

Color patterns of Cretaceous pleurotomariid gastropods from Hokkaido

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(With 1 text-figure and 2 plates)

白亜紀オキナエビスガイ科巻貝の色模様

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Pleurotomaria fausta, *P. yezoensis* 2種に色模様が発見された。色模様は、両種の殻の外層に認められ、明色の基地に帯赤色の放射色帯で、殻表面の彫刻と調和している。これらの色模様は、亜深海性の現生属 *Mikadotrochus*, *Perotrochus* と共通である。化石種の色素は、メラニン類と推定される。

Introduction

Little is known about the color patterns of fossil gastropods. In the Silurian *Platyceras deceptivum* the color patterns consist of spiral bands in the outer layer of the shell, and the presence of melanin pigments have been inferred observing the preserved specimens in weathered limestone (KŘIŽ and LUKEŠ 1974). Early Carboniferous pleurotomariid, *Mourlonia carinata* (J. SOWEBBY), is characterized by zigzag bands above the selenizone (NEWTON, 1907). Late Carboniferous *Naticopsis* (*Naticopsis*) *wortheniana* have spiral bands. The shell is composed of thin outer prismatic layer of calcite and thick inner layer of aragonite; these have been determined by examining preserved specimens in limestone rich in asphalt (SQUIRES, 1976). The middle Permian pleurotomariid, *Euconospira nipponica*, has striped patterns which are oblique to the growth lines of the shell surface. This specimen was found embedded in bituminous limestone (HAYASAKA, 1953). The color markings of certain Cretaceous species of the Neritacea have oblique stripes to the growth lines of the shell (HAYAMI and KASE, personal comm.).

COMFORT (1950) has suggested that molluscan shell pigments consist mostly of blackish, brownish, and reddish melanins, purple indigoids, and pyrroles. The pyrroles are widely found in the form of porphyrins in many species of Recent molluscs.

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The color patterns of ammonites are known from the calcareous nodules found embedded in Late Cretaceous deposits of the meridional zone of Hokkaido (MATSUMOTO and HIRANO, 1976; TANABE and KANIE, 1978).

In this paper we describe the color markings of two species of *Pleurotomaria* (s.s.) from the Upper Cretaceous of Hokkaido, and discuss their comparative aspects with those of living pleurotomariid gastropods.

Description of color patterns

Specimen A. *Pleurotomaria fausta* KANIE et HABE, 1973

(Pl. 1, fig. 1a, 1b)

Material: TAKAHASHI's private collection, from the Rubeshibegoe-no-sawa (44°43'N, 142°1'E), Abeshinai area, north Hokkaido. Geological age, Middle Campanian. Coll. T. TAKAHASHI.

Description: Colour patterns exist in the outer layer of the shell. The patterns are dark-purple radial stripes on a light-brown ground. They are preserved at the upper part of peripheral bulge, but not at the base. The stripe patterns of the upper and lower areas near the selenizone are convex in adapertural direction. The color patterns inside of the selenizone are concave in the direction of the aperture. These patterns are in harmony with the surface sculptures, namely collabral threads. Both outer and inner shell layers are made up of aragonite.

Specimen B. *Pleurotomaria fausta* KANIE et HABE, 1973

(Pl. 1, fig. 2a, 2b)

Material: MSM. PM15067 (errors for 100; Holotype in KANIE and HABE, 1973), from Sannai (45°31'N, 142°3'E), Cape Soya, north Hokkaido. Geological age, Middle Campanian. Coll. T. MIYAUCHI.

Description: The color patterns are present on the surface layer of the last and subsequent whorls but not at the base. They are black-spotted in appearance along the collabral threads and become stronger toward the suture. The outer shell is composed of calcite.

Specimen C. *Pleurotomaria yezoensis* KANIE, 1980

(Pl. 1, fig. 3a, 3b)

Material: MIZUNO's private collection, from the Ikandai Beach (42°11'N, 142°44'E), Urakawa area, southern-central Hokkaido. Geological age, Early Campanian. Coll. Y. MIZUNO.

Description: Color patterns are observed at the flank and selenizone of the penultimate whorl. The markings consist of confined to the layer of the outer surface. The patterns are reddish brown radial stripes on a light-colored ground. The stripe patterns of the upper and lower areas near the selenizone are convex in adapertural direction. The color patterns of the inside of the selenizone are

concave in the direction of the aperture. These patterns are in harmony with the surface sculptures, such as the collabral threads. Both the outer and inner shell layer are composed largely of high-silicate analcime.

Comparison with modern pleurotomariids

Color patterns: Three modern species of pleurotomariid gastropods are illustrated in figures 1-3 of plate 2. Their color patterns show reddish radial stripes on white grounds. The stripe patterns are also found in the foot of *Mikadotrochus hirasei* (PILSBRY) (Text-figure 1). Thus, the color patterns of the shell also appear to be derived from the soft parts of the animal. Three Cretaceous specimens described above therefore have similarities with those of modern species.

Shell structure and mineral composition: The shell profile of the upper part from a slit band is shown in figure 4 of plate 2. Examination of *Mikadotrochus beyrichii* (HILGENDOLF), from off Choshi (precise locality uncertain), Chiba Prefecture indicates the presence of outer, central and inner shell layers, and the layers consist of crossed lamellar, myostracum, and prismatic structures, respectively. Both outer and inner shell layers are found composed of aragonite analyzed using an X-ray diffractometer.



Text-figure 1. Color patterns in living *Mikadotrochus hirasei* maintained in Marine Laboratory, Chiba University. Shell diameter about 7 cm. Photo by KANIE on 26th April, 1980.

Discussion

The color patterns of two species of Cretaceous *Pleurotomaria* show similarities with those of some modern species of *Mikadotrochus* and *Perotrochus*. They involve reddish radial stripes on light-colored grounds. However, the patterns of fossil gastropods previously reported and those of many modern species without pleurotomariids are mostly of spiral bands. Thus, the color markings of pleurotomariid gastropods are quite diagnostic.

The function of these patterns are still unclear. It is well-known that the reddish color markings are generally common in deep water invertebrates. The circumstances of the living pleurotomariids in the Pacific waters off Choshi are as follows: *Mikadotrochus beyrichii* from a depth of 88–230 m on the rocky bottoms (WATANABE and TSURUOKA, 1980); *M. hirasei* from 80–200 m on the rocky bottoms (WATANABE, personal comm.); *Perotrochus diluculum* OKUTANI from 200–250 m on the rocky bottoms (WATANABE and TSURUOKA, 1980) or 250–280 m (OKUTANI, 1980). Thus, the living pleurotomariid gastropods are regarded as deep sea benthos.

The color patterns of certain designated *Pleurotomaria* (s.s.) consist of reddish radial stripes on light-colored grounds just like those of tetragonitid ammonites and living *Nautilus*, which have been assumed to be off-shore and/or deep sea animals (TANABE and KANIE, 1978). Most gastropods and certain ammonites (e.g., *Protexanites* and *Paratexanites*, which are regarded as shallow sea and/or off shore animals, however they have spiral color bands. Permian *Euconospira* with oblique color patterns has been interpreted as a warm, clear and shallow water animal analogous to certain modern gastropods (HAYASAKA, 1953).

The compositions of the pigments of Cretaceous *Pleurotomaria* species and the living species are still uncertain. The pigments studied are still stable, although the aragonitic composition of the outer and inner layers which bear the pigments have been replaced by calcite or analcime. FOX (1966) suggests that true melanins are insoluble in most liquid media though disperse in alkalis, while tetrapyrroles are soluble in water. Therefore, the pigments of present pleurotomariids are possibly assignable to melanins. These color bands exist in the outer shell layer as in other species of gastropods, e.g., *Naticopsis wortheniana* (SQUIRES, 1976), *Platyceras deceptivum* (KŘÍŽ and LUKEŠ, 1974), *Euconospira* (HAYASAKA, 1953), and living *Cellana nigrolineata* (unpublished data) and certain species of Cretaceous ammonites (MATSUMOTO and HIRANO, 1976; TANABE and KANIE, 1978).

Summary

Color patterns are preserved in the outer shell layers of two species of pleurotomariid gastropods, viz., *Pleurotomaria fausta* and *P. yezoensis*. They are

found in the calcareous nodules of the Upper Cretaceous from Hokkaido. The color patterns of the present species are reddish radial stripes along the sculptures of the collabral threads on the light-colored grounds of the flank which resemble those of living *Mikadotrochus* and *Perotrochus*. Due to similarities in the color markings, two Cretaceous species are regarded as rather deep sea animals. The pigments of the color bands appear to remain in the fossilized specimens, whereas the aragonite become replaced by calcite or analcime. Therefore, it is suggested that the pigments are probably of melanin composition.

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Explanation of plates 1-2

Plate 1

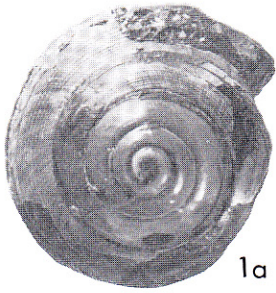
- Fig. 1a-b. *Pleurotomaria fausta* KANIE et HABE, with color radial stripes on the outer shell layer. TAKAHASHI's private collection. Loc. the middle part of the Rubeshibegoe-no-sawa, Abeshinai area, north Hokkaido.
 1a. apical view ($\times 1$); 1b. apical view ($\times 2$).
- Fig. 2a-b. *Pleurotomaria fausta* KANIE et HABE, with radial color spots. National Science Museum specimen (NSM. PM15067). Loc. Sannai, Cape Soya, north Hokkaido.
 2a. side view ($\times 2.5$); 2b. apical view ($\times 1$).
- Fig. 3a-b. *Pleurotomaria yezoensis* KANIE, with radial color stripes. MIZUNO's private collection. Loc. Ikandai Beach, Urakawa area, southern-central Hokkaido.
 3a. apical view ($\times 1$); 3b. apical view ($\times 2$).

Photos by KANIE.

Plate 2

- Figs. 1-3. Color patterns in three living pleurotomariid gastropods.
1. *Mikadotrochus hirasei* (PILSBRY). Yokosuka City Museum specimen (YCM. ZH2). Loc. off Kochi. (3/4).
 2. *Mikadotrochus beyrichii* (HILGENDOLF). YCM. ZH 8001. Loc. off Tsurugizaki (Kenzaki), Tokyo Bay. (3/4).
 3. *Perotrochus teramachii* KURODA. YCM. ZH 8002. Loc. off Taiwan. (3/4).
- Fig. 4. Shell structure of the flank region between SU and SE of *Mikadotrochus beyrichii* (HILGENDOLF). YCM. ZH 8003. Replica on an acethylcellulose film. ($\times 10$). o outer layer of crossed lamellae; i inner layer of prisms; m myostracum; su suture; se selenizone.

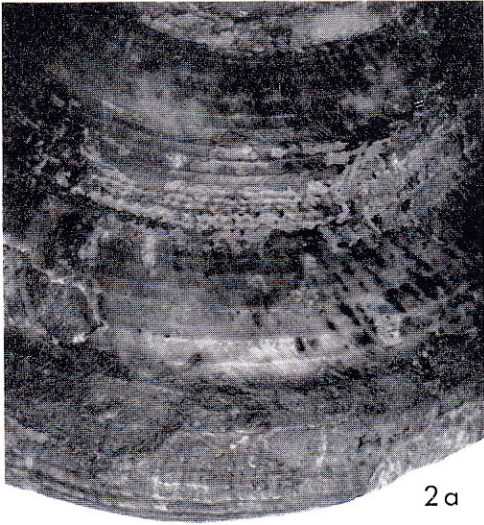
Photos by KANIE.



1a



1b



2a



2b



3a



3b

