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Occurrence of *Aturia* (Cephalopoda: Nautilida) from the Miocene Bihoku Group of Hiroshima Prefecture, southwestern Japan

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Abstract

Aturia fossils were obtained from the Middle Miocene Itabashi Formation, Bihoku Group, in Shinjo-cho and Higashihonmachi, Shobara City, Hiroshima Prefecture. As the results of the taxonomic study of the fossils, it is confirmed that these specimens are referable to *Aturia cubaensis* (Lea) in shell shape and in major features of its sculpture. It is thought that one of these specimens had been drifted on the warm oceanic current for about a half to one year after death, and it deposited in the sublittoral zone of the muddy bottom in the Setouchi sedimentary basin.

Key words: *Aturia cubaensis*, upper Middle Miocene, Bihoku Group, Shobara City, Hiroshima Prefecture

Introduction

Aturia fossils were found in the Miocene Bihoku Group, in Shobara City, Hiroshima Prefecture, southwestern Japan. The occurrence of the nautiloid fossil is so rare from the Miocene Bihoku Group that *Aturia* fossils have been reported from Hiroshima Prefecture (Tanaka *et al*., 2000), and the nautiloid fossil from Okayama Prefecture (Kishimoto, 1982) up to date. However the occurrence of the *Aturia* fossil is important to reconstruct the evolutionary history of the group and to know the paleogeography and paleoflumenology at that time.

Geologic settings

Aturia fossils including fragmental specimens were obtained by T. Yamaoka and H. Ohsawa, from the siltstone of the Itabashi Formation (=Upper Shale Formation), Bihoku Group, at the road-cliff (A of Fig. 1) of Shinjo-cho; whereas a large-sized adult specimen was obtained by N. Hamada, from the same formation at the river bed (B of Fig. 1) of Saijo River, 4-chome, Higashihonmachi, Shobara City, Hiroshima Prefecture.

Concerning the molluscan fossils from the Bihoku Group in and around Shobara City, the littoral inhabitants represented by *Vicarya* assemblage, were first described on the basis of the specimens from Suketo and Shinchiku-cho (=Miyauchi-cho) (Otuka, 1938). Recently Okamoto *et al*. (1990) reported the molluscan fossils from the Lower Sandstone Formation and the Upper Shale Formation in the Kaisekidani Area, Miyauchi-cho, and Okamoto (1992) described the change of the molluscan assemblages from the Lower Sandstone Formation to the Upper Shale Formation of the Bihoku Group, on the basis of the molluscan fossils from the Kaisekidani Area in Miyauchi-cho and the Shinjo-Korematsu-cho Area. These studies on the sedimentary facies and molluscan assemblages revealed that the water depth of the Bihoku Group increases rapidly from the base to the top.

Takayasu *et al*. (1992) made clear the Miocene

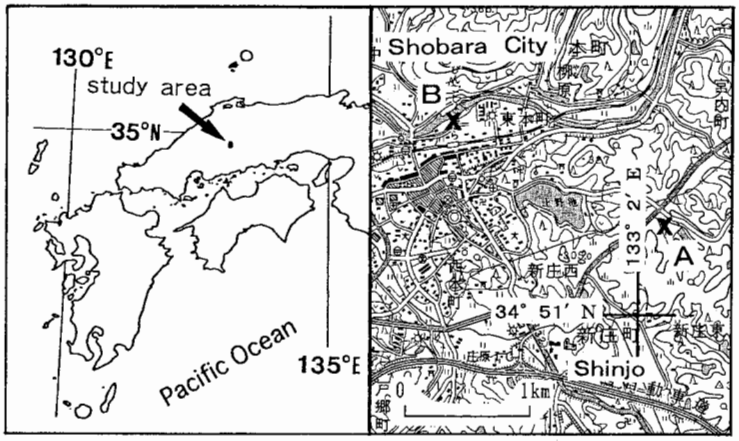


Fig. 1. Map showing the locality of the present *Aturia* fossils.
(cited from the 1/50,000 quadrangle of "Shobara")
X= fossil locality.
A: the road-cliff of shinjo-cho, Shobara City.
B: the river bed of Saijo River, 4-chome, Higashihonmachi, Shobara City.

stratigraphy and paleogeography of the San'in district, and simultaneously Ueda and Takayasu (1992) revealed the molluscan faunal and paleoenvironmental changes of the Tertiary formations in the San'in district. According to them, during the early Middle Miocene, the Setouchi Sedimentary Province opened on the north to northwest sea.

Tomida *et al*. (1999) described a pleurotomariid gastropod *Perotrochus* sp. from the early Middle Miocene Itabashi Formation of the Bihoku Group, at Shinjo-nishi, Shobara City. They concluded that the mode of occurrence of the pleurotomariid fossils in the Itabashi Formation in this area, indicates the para-autochthonous mode of occurrence in the subneritic to bathyal zones. At the two localities of the present *Aturia* fossils, the Itabashi Formation yielded a few other molluscan fossils; at Shinjo-cho (A of Fig. 1), it yielded *Phalium yokoyamai* Nomura and Hatai, *Gemmula* sp., *Acila submirabilis* Makiyama, *Ennucula* sp., *Ostrea* sp., *Macoma* sp., and *Fissidentalium yokoyamai* (Makiyama); whereas at Higashihonmachi (B of Fig. 1), it yielded *Calliostoma* sp., *Acila submirabilis* Makiyama, *Ennucula* sp., *Ostrea* sp., Gryphaeid, *Macoma* sp., *Cultellus izumoensis* Yokoyama, and *Fissidentalium yokoyamai* (Makiyama). The formers are the mixture of the euneritic to subneritic inhabitants of the muddy bottom, and the laters are the little shallower inhabitants than the formers.

Systematics

Class Cephalopoda Cuvier, 1797
Order Nautilida Agassiz, 1847
Family Aturiidae Chapman, 1857
Genus *Aturia* Bronn, 1838

Type species: *Nautilus aturi* Basterot, 1825.

Aturia cubaensis (Lea, 1841)

(Figs. 2.1-3; Fig. 3)

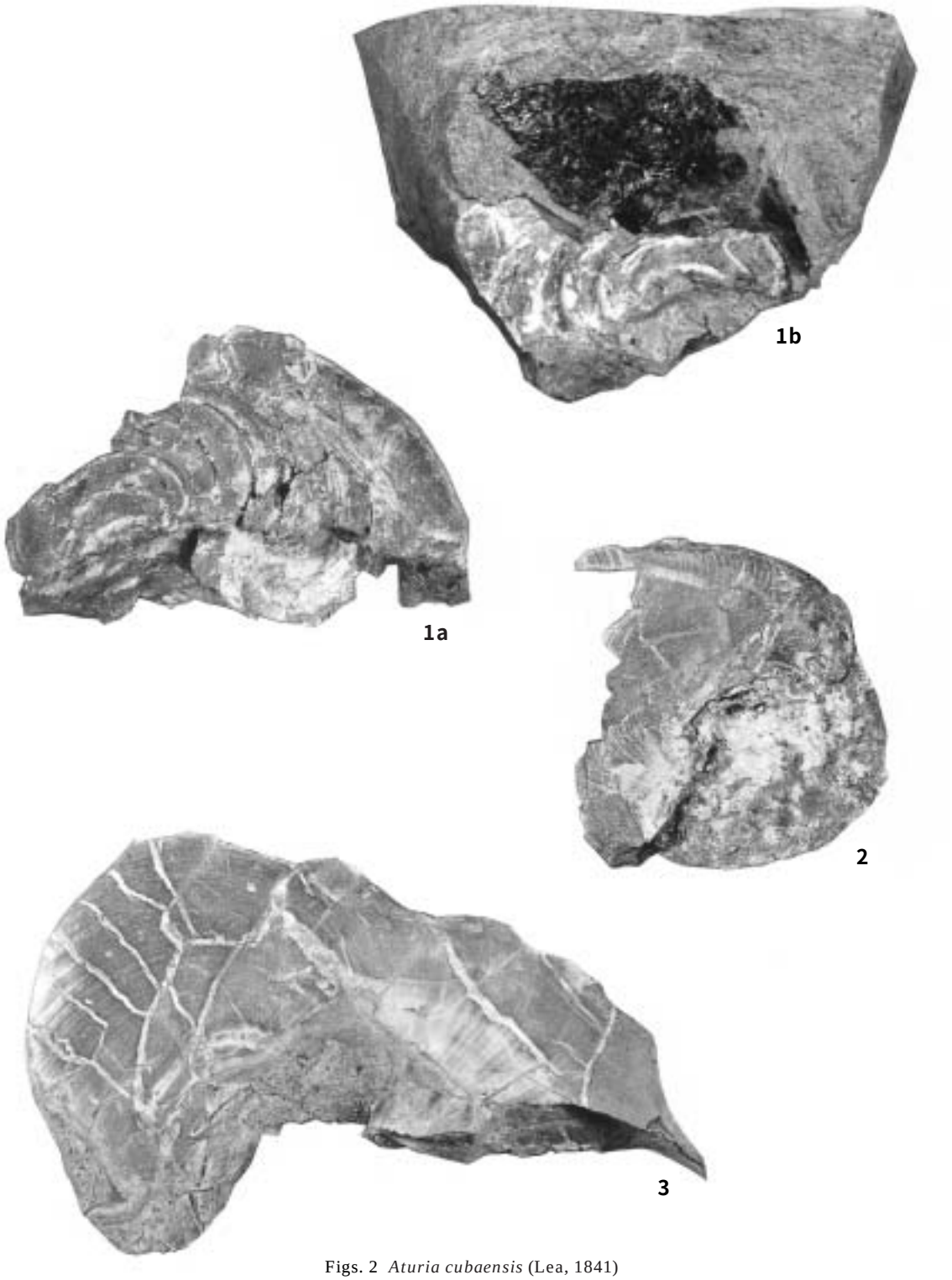
Synonymy: see Tomida (1992); p. 230.

Materials: Two phragmocones (MFM21008: figs. 2.1a, b; and MFM21009: fig. 2.2) were obtained at the road-cliff of Shinjo-cho, and a large-sized adult specimen (HMN-F00005: figs. 2.3, 3) was obtained at the river bed of Saijo River, 4-chome, Higashihonmachi, from the early Middle Miocene Itabashi Formation of the Bihoku Group, in Shobara City, Hiroshima Prefecture. These are ill-presereved, and laterally compressed.

Measurements: Shell length ca. 72.0mm × 51.0mm (MFM21008); Max. diameter 61.5mm, min. diameter 50.5mm (MFM21009); Max. diameter ca. 153.0mm (HMN-F00005).

Description of the specimens: Shell large, nautilicone, involute and laterally compressed. Whorl surface flat but ornamented with many fine growth lines. Septal suture: lateral lobe with an acutely pointed extremity and inflated sides, and no turn between the lateral lobe and the lateral saddle. Umbilicus rather small and half-closed with an umbilical pocket.

Comparison: This is referable to *Aturia cubaensis* (Lea, 1841), a world-wide species first described from the Miocene of Cuba, in having a shell with a pointed extremity of the lateral lobe, the largely rounded lateral saddle, and no turn between the lateral lobe and the lateral saddle. This species resembles *Aturia aturi* (Basterot, 1825), an early Miocene species, but it differs from *A. aturi*, in having no turn between the lateral lobe and the lateral saddle. This species also resembles *Aturia*



Figs. 2 *Aturia cubaensis* (Lea, 1841)

1a: lateral view of the inner mould, ×1, MFM21008 from the lower Middle Miocene Bihoku Group, at the road-cliff of Shinjo-cho, Shobara City, Hiroshima Pref. b: lateral view of the outer mould, ×1, ditto. 2. lateral view, ×1, MFM21009, ditto. 3. lateral view, ×0.7, HMN-F00005 from the lower Middle Miocene Bihoku Group, at the river bed of Saijo River, 4-chome, Higashihonmachi, Shobara City, Hiroshima Pref.

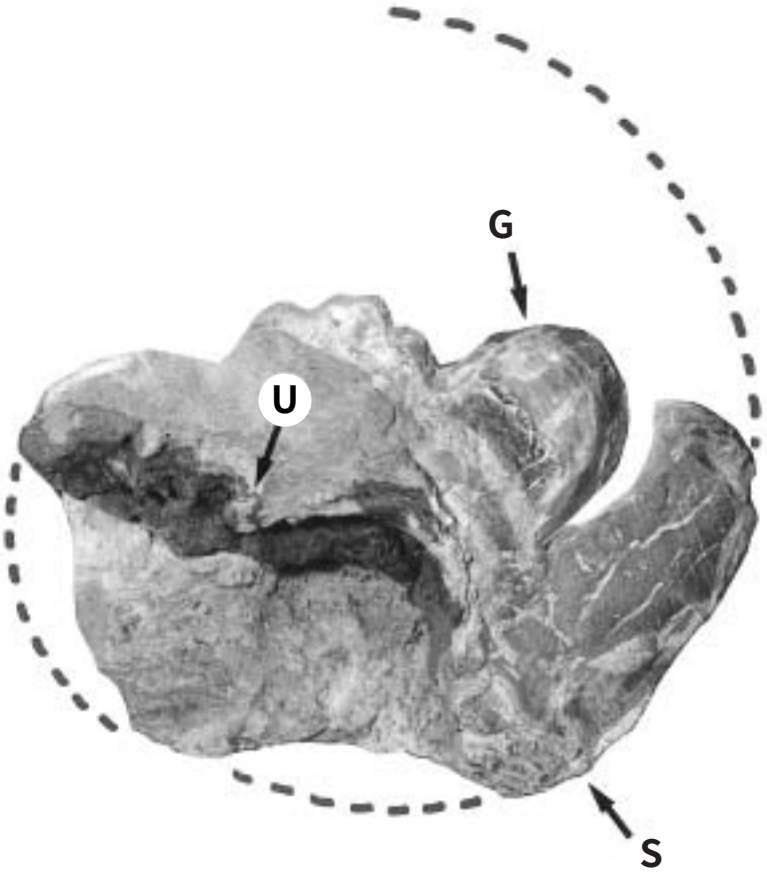


Fig. 3. *Aturia cubaensis* (Lea) attached by a gryphaeid species.
(×0.7: this is the right lateral side of the same specimen of fig. 2.3)
Arrow G: a gryphaeid species. Arrow S: the ultimate septal suture. Arrow U: umbilicus.

coxi Miller, 1947, a Middle to Late Miocene species of Zanzibar Protectorate, Australia, New Zealand and Japan (Tomida, 1983; Ozawa and Tomida, 1996), in having a pointed extremity of the lateral lobe, the largely rounded lateral saddle, and no turn between the lateral lobe and the lateral saddle. But it is distinguished from A. *coxi* by having septa not so close to one another, rather large and half-opened umbilicus, and without a ventral lobe.

Remarks: Two specimens Fig. 2.2 and Figs. 2.3, 3) are about complete phragmocones with somewhat damage to apertures of the living chambers. But one (Figs. 2.3, 3) of these specimens was attached by a gryphaeid species (Fig. 3) of about 25mm in length and about 35mm in width, and a very small another, on the inner wall surface of living chamber. The other specimen (Figs. 2.1a, b) is a phragmocone with the largely damaged venter.

Discussion

In the San'in district, except the Shobara area, *Aturia* fossils were reported from the Susa Group in Susa-cho, Yamaguchi Pref. (Okamoto and Suyama, 1975); the Yuya-wan Group in Yuya-cho, Yamaguchi Pref. (Okamoto, 1977); the Togane Formation at Senjojiki, Togane, Shimane Pref. (Kobayashi and Masatani, 1955; Okubo, 1975); the Masuda Group in Masuda City, Shimane Pref. (Tsuru, 1987); the Fujina Formation in Matsue City, Shimane Pref. (Kobayashi, 1960; Sakumoto *et al*., 1996).

These localities are located in the coastal regions of the Japan Sea. As already mentioned, during the early Middle Miocene, there was the most increase in transgression and the Setouchi Sedimentary Province opened on north to northwest, the proto-Japan Sea. A shell (Fig. 2.2) of the present *Aturia* fossils remains about completely and is half lacking in the living chamber. An another shell (Figs. 2.3, 3) is preserved in a similar state as the former specimen (Fig. 2.2) but several individuals of a gryphaeid species attached on the inner wall surface of living chamber. In the present ocean, most of the gryphaeid species live in tropical and subtropical waters, attaching on the hard substratum in a water-depth less than 20m. The shell length of the gryphaeid indicates that it took at least about a half year to one year to grow up its size. This may indicate that the individual had

been drifted on the oceanic current more than a half year after death. Hamada (1965) pointed out that all of *Nautilus* shells were damaged to the extremity of the living chamber, and the 80% of them were lacked in the living chamber, during they had been drifted. From these facts, it may be inferred that the present *Aturia* specimens had been drifted on the warm oceanic current for about a half to one year after death, and at last it deposited in the sublittoral zone of the muddy bottom in the Setouchi sedimentary basin.

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