

## Occurrences of some Cretaceous limpets in the Pacific and the U. S. Western Interior regions\*\*

Yasumitsu KANIE\*

(With 1 text-figure)

### 太平洋沿岸と北アメリカ西部内陸地域における 白亜紀笠形貝の産出層準\*\*

蟹江 康光\*

インドー太平洋沿岸地方と北アメリカ西部内陸・湾岸地方の白亜紀泥質堆積物から A・B・C 3形態の笠形貝が報告されている。A グループは笠形巻貝で円錐形あるいは低円錐形あるいは低円錐殻を有する。B グループの巻貝は殻表面前方に竜骨がある。C グループは盤泳クラゲ類に属し表面に放射状の隆起が一方に認められる。

インドー太平洋区域で A グループに属するものは "*Anisomyon*" *meekeei* (上部セノニアン～サントニアン), "*A*" *transformis* (下部カンパニアン), "*A*" *giganteus-Gigantocapulus giganteus* (中部カンパニアン), "*A*" *problematicus* (下部マストリヒシアン) である。西部内陸湾岸区域では上部カンパニアンから上部マストリヒシアンに 7 種知られている。B グループでは北海道のマストリヒシアンに "*A*" *ezoensis* (下部マストリヒシアン) があり、西部内陸・湾岸区域では中部カンパニアン～下部マストリヒシアンに 8 種報告がある。C グループでは外形的に *Palaeophacmaea* 属に比較される種がインドと日本でパレミアン～アルビアンに知られているが、内陸西部湾岸地方に報告がない。すなわちインドー太平洋地方と西部内陸・湾岸地方との間で笠形貝の共通種はなく、白亜紀後期には異なる生物地理区にあったといえる。

### Introduction

Many species of limpets have been reported from marine Cretaceous deposits of the northern Pacific coast. Their biostratigraphic occurrences and systematic paleontology have been presented by several authors (SCHMIDT, 1873; YOKOYAMA, 1890; MATSUMOTO, 1943; DUNDO *et al.*, 1974; KANIE, 1975, 1977; HAYAMI and KASE, 1977; etc.). "*Anisomyon*" *cassidarius* (YOKOYAMA) has been reported from the Lower Turonian to Santonian, "*A*." *transformis* DUNDO has been reported from the Lower Campanian, "*A*." *giganteus* (SCHMIDT) has been reported from the Middle Campanian and "*A*." *problematicus* (NAGAO *et OTATUME*) has been reported from the Lower Maastrichtian. HAYAMI and KANIE (1980) named *Gigantocapulus giganteus* for the type B of *Anisomyon*

\* Yokosuka City Museum, Yokosuka 238, Japan. 横須賀市自然博物館

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*giganteus* (KANIE, 1975). The taxonomic position of "*Anisomyon*" and *Gigantocapulus* is in the Mesogastropoda, and it could be inferred that the species had a feeding habitat similar to that of the living patelloids (Mesogastropoda), as judged from their occurrences (KANIE, 1975). Several specimens of *Gigantocapulus giganteus* are attached to the shell surfaces of *Inoceramus* (*Sphenoceramus*) *schmidti* (HAYAMI and KASE, 1977); the mode of life of this species is regarded as a parasite attached to the inoceramid valves (HAYAMI and KANIE, 1980). "*A.*" *annulatus* (YOKOYAMA) is known from the Lower Cretaceous, and "*A.*" *ezoensis* NAGAO et ÔTATUME occur in the Lower Maastrichtian. Recently the taxonomic position of "*A.*" *annulatus* was transferred into the Chondrophorine of medusoid Hydrozoa by STANLEY and KANIE (in press).

More than 15 species of patelliform gastropods have been recorded from Cretaceous deposits (Middle Campanian to Upper Maastrichtian) of the U. S. Western Interior and Gulf coast province (MEEK and HAYDEN, 1857, 1860; MEEK, 1876; STEPHENSON, 1941; SOHL, 1960, 1964a, 1964b, 1967a). Taxonomically some the American forms belong to the Mesogastropoda (e.g. *Capulus*) and to the Basommatophora (e.g. *Siphonaria*, *Anisomyon*). Some anisomyonid species in chalk or chalky marl are attached commonly to recumbent inoceramid species, and the anisomyonid species in limestone are attached to inoceramid or ostreid species (SOHL, 1967b; E. G. KAUFFMAN, personal comm.).

#### Biostratigraphic occurrences in the Indo-Pacific region

Many species of limpets have been reported from the Indo-Pacific region. Patelloid fossils are discriminated into three groups, here called A, B and C, based on the morphological characters.

Group A. "*Anisomyon*" *cassidarius* occurs in sandy mudstone or mudstone (Lower Turonian to Santonian), "*A.*" *transformis* occurs in sandy mudstone or fine-grained sandstone (Lower Campanian), and "*A.*" *giganteus* and *Gigantocapulus giganteus* occur in sandy mudstone or fine-grained sandstone (Middle Campanian). It has been concluded that "*A.*" *giganteus* evolved from "*A.*" *cassidarius* by way of "*A.*" *transformis* (KANIE, 1975, 1977). These species probably adapted themselves to increased current actions during the Campanian, as seas became shallower. Several species, which are morphologically somewhat similar to "*A.*" *cassidarius*, have been reported from fine-grained Cretaceous deposits in the Pacific coast region of North America. These occur mostly as internal molds. Therefore, it is difficult to compare them satisfactorily with the Japanese species. These forms are "*A.*" *meekii* GABB from the Upper Cenomanian of California (GABB, 1864; ANDERSON, 1958); "*Capulus*" *corrugatus*? WADE and "*Helcion*" *giganteus vancouverensis* WHITEAVES from the Campanian of Vancouver (WHITEAVES, 1903). Species closely allied with "*Anisomyon*"



*cassidarius* are known from Campanian deposits of southern India (FORBES, 1846; STOLICZKA, 1868). These forms are "*Helcion*" *corrugatum* (FORBES) and "*Tectura*"? *elevata* (FORBES). "*Anisomyon*" *problematicus* has been found in sandy mudstone of the Lower Maastrichtian in Hokkaido (NAGAO and ÔTATUME, 1938), Awaji-shima, Southwest Japan (SASAI, 1936) and in the zone of *Inoceramus* (*Endocostea*) *shikotanensis* of the Koryak Highlands (DUNDO *et al.*, 1974). The phylogenetic relationship between the Middle Campanian "*A.*" *giganteus* and the Lower Maastrichtian "*A.*" *problematicus* is uncertain, because no species of "*Anisomyon*" has been collected from the Upper Campanian, and no graduations are known between the two species.

Group B. Several species described as *Anisomyon*, with anterior carinae in outline, are of doubtful generic position, and should be placed elsewhere. "*A.*" *ezoensis*, from sandy mudstone (Lower Maastrichtian) of southern Hokkaido (NAGAO and ÔTATUME, 1938) is an example of this group.

Group C. This group should be placed in Chondrophorines of medusoid Hydrozoa. *Palaelophacmaea annulata* (YOKOYAMA) has been reported from the Upper Barremian of the Ishido Formation (MATSUKAWA, 1977). *Palaelophacmaea*? sp. from the Upper Aptian Tanohata Formation (KASE, personal comm.), and another *Palaelophacmaea*? sp. has been reported from the Middle Albian Yatsushiro Formation. This group is characterized by concentric corrugations and elevated radial ridges at the anterior? part of the shell surface and exceedingly thin shell. These species are distributed irregularly in sandy mudstone or fine-grained sandstone. This group might have a close relationship to Santonian *Brunonia* from Germany.

#### Biostratigraphic occurrences in the U. S. Western Interior and Gulf Coast Province

At least two groups of patelloids have been recorded from the Campanian and Maastrichtian deposits. No species belonging to Group C have been recorded from the Western Interior province.

Group A. This group is represented by "*Anisomyon*" *patelliformis* MEEK et HAYDEN, from the Lower Maastrichtian of Nebraska (MEEK and HAYDEN 1857, 1860; MEEK, 1867; SOHL, 1967a) and Wyoming (SOHL, 1967a); "*A.*" *alveolus* MEEK et HAYDEN and "*A.*" *subovatus* MEEK et HAYDEN, from Lower Maastrichtian of Nebraska (MEEK, 1876); "*A.*" *haydeni* SHUMARD, from the Lower Maastrichtian of Texas and Arkansas (STEPHENSON, 1941); "*Capulus*" *monroei* SOHL, from the Upper Campanian of Tennessee (SOHL, 1960); "*C.*" *microcostatus* Stephenson, from Upper Maastrichtian of Texas (STEPHENSON, 1941); "*Siphonaria*" *wieserie* (WADE), from the Upper Campanian of Tennessee (SOHL, 1964a), etc.

Group B. This group is represented by "*Anisomyon borealis* (MORTON), "*A. centrale* MEEK, from the Upper Campanian of Wyoming and adjacent areas (SOHL, 1967a) and Texas (STEPHENSON, 1941); "*Capulus corrugatus* WADE and "*C. cuthandensis* STEPHENSON, from the Lower Maastrichtian of Tennessee (SOHL, 1960); "*C. spangleri* HENDERSON, "*C. cuthandensis* STEPHENSON and "*C. electus* STEPHENSON, from the Lower Maastrichtian of Texas (STEPHENSON, 1941); "*Anisomyon shumardi* MEEK et HAYDEN and "*A. sexsulcatus* MEEK et HAYDEN, from the Lower Maastrichtian of Nebraska (MEEK, 1876), etc. Thus, numerous species have been recorded from the Campanian to Maastrichtian deposits of the Western Interior and Gulf coast province.

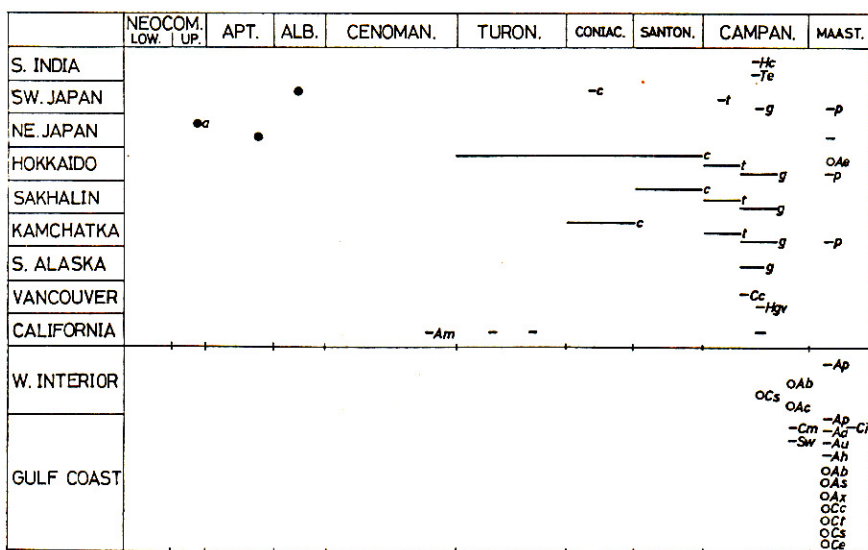


Fig. 1. Distribution of limped species in Cretaceous deposits of the Indo-Pacific and U. S. Western Interior regions.

—=Group A, Hc="Helcion" *corrugatum*, Te="Tectura"? *elevata*, c="Anisomyon" *cassidarius*, t="A." *transformis*, g="A." *giganteus* and *Gigantocapulus giganteus*, p="A." *problematicus*, Hgv="Helcion" *giganteus vancouverensis*, Am="Anisomyon" *meekei*, Ah="A." *haydeni*, Ap="A." *patelliformis*, Aa="A." *alveolus*, Au="A." *subovatus*, Cc="Capulus" *corrugatus*, Cm="C." *monroei*, Ci="C."? *microcostatus*, Sw="Siphonaria" *wieserie*. ○=Group B, Ae="Anisomyon" *ezoensis*, Ab="A." *borealis*, Ac="A." *centrale*, As="A." *shumardi*, Ax="A." *sexsulcatus*, Ct="Capulus" *cuthandensis*, Cs="C." *spangleri*, Ce="C." *electus*. ●=Group C, a=*Palaelophacmaea annulata*.

### Concluding remarks

Patelliform shells of the Indo-Pacific and U. S. Western Interior regions are discriminated into three morphological groups.

Group A appeared at least in the Late Cenomanian and disappeared in the Early Maastrichtian of the Indo-Pacific region, whilst it occurs in the Upper



Campanian and Lower Maastrichtian deposits in the U. S. Western Interior and Gulf coast province. The genus *Anisomyon* (s. s.) is referred to the Mesogastropoda on the basis of morphological characters (KANIE, 1975), although HAYAMI and KANIE (1980) proposed *Gigantocapulus* (previously named the type B of *Anisomyon giganteus* by KANIE in 1975) for the Pacific species.

Only one species of Group B, "*Anisomyon*" *ezoensis* (Lower Maastrichtian) is known from Cretaceous rocks of the Pacific region, whereas numerous species had evolved in Campanian and Early Maastrichtian shallow seas of the U. S. Western Interior province. This group is characterized by an anterior radial depression(s). SOHL (1967a) interpreted these as members of the Basommatophora, based on the muscle scar morphology of "*A.*" *borealis* and "*A.*" *centrale*.

Group C is characterized by raised radial ridge(s) on the shell surface. The taxonomic position is in Chondrophorina in medusoid Hydrozoa. The fossils have been reported from the Barremian to Albian deposits of Japan, as well as from the Aptian of England, the Valanginian of southwestern Crimea, and so on. The group may have a connection with the Boreal fauna. No species of Group C are known from the U. S. Western province.

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