgroup is composed of lightly greenish,

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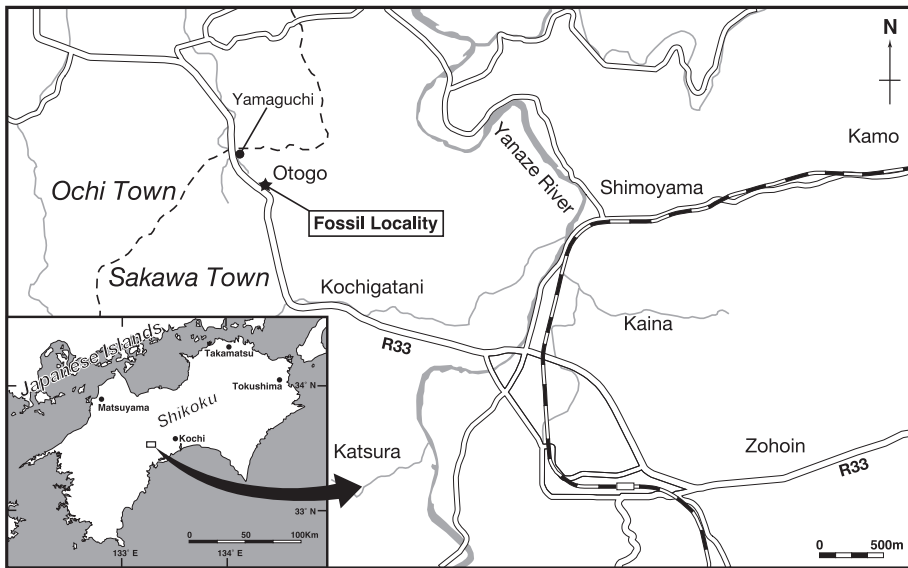


Fig. 1. Index map showing the fossil locality from which *Arcestes* sp. was collected. A specimen described as *Proarcestes* aff. *bicarinatus* by Shimizu (1931) was collected from the Yamaguchi area. Note that Kobayashi *et al.* (1940) plotted the position of the Yamaguchi area somewhat north from the actual location.

massive, fine sandstone with gravel (Hata, 1991). The upper part consists of sandy mudstone, fine sandstone and alternating beds of sandstone and mudstone (Hata, 1991). The Upper Kochigatani Subgroup is composed mainly of sandy mudstone and massive muddy sandstone, which are frequently intercalated with gravelly layers (Hata, 1991).

Toshimitsu *et al.* (2007) recently subdivided the group into three parts: lower part (= lower part of the Lower Kochigatani Subgroup by Katto *et al.*, 1956); middle part (= upper part of the Lower Kochigatani Subgroup by Katto *et al.*, 1956); upper part (= Upper Kochigatani Subgroup by Katto *et al.*, 1956).

The middle part of the group is well exposed at a large outcrop along the National Highway 33 in the Ootogo area, Sakawa Town, Kochi Prefecture (Figs. 1, 2), in which a 56 m thick continuous succession is visible. The strata strike E-W and dip northward at an angle of 70-80°, and the vertical and overturned beddings are partly exposed (Fig. 3). They are divided into three litho-facies, in ascending order as follows: 1) black mudstone, 2) alternating beds of sandstone and mudstone, and 3) sandy mudstone (Figs. 3, 4; Mimoto, 2001).

The black mudstone facies (greater than 30 m) consists mainly of slightly siliceous black mudstone intercalated with abundant greenish-white acidic tuff layers, which are 1-100 cm thick. This facies yields abundant fossils such as bivalve *Otapiria dubia* (Ichikawa) and *Halobia* sp., gastropod, and stalks of crinoid *Balanocrinus* sp. (Fig. 4; Mimoto, 2001).

The alternating beds of sandstone and mudstone facies (19 m) overlies the black mudstone facies with erosional surfaces by channel (Mimoto, 2001). The lower part of this facies is composed mainly of very fine to fine-grained sandstone intercalated with thin mudstone layers. The sandstone beds are several tens to 100 cm thick, and gradually become thinner toward the upper part (Fig. 4). Most

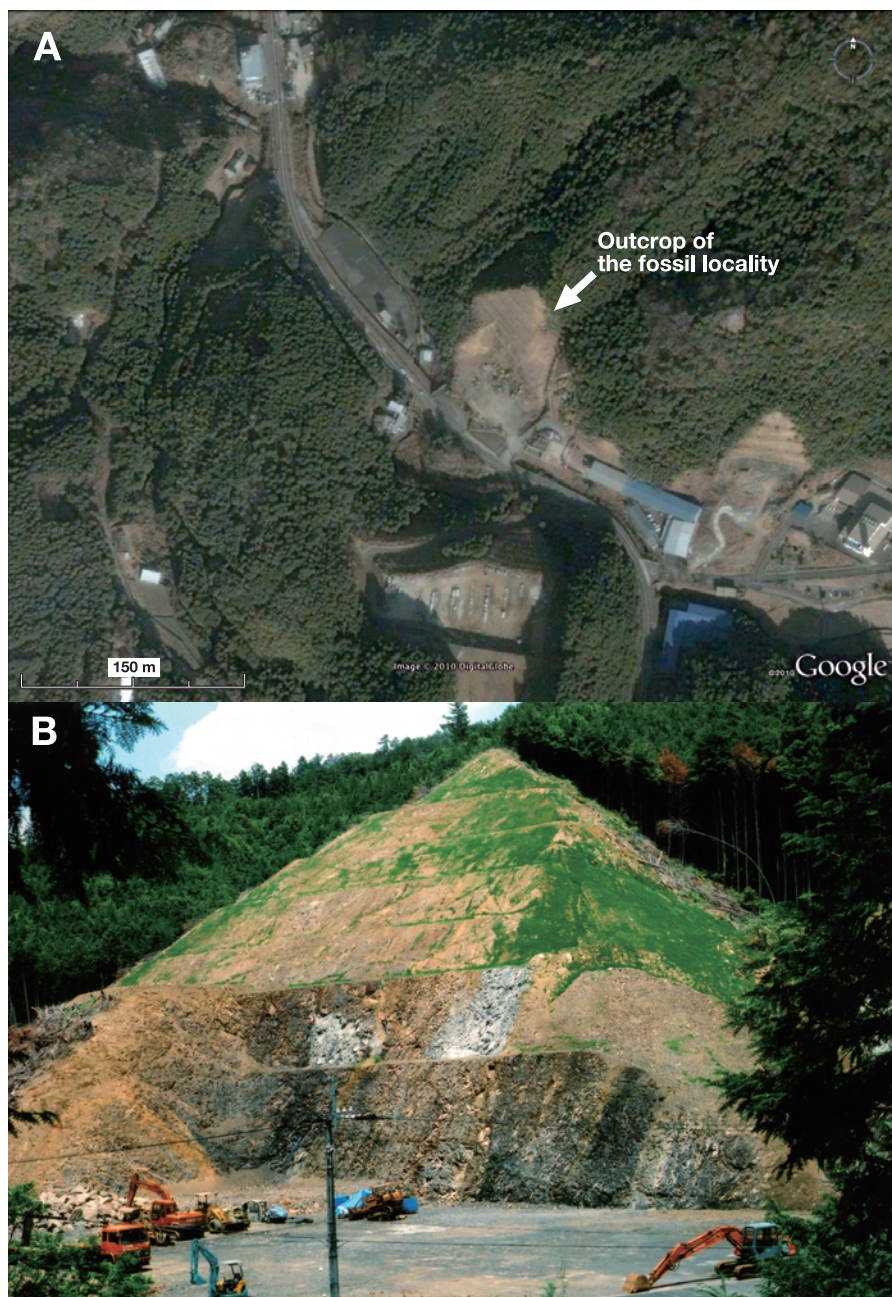


Fig. 2. A: Satellite photograph of the Otogo area, Sakawa Town, Kochi Prefecture, Japan. B: Outcrop of the Kochigatani Group from which *Arcestes* sp. was collected. The photograph was taken in May 2000.

sandstone beds in the upper part of the facies are 20-30 cm thick. Bivalves and gastropods were found from a float block of thick sandstone, which probably came from this facies (Mimoto, 2001).

The sandy mudstone facies (greater than 7 m) consists mainly of sandy mudstone intercalated with acidic tuff layers, which includes a thick layer in the middle part. The acidic tuff layers are significantly less than the black mudstone facies. This facies contains numerous plant remains and bivalves such as *Tosapecten suzukii suzukii* (Kobayashi) (Fig. 4).

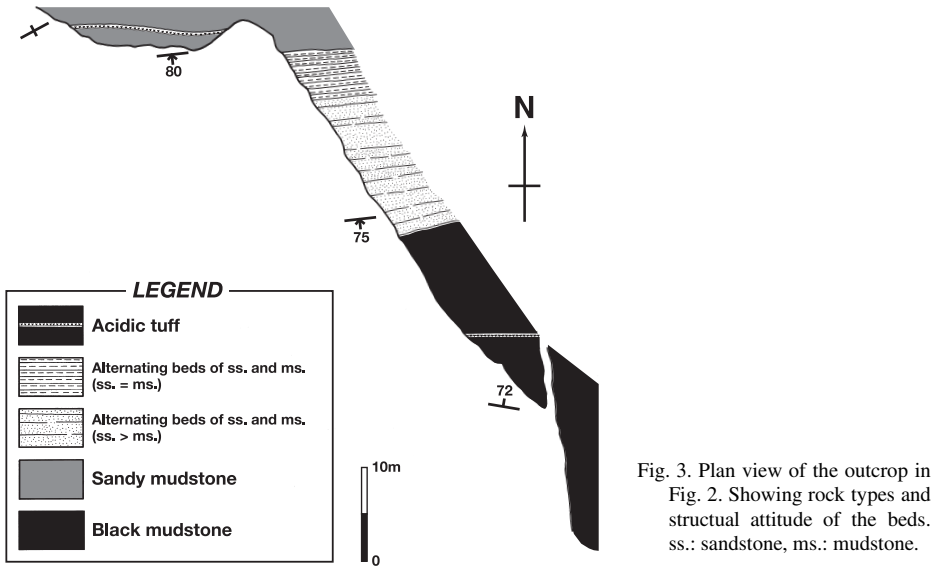


Fig. 3. Plan view of the outcrop in Fig. 2. Showing rock types and structural attitude of the beds. ss.: sandstone, ms.: mudstone.

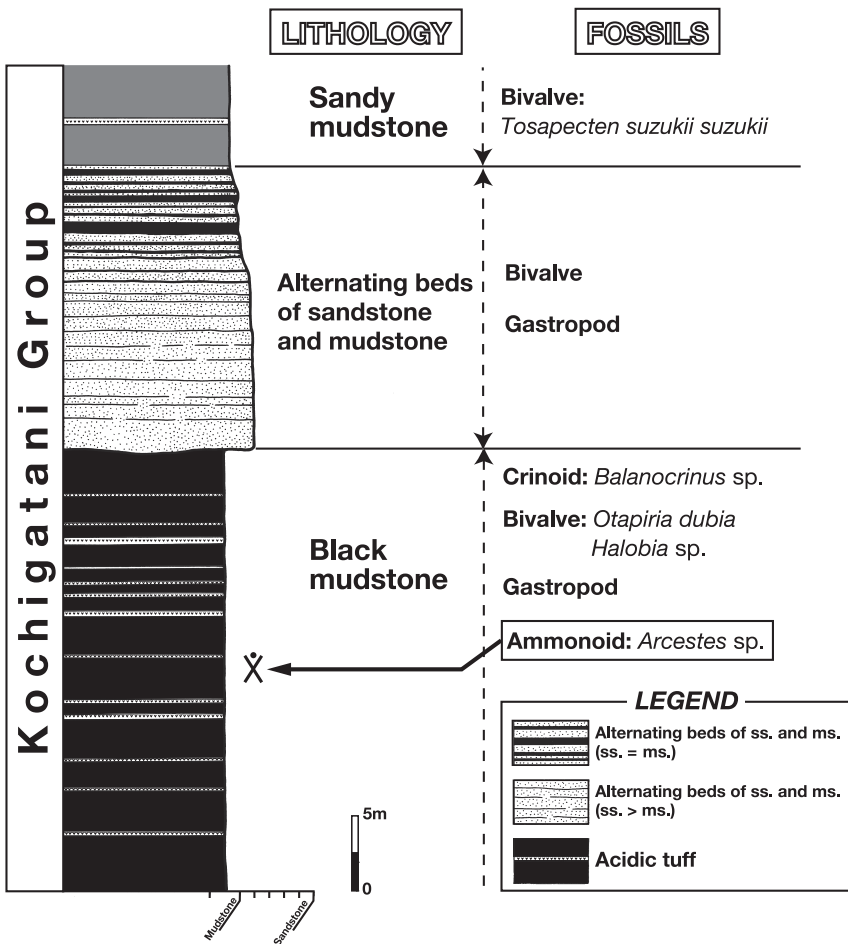


Fig. 4. Columnar section of the outcrop shown on Figs. 2 and 3, showing stratigraphic occurrences of *Arcestes* sp. and other fossils. ss.: sandstone, ms.: mudstone.

A specimen assignable to *Arcestes* sp. was obtained from the black mudstone facies from this large outcrop (Fig. 4).

### Paleontological description

Morphological terms are those used in the Treatise on Invertebrate Paleontology (Arkell *et al.*, 1957). Quantifiers used to describe the shape of ammonoid shell are the same as those reported by Matsumoto (1954, p. 246) and modified by Haggart (1989, table 8.1).

*Institution abbreviation:* TKPM = Tokushima Prefectural Museum.

Order Ceratitida Hyatt, 1884

Superfamily Arcestaceae Mojsisovics, 1875

Family Arcestidae Mojsisovics, 1875

Genus *Arcestes* Suess, 1865

*Type species:* *Ammonites galeiformis* Hauer, 1846.

*Discussion:* *Arcestes* is morphologically very similar to *Proarcestes* Mojsisovics, 1893, but periodic constrictions are confined to the phragmocone, and the body chamber shows some mature modifications (Spath, 1951; Arkell *et al.*, 1957). In contrast, *Proarcestes* possesses constrictions and flared ribs on phragmocone and body chamber. Also, the body chamber shows no modification.

*Occurrence:* Carnian to Rhaetian in the Arctic, Pacific and Tethys regions (Arkell *et al.*, 1957; Tozer, 1981; Konstantinov, 2008; Charlton *et al.*, 2009).

*Arcestes* sp.

(Figs. 5, 6)

*Material examined:* TKPM.GFI5387, measuring 68.8 mm in diameter, was extracted from a calcareous concretion embedded in black mudstone in the middle part of the Upper Triassic Kochigatani Group at an outcrop exposed along the National Highway 33, the Ootogo area, Sakawa Town, Kochi Prefecture (133° 15' 42.1"E, 33° 31' 18.3"N).

*Description:* Very involute and depressed shell with semicircular whorl section. Maximum whorl width occurs on umbilical shoulders. Coiling rate clearly decreases at three-quarters of outer whorl and last quarter whorl is slightly contracted. Umbilicus probably very narrow. Shell surface smooth, but exhibits very weak ribs, which increase in strength toward the apertural margin, on apertural part; a strong apertural constriction and a ventrolateral salient at apertural margin. Suture line is finely and deeply incised, partly visible on inner whorl. Outer whorl is occupied by body chamber.

*Remarks:* The body chamber of TKPM.GFI5387 is characterized by having some changes in coiling on the last quarter whorl, slightly contracted last quarter whorl, development of an apertural constriction and formation of a ventrolateral salient at apertural margin. Similar features have been



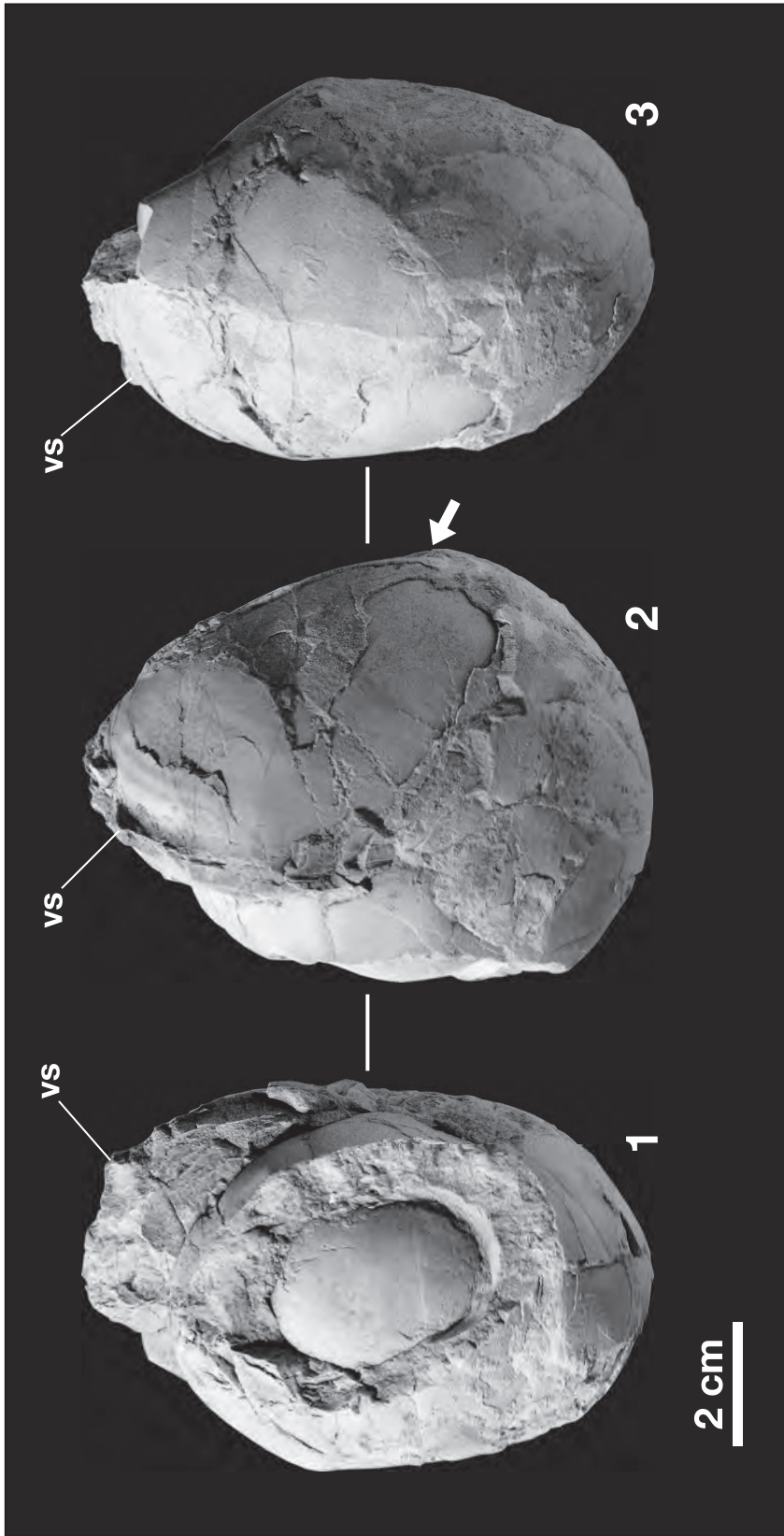


Fig. 5. *Arrestes* sp., TKPM.GF5387, from the Otago area, Sakawa Town, Kochi Prefecture, Japan. 1: Apertural view. 2: Right lateral view. 3: Ventral view. vs: Ventrolateral salient. Arrow of 2 indicates position of decrease of coiling rate.

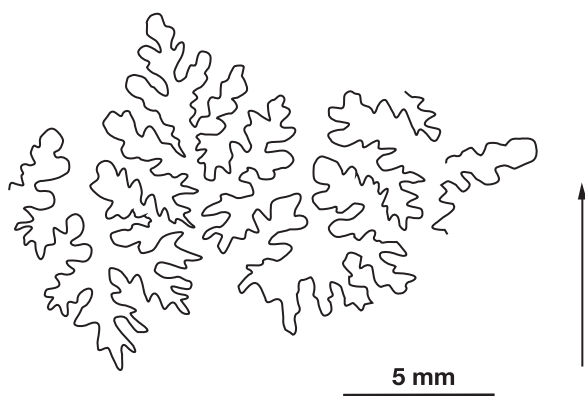


Fig. 6. Suture line of *Arcestes* sp., TKPM.GFI5387, from the Ootogo area, Sakawa Town, Kochi Prefecture, Japan. Arrow indicates the position of siphuncle.

known in adult shells of many Paleozoic and Mesozoic ammonoids as mature modifications (Davis, 1972; Davis *et al.*, 1996). These facts suggest that TKPM.GFI5387 is a mature shell.

TKPM.GFI5387 possesses no constrictions in the body chamber except for an apertural constriction in addition to some body chamber modifications. These features enable us to identify it as *Arcestes*, although no definitive species assignment can be made.

## Discussion

### Age of the Kochigatani Group in the Ootogo area

*Arcestes* is one of the cosmopolitan genera of the Late Triassic (Arkell *et al.*, 1957; Tozer, 1981; Konstantinov, 2008; Charlton *et al.*, 2009). Occurrence of *Arcestes* sp. from the black mudstone facies of the middle part of the Kochigatani Group in the Ootogo area suggests that the portion is of Late Triassic Epoch (Carnian-Rhaetian). Mimoto (2001) collected bivalves assigned to *Halobia* sp. from the black mudstone facies and *Tosapekten suzukii suzukii* from the Sandy mudstone facies in the same outcrop (Fig. 4). *Halobia* typically ranges from Carnian to Norian (McRoberts, 2010). The taxon range of *Tosapekten* is Late Triassic Epoch (Cox *et al.*, 1969; McRoberts, 2010). Judging from stratigraphic ranges of each taxa, depositional age of the Kochigatani Group in the Ootogo area is restricted from Carnian to Norian.

### Locality of “*Proarcestes* aff. *bicarinatus*”

Shimizu (1931) described a tiny but well preserved specimen as *Proarcestes* aff. *bicarinatus* Münster, 1841 from the siliceous shale in the Yamaguchi area, Sakawa Town (Fig. 1). However, exact locality and horizon of the specimen were not described. Some authors attempted to determine the locality, but they could not find any exposures of siliceous shale in the Yamaguchi area (Kobayashi *et al.*, 1940; Kobayashi and Ichikawa, 1950a; Kobayashi, 1962). We also had the same results.

Exposures of the siliceous shale are distributed in the Ootogo area, which is located on the same creek approximately 250 m upriver from the Yamaguchi area (Fig. 1). We discovered a specimen of *Arcestes* sp. described herein from that area. Three dimensional preservation of the specimen is very

similar to that of Shimizu's specimen. These facts certainly suggest that the Shimizu's specimen may have been obtained from a float block derived from the black mudstone in the Otogo area.

It should be noted that assignment of Shimizu's specimen to *Proarcestes* aff. *bicarinatus* is uncertain because of its tiny shell. It may simply be a juvenile arcestd shell.

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\*English translation from the original written in Japanese

摘 要

高知県佐川町の川内ヶ谷層群より発見された三畳紀後期アンモノイド *Arcestes*

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高知県佐川町乙川地域に露出する川内ヶ谷層群中部から保存良好な三畳紀アンモノイドの *Arcestes* sp. が産出した。殻直径は 68.8 mm, 住房後半部での螺環高の増大率の減少, 殻口部での殻の引き締まり, 殻口縁に発達する強いくびれや突起など成熟殻の特徴を示す。 *Arcestes* 属は三畳紀後期に汎世界的に分布したグループであり, *Arcestes* および同地域から産出する二枚貝化石 (*Halobia*, *Tosapecten*) から, 乙川地域に露出する川内ヶ谷層群中部の堆積年代は三畳紀後期のカーニアン期からノーリアン期を示す。

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