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# Two new ammonoid genera of the subfamily Gabbioceratinae from the Upper Albian (Lower Cretaceous) of Hokkaido, Japan

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**Abstract. Two ammonoids of the subfamily Gabbioceratinae, *Obataceras manjiense* gen. et sp. nov. and *Tanabeceras pombetsense* gen. et sp. nov., are described from the Upper Albian of Hokkaido, Japan. The Gabbioceratinae evolved and radiated mainly in the Mediterranean area during Late Aptian to Middle Albian times, but thereafter disappeared from the region. The occurrences of Gabbioceratinae in Hokkaido suggest that their geographical distribution was extended to the Northwest Pacific before the Late Albian, where they then flourished from Late Albian to Cenomanian time.**

**Key words: Albian, ammonoid, Cretaceous, Gabbioceratinae, *Obataceras*, *Tanabeceras***

## Introduction

The subfamily Gabbioceratinae Breistroffer, 1953 of the family Gaudryceratidae Spath, 1927 is characterized by having highly depressed whorls with an angular umbilical shoulder at certain growth stages. Two genera, *Gabbioceras* Hyatt, 1900 and *Jauberticeras* Jacob, 1907, have been traditionally recognized within the subfamily (Murphy, 1967a; Klein *et al*., 2009; Hoffmann, 2010). *Gabbioceras lamberti* (Breistroffer, 1937), the oldest member of the subfamily, from the lower Upper Aptian is considered to be an offshoot of *Eogaudryceras* Spath, 1927 (Wiedmann, 1962). The subfamily evolved and radiated in the lower to middle latitudes during Late Aptian and Albian time, and in the Northwest Pacific and Madagascar during Cenomanian time (Murphy, 1967a; Collignon, 1964; Shigeta, 1996).

In Hokkaido (Japan) and Sakhalin (Russia), two endemic species of *Gabbioceras* have been described from the Lower to Middle Cenomanian of the Yezo Group (Shigeta, 1996; Nishida *et al*., 1997; Hayakawa and Nishino, 1999; Kawabe, 2000; Yazykova *et al*., 2004). However, no specimens referable to the Gabbioceratinae have been reported from the Aptian and Albian in the Northwest Pacific.

Although gaudryceratid ammonoids occur abundantly in the Albian of Hokkaido and Sakhalin, they are mainly restricted to the genera *Anagaudryceras* Shimizu, 1934 and *Zelandites* Marshall, 1926 (Matsumoto, 1938; Obata *et al*., 1981; Futakami, 1982, 1996). There have been a few reports of specimens tentatively identified as *Parajaubertella* Matsumoto, 1943 from the Manji and Mikasa areas of central Hokkaido (Obata and Futakami, 1977; Futakami, 1996). However, *Parajaubertella* has a highly depressed but rounded whorl section and is very similar to *Gabbioceras*, but it lacks a pronounced lateral angulation (Matsumoto, 1943). Wiedmann (1962) considered the genus to be a synonym of *Gabbioceras*, but both genera can be clearly distinguished by the differences in umbilical shape, suture line and other characters (Murphy, 1967a; Jones, 1967; Matsumoto, 1995; Hoffmann, 2010).

We recently examined the specimens assigned to *Parajaubertella* aff. *kawakitana* Matsumoto, 1943 by Obata and Futakami (1977) and Futakami (1996) from the Albian of Hokkaido, and we herein recognize them

as members of the Gabbioceratinae. In this paper, we describe them and discuss their biogeographical significance.

## Notes on stratigraphy

The Cretaceous Yezo Group, ranging in age from Aptian to Maastrichtian, is widely distributed in a 1000 km-long outcrop belt running in a north-south direction in the central zone of Hokkaido, Japan and the West Sakhalin Mountains, Russia (Matsumoto, 1954; Shigeta and Maeda, 2005). Their sediments are thought to have been deposited in the ancient Yezo forearc basin along the eastern margin of the paleo-Asian continent (Okada, 1979, 1983).

In the Manji and Mikasa areas, the Yezo Group ranges from the Albian to the Santonian and is subdivided into the Hikagenosawa, Mikasa and Haborogawa formations, in ascending order (Takashima *et al*., 2004). The Hikagenosawa Formation consists of laminated mudstone with sandstone-bed intercalations, while the Mikasa Formation is comprised mainly of hummocky cross-stratified sandstone (Ando, 1990). Mudstones of the Hikagenosawa Formation contain rare, poorly preserved Albian megafossils, but well preserved fossils are sometimes found within calcareous concretions (Obata and Futakami, 1975; Futakami, 1996). Much of the Mikasa Formation is fossiliferous with Early Cenomanian to Late Turonian ammonoids and inoceramids occurring abundantly in both the host rock and calcareous concretions (Matsumoto, 1965; Obata and Futakami, 1975; Ando, 1990). The Haborogawa Formation consists mainly of bioturbated mudstone interbedded with white tuff layers and spherical calcareous concretions, which contain well preserved Coniacian to Santonian ammonoids and inoceramids (Obata and Futakami, 1975).

One specimen assigned to *Parajaubertella* aff. *kawakitana* by Futakami (1996) was obtained from a float calcareous concretion at Loc. Pn1032F along the middle reaches of the Pombetsu River in the Mikasa area. The other four specimens, one of which was illustrated, were extracted by Obata and Futakami (1975, 1977) from float blocks of cold-seep carbonate at Loc. SK1F11 and 1F31 along the upper reaches of the Shikoro-zawa River in the Manji area. Although it is uncertain from which horizons the concretion and blocks came, judging from the localities at which they were found and their matrix types, they almost certainly came from the Hikagenosawa Formation.

## Paleontological description

Systematic descriptions basically follow the classification established by Klein *et al*. (2009). Morphological terms in the systematic description are those used in the Treatise on Invertebrate Paleontology (Moore, 1957). Quantifiers used to describe the shape of ammonoid shell replicate those proposed by Matsumoto (1954, p. 246) and modified by Haggart (1989, table 8.1).

*Abbreviations for shell dimensions*.—D = shell diameter; U = umbilical diameter; H = whorl height; W = whorl width.

*Suture line terminology and abbreviations*.—We utilize the suture line terminology and abbreviations of Wedekind (1916). E = external lobe; L= lateral lobe; $U_1$ = first umbilical lobe; $U_2$ = second umbilical lobe; $U_3$ = third umbilical lobe; $I_S$ = septal lobe. See also Kullmann and Wiedmann (1970).

*Institution abbreviations*.—NMNS = National Museum of Nature and Science, Tsukuba; MCM = Mikasa City Museum, Mikasa.

### Superfamily Tetragonitoidea Hyatt, 1900
### Family Gaudryceratidae Spath, 1927
### Subfamily Gabbioceratinae Breistroffer, 1953

This group is characterized by highly depressed whorls with an angular umbilical shoulder at certain growth stages (Murphy, 1967a, 1967b). The suture shows early gaudryceratid-type characteristics (see following description and discussion).

*Composition*.—Four genera: *Gabbioceras* Hyatt, 1900, *Jauberticeras* Jacob, 1907, *Obataceras* Shigeta, Futakami and Hoffmann gen nov. and *Tanabeceras* Shigeta, Futakami and Hoffmann gen nov. constitute the subfamily. The first two genera are briefly noted, and the latter two are newly described below.

*Remarks*.—Traditionally, two genera, *Gabbioceras* and *Jauberticeras*, have been recognized within the subfamily Gabbioceratinae (Murphy, 1967a; Klein *et al*., 2009; Hoffmann, 2010), but we herein propose the addition of two new genera, *Obataceras* and *Tanabeceras*, based on distinct characters without intermediate forms. These characters include 1) a slightly convex or rounded venter, 2) an aperture whose ventral portion is either convex or slightly concave, and 3) a suture with two or three well defined umbilical lobes (Figure 1). In general**,** the apertural shape and suture line are stable among the higher taxonomic groups of ammonoids (Wright *et al*., 1996).

*Occurrence*.—Upper Aptian to Middle Cenomanian.

### Genus ***Jauberticeras*** Jacob, 1907

*Type species*.—*Ammonites jaubertianus* d'Orbigny, 1850.

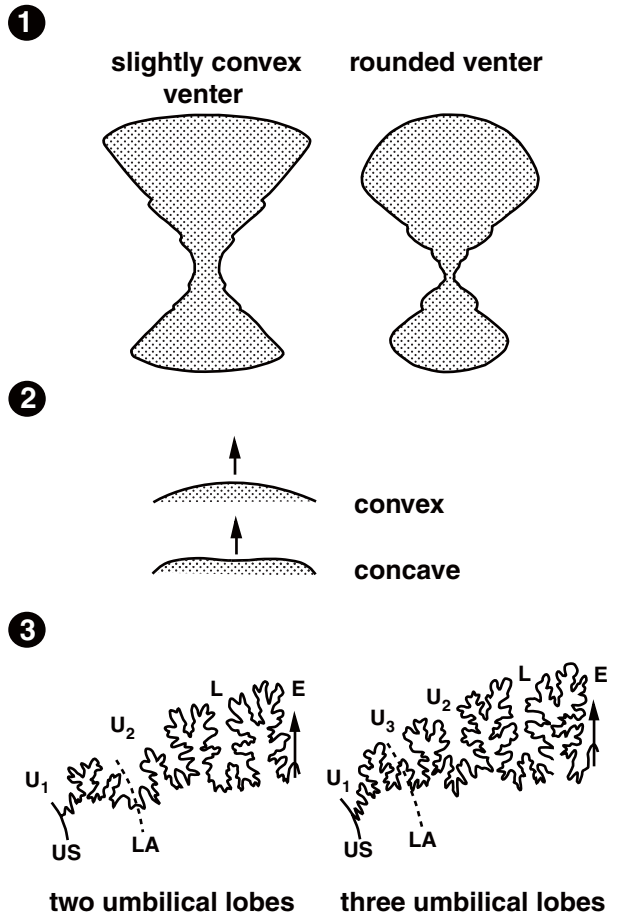


**Figure 1.** Morphological features of the subfamily Gabbioceratinae. **1**, whorl cross section showing characteristic shape of venter; **2**, shape of ventral portion of aperture. Arrow represents the growth direction; **3**, external suture line. Arrow indicates the position of the siphuncle. Solid line and broken line indicate position of umbilical seam (US) and lateral angulation (LA). E, external lobe; L, lateral lobe; $U_1$, first umbilical lobe; $U_2$, second umbilical lobe; $U_3$, third umbilical lobe.

*Diagnosis*.—Gabbioceratinae having subtrapezoidal to trapezoidal, depressed whorl with slightly convex venter and fairly wide, funnel-shaped umbilicus with an angular shoulder. Shell surface ornamented with growth lines, fine ribs, and constrictions, which project forward on venter (Hoffmann, 2010).

*Remarks*.—The suture line formula of *Jauberticeras jaubertianum*, *J. collignoni* Murphy, 1967a and *J. villoutreysi* Murphy, 1967a is $ELU_2U_1I_S$, showing early gaudryceratid-type characteristics with bifid lateral saddle and two well defined umbilical lobes. The lateral angulation is located in the middle of $U_2$ (Murphy, 1967a; Kennedy and Klinger, 1977; Hoffmann, 2010).

*Occurrence*.—Upper Aptian of southern France, Hungary, and Caucasus, Albian of Madagascar, South Africa, southern France and Caucasus (Wiedmann, 1962; Collignon, 1964; Drushchits, 1960; Murphy, 1967a; Sharikadze *et al*., 1974; Kennedy and Klinger, 1977; Szives *et al*., 2007).

## Genus ***Gabbioceras*** Hyatt, 1900

*Type species*.—*Ammonites batesi* Gabb, 1869 (*non* Trask, 1855) = *Lytoceras* (*Gabbioceras*) *angulatum* Anderson, 1902.

*Emended diagnosis*.—Gabbioceratinae having rounded venter, depressed whorls and moderately wide, funnel-shaped umbilicus with angular umbilical shoulder at preadult growth stage. Growth lines, fine ribs and constrictions project forward on venter.

*Remarks*.—The suture line formula of *Gabbioceras angulatum* and *G. lamberti* is $ELU_2U_1I_S$, showing early gaudryceratid-type characteristics with bifid lateral saddle and two well defined umbilical lobes. The lateral angulation is located in the middle of $U_2$ (Murphy, 1967a; Hoffmann, 2010).

*Occurrence*.—Upper Aptian of southern France, Hungary, Caucasus, and northern California, Lower Albian of Madagascar and southern France (Wiedmann, 1962; Collignon, 1964; Murphy, 1967a; Egoian, 1969; Szives *et al*., 2007).

## Genus ***Obataceras*** gen. nov.

*Type species*.—*Obataceras manjiense* Shigeta, Futakami and Hoffmann sp. nov.

*Diagnosis*.—Very involute Gabbioceratinae having rounded venter, depressed whorls and narrow, deep, funnel-shaped umbilicus with angular or subangular umbilical shoulder. Growth lines and ribs project forward on venter. Suture line formula $ELU_2U_3U_1I_S$, exhibits early gaudryceratid-type characters with bifid lateral saddles and three well defined umbilical lobes. Lateral angulation located in middle of $U_3$.

*Etymology*.—Named after Ikuwo Obata (Emeritus Director, National Museum of Nature and Science, Tsukuba).

*Discussion*.—*Obataceras* gen. nov. is very close to *Gabbioceras* in having an aperture whose ventral portion is convex, but it can be easily distinguished by its more advanced suture, which is characterized by three well defined umbilical lobes in its external suture. At present, two species, i.e., *Obataceras manjiense* Shigeta, Futakami and Hoffmann gen. et sp. nov. and *Jauberticeras beraketense* Collignon, 1964 can be assigned to the present genus.

*Occurrence*.—Upper Albian of Hokkaido and Lower

Cenomanian of Madagascar (Collignon, 1964).

### ***Obataceras manjiense*** sp. nov.

Figures 2.1–2.14, 3

*Parajaubertella* aff. *kawakitana* Matsumoto. Obata and Futakami, 1977, fig. 1a, 1b, 1c.

*Type specimens*.—Holotype, NMNS PM7442, from Loc. SK1F11; paratypes, one specimen, NMNS PM23444, from Loc. SK1F11, two specimens, NMNS PM23445, 23446, from Loc. SK1F31, along the upper reaches of the Shikoro-zawa River in the Manji area (see Obata and Futakami, 1975, fig. 4).

*Diagnosis*.—*Obataceras* with broadly arched venter and a fairly narrow, deep umbilicus with a subangular umbilical shoulder.

*Etymology*.—Named after the Manji area, central Hokkaido.

*Description*.—Very involute, very depressed shell with reniform whorl section with gently convex umbilical wall, subangular umbilical shoulder, and broadly arched venter. Maximum whorl width occurs on umbilical shoulders at one fifth of whorl height from umbilical seam to venter. Umbilicus fairly narrow, deep and funnel-shaped. Ornamentation consists of constrictions as well as prorsiradiate growth lines, which project forward on venter. Suture early gaudryceratid-type characters with bifid lateral saddle and three well defined umbilical lobes.

*Measurements*.—Taken at D = 19.0 mm of NMNS PM7442, U = 5.0 mm, H = 8.1 mm, W = 17.3 mm, U/D = 0.26, W/H = 2.1.

*Occurrence*.—The described specimens were extracted from float blocks of cold-seep carbonates along the upper reaches of the Shikoro-zawa River in the Manji area, together with specimens referable to *Mortoniceras* (*Deiradoceras*), a typical Late Albian ammonoid (Obata and Futakami, 1975; Ogiwara, 2004).

*Comparison*.—This new species is very close to *Obataceras beraketense*, but its umbilicus is much narrower.

## Genus ***Tanabeceras*** gen. nov.

*Type species*.—*Gabbioceras yezoense* Shigeta, 1996.

*Diagnosis*.—Very involute Gabbioceratinae having a depressed, reniform whorl section characterized by a rounded venter and a fairly narrow, deep, funnel-shaped umbilicus with an angular or subangular shoulder. Shell surface ornamented with growth lines, fine ribs, and constrictions, which are prorsiradiate on inner flank, rectiradiate or slightly rursiradiate on outer flank and form a very shallow sinus as they cross the venter. Suture line formula $ELU_2U_1I_S$, reveals early gaudryceratid-type characters with bifid lateral saddles and two well defined umbilical lobes. Lateral angulation located in middle of $U_2$.

*Etymology*.—Named after Kazushige Tanabe (Emeritus Professor, University of Tokyo).

*Discussion*.—*Tanabeceras* gen. nov. is easily distinguished from other genera of the Gabbioceratinae by the slightly concave ventral portion of its aperture. At present, five species, i.e., *Tanabeceras pombetsense* Shigeta, Futakami and Hoffmann gen. et sp. nov., *Gabbioceras mikasaense* Shigeta, 1996, *G. yezoense* Shigeta, 1996, *G. drushtchici* Wiedmann, 1962 and *Ammonites michelianum* d'Orbigny, 1850 may be assigned to the present genus. The apertural shape of *Jauberticeras muntaneri* Wiedmann, 1962 has never been described, but its fairly narrow, deep umbilicus and suture with two well defined umbilical lobes enable us to assign it with near certainty to this new genus.

The specimen described as *Gabbioceras* aff. *michelianum* from the Lower Albian of California by Murphy (1967b, pl. 4, figs. 6, 7) has a wider umbilicus than the lectotype of *Ammonites michelianum*, and is similar to the umbilicus in the young stages of *G. angulatum* and *G. lamberti*. Its apertural shape and external suture suggest that this specimen belongs to *Tanabeceras*. The specimens described as *Jaubertella micheliana* from the Lower Albian of Georgia by Sharikadze *et al*. (1974, p. 31, pl. 1, fig. 3) and from the Lower Albian of the Caucasus by Egoian (1969, p. 135, pl. 3, figs. 2, 3) are assigned with near certainty to *Tanabeceras* due to their morphological similarity.

*Occurrence*.—Albian of the Caucasus, Georgia, southern France, Majorca, northern California, Cenomanian of Hokkaido and Sakhalin (Wiedmann, 1962; Murphy, 1967a, 1967b; Sharikadze *et al*., 1974; Shigeta, 1996; Hayakawa and Nishino, 1999; Yazykova *et al*., 2004).

### ***Tanabeceras pombetsense*** sp. nov.

Figures 2.15–2.19, 4

*Parajaubertella* aff. *kawakitana* Matsumoto. Futakami, 1996, pl. 23, fig. 1a, 1b.

*Holotype*.—MCM.M0184, consists of a phragmocone and part of the body chamber, from Loc. Pn1032F along the middle reaches of the Pombetsu River in the Mikasa area (see Futakami, 1996, fig. 7). Shell diameter at the last septum is about 20 mm, and if the entire body chamber had been preserved, its diameter would be less than 45 mm.

*Diagnosis*.—*Tanabeceras* with body chamber orna-

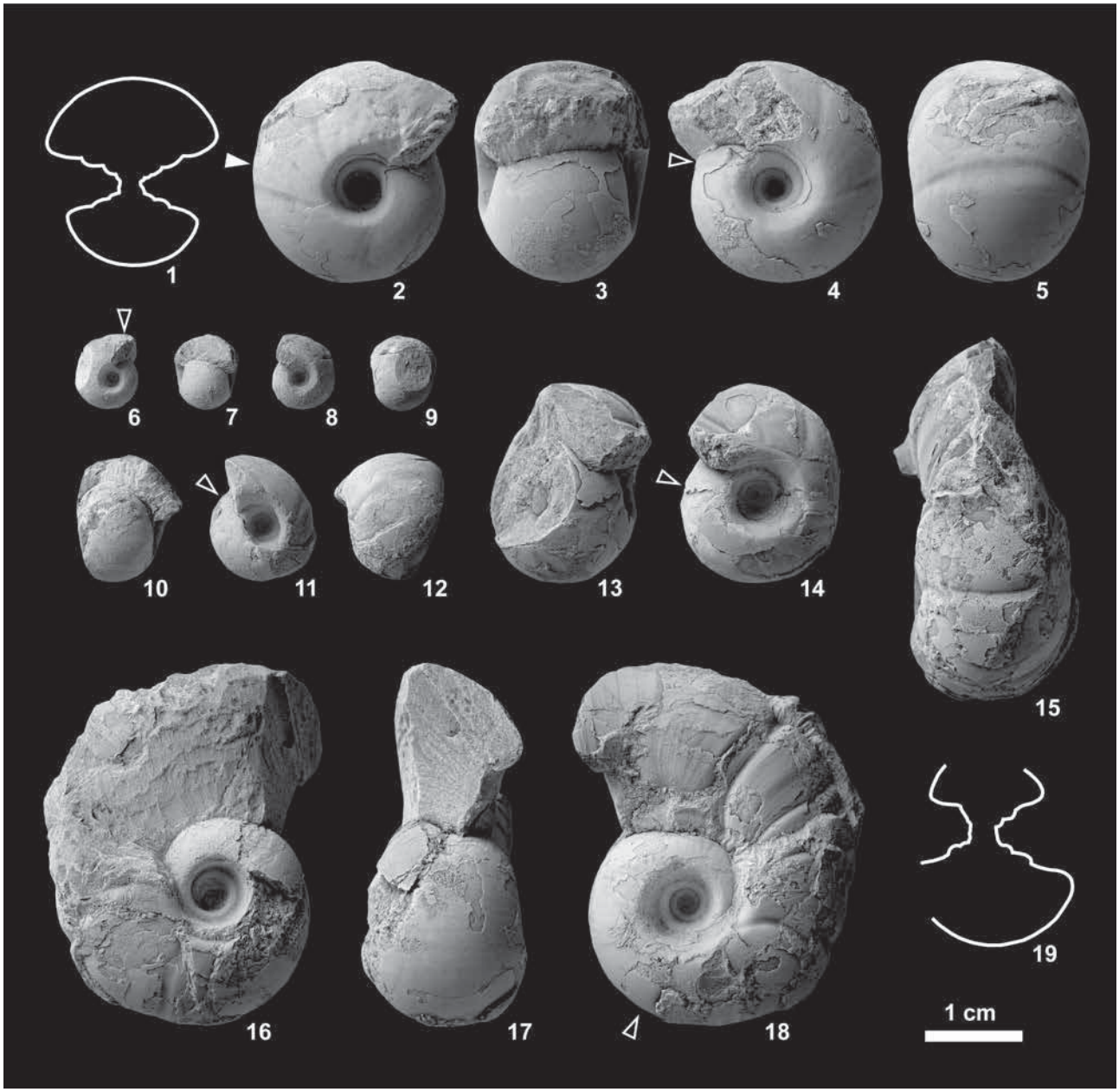


**Figure 2.** Two new ammonoid genera of the subfamily Gabbioceratinae from the Upper Albian of Hokkaido. **1–14**, *Obataceras manjiense* Shigeta, Futakami and Hoffmann gen. et sp. nov. from the Manji area. **1–5**, NMNS PM7442 (holotype); **6–9**, NMNS PM23446 (paratype); **10–12**, NMNS PM23445 (paratype); **13–14**, NMNS PM23444 (paratype); **15–19**, *Tanabeceras pombetsense* Shigeta, Futakami and Hoffmann gen. et sp. nov., MCM.M0184 (holotype), from the Mikasa area. Arrow indicates position of the last septum. Whorl cross sections are drawn at the position indicated by white arrow.

mentation characterized by flat-topped, bandike or low foldlike, broad major ribs.

*Etymology*.—Named after the Pombetsu River in the Mikasa area.

*Description*.—Very involute, very depressed shell with a depressed reniform whorl section characterized by a slightly concave umbilical wall, subangular umbilical shoulder, and broadly arched venter. Maximum whorl width occurs on umbilical shoulders at one fourth of whorl height from umbilical seam to venter. Umbilicus fairly narrow, deep and funnel-shaped. Phragmocone shell surface smooth. Body chamber ornamented with

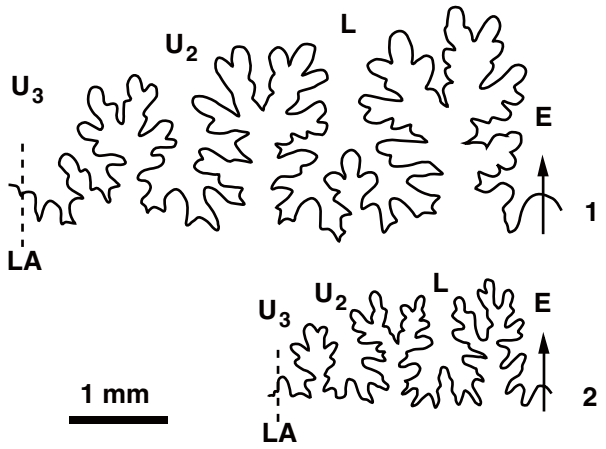


**Figure 3.** Suture line of *Obataceras manjiense* Shigeta, Futakami and Hoffmann gen. et sp. nov. with three umbilical lobes, from the Manji area, Hokkaido. **1**, NMNS PM23445 (paratype) at whorl height = 5.2 mm; **2**, NMNS PM23446 (paratype) at whorl height = 2.9 mm.

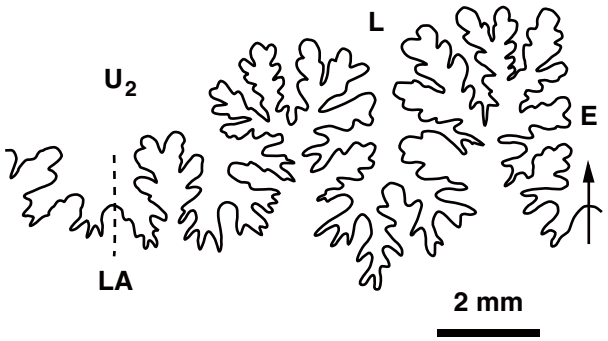


**Figure 4.** Suture line of *Tanabeceras pombetsense* Shigeta, Futakami and Hoffmann gen. et sp. nov. with two umbilical lobes, MCM.M0184 (holotype), from the Mikasa area, Hokkaido, at whorl height = 6.8 mm.

fine lirae and flat-topped, bandlike or low foldlike, broad major ribs with narrowly grooved interspaces, which arise at umbilical seam, curve backwards on umbilical shoulder, become slightly rursiradiate, and cross venter in a broad, slightly concave arch. Suture characterized as early gaudryceratid-type characters with bifid lateral saddle.

*Measurements*.—Taken at the last septum of MCM. M0184, D = 20.0 mm, U = 5.3 mm, H = 8.4 mm, W = 16.8 mm, U/D = 0.26, W/H = 2.0.

*Occurrence*.—The holotype, MCM.M0184, was collected from a float calcareous concretion along the middle reaches of the Pombetsu River in the Mikasa area. Although the exact horizon from which the concretion came is uncertain, judging from the locality, it probably came from the mudstone of the lower to middle parts of the Hikagenosawa Formation (Takashima *et al*., 2004). In the Mikasa area this formation contains *Oxytropidoceras* (*Adkinsites*) sp. in the lowest part and *Cantabrigites imaii* (Yabe and Shimizu, 1931) in the main part (Matsumoto, 1965; Futakami *et al*., 2008). The former occurs in the Middle to Upper Albian (Wright *et al*., 1996), and the latter is restricted to the Upper Albian (Toshimitsu and Hirano, 2000). Therefore, the holotype's source is likely the Upper Albian.

*Comparison*.—This new species is easily distinguished from other species and a possible candidate species of *Tanabeceras* by the broad major ribs on its body chamber. The phragmocone is very close to the other Albian species of *Tanabeceras*, such as *T. micheliaanum* and *T. drushtchici*, and the candidate species "*Jauberticeras*"*muntaneri*, but its umbilicus is much narrower. This new species differs from the Cenomanian *T. yezoense* and *T. mikasaense* by its slightly concave umbilical wall.

## Discussion

The oldest member of the subfamily Gabbioceratinae is *Gabbioceras lamberti* from the lower Upper Aptian, and according to Coquand (1880) and Wiedmann (1962) it is considered to be an offshoot of *Eogaudryceras numidum* (Coquand, 1880). During Late Aptian time, *G. lamberti* flourished in the Mediterranean area, while *G. angulatum* became widely distributed in California (Wiedmann, 1962; Murphy, 1967a; Figure 5).

*Gabbioceras lamberti* probably gave rise to *Jauberticeras* via *J. jaubertianum* during Late Aptian time (Kennedy and Klinger, 1977). *Jauberticeras* flourished in the Mediterranean area during Late Aptian to Middle Albian time (Drushchits, 1960; Murphy, 1967a; Szives *et al*., 2007) and in South Africa and Madagascar during Middle to Late Albian time (Kennedy and Klinger, 1977; Figure 5).

*Obataceras* has a more advanced suture than other genera of Gabbioceratinae, and it probably is an offshoot of *Gabbioceras*, because the ventral portion of each taxon's aperture is projected forward. *Obataceras* is known from the Upper Albian of Hokkaido and the Lower Cenomanian of Madagascar (Collignon, 1964; Figure 6). Although specimens referable to either genus have never been reported from the Middle Albian, *Obataceras* was probably derived from *Gabbioceras* during Early to Middle Albian time, because the youngest known *Gabbioceras* is from the Lower Albian.

*Tanabeceras* probably evolved from *Gabbioceras* during Early Albian time, and then became widely distributed in California and the Mediterranean area during

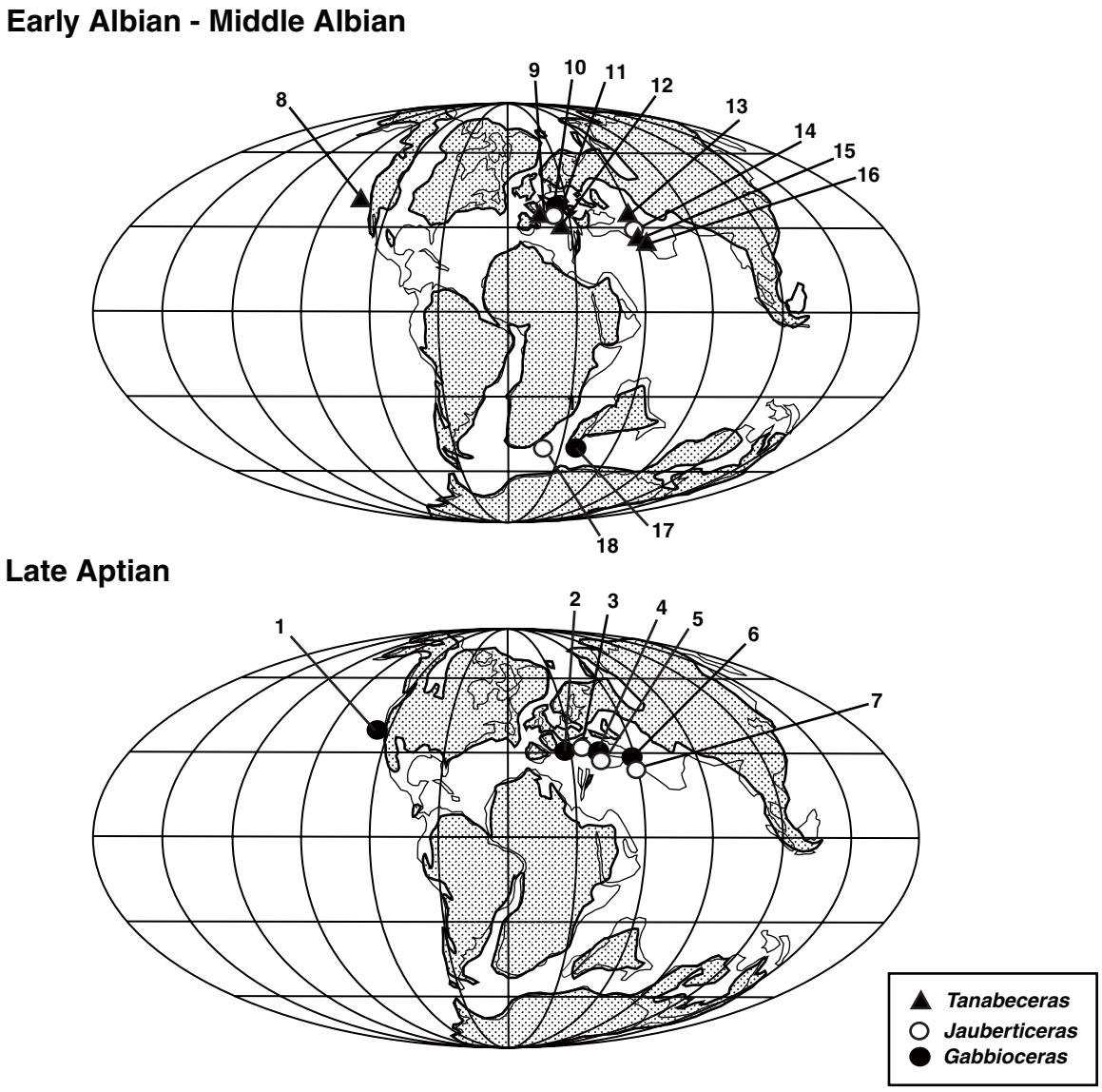


**Figure 5.** Paleogeographical distribution of the Gabbioceratinae during Late Aptian to Middle Albian time. Paleomaps from Smith *et al*. (1994). **1,** *Gabbioceras angulatum* (Anderson, 1902); **2,** *G. lamberti* (Breistroffer, 1937); **3,** *Jauberticeras jaubertianum* (d'Orbigny, 1850); **4,** *G. lamberti*, Szives *et al*. (2007); **5,** *J. jaubertianum*, Szives *et al*. (2007); **6,** *G. lamberti*, Drushchits (1960); **7,** *J. jaubertianum*, Egoian (1969); **8,** *Tanabeceras* aff. *michelianum*, Murphy (1967b); **9,** *Tanabeceras muntaneri* (Wiedmann, 1962); **10,** *G. lanternoi* (Wiedmann, 1962); **11,** *J. villoutreysi* Murphy, 1967a; **12,** *T. michelianum* (d'Orbigny, 1850); **13,** *T. drushtchici* (Wiedmann, 1962); **14,** *J. jaubertianum*, Sharikadze *et al*. (1974); **15,** *T. drushtchici*, Sharikadze *et al*. (1974); **16,** *T. michelianum*, Egoian (1969); **17,** *Gabbioceras jacobi* Murphy, 1967a; **18,** *J. collignoni*, Kennedy and Klinger (1977).

Early to Middle Albian time (Murphy, 1967a; Figure 6). However, it then disappeared from both areas and the Late Albian to Cenomanian members are known only from Hokkaido and Sakhalin (Shigeta, 1996; Hayakawa and Nishino, 1999; Yazykova *et al*., 2004).

The oldest occurrence of the Gabbioceratinae in Hokkaido has not yet been accurately determined, because megafossils are rather rare in Upper Aptian to Middle Albian sediments (Futakami, 1996; Iba, 2009). In contrast, the Miyako Group in Northeast Japan contains abundant Late Aptian to Early Albian ammonoid faunas. In spite of extensive search efforts, specimens assignable to the Gabbioceratinae have not yet been discovered (Obata, 1967a, 1967b, 1969, 1973, 1975; Obata and Matsukawa, 1980; Obata and Futakami, 1992), which suggests that the Gabbioceratinae did not exist in the

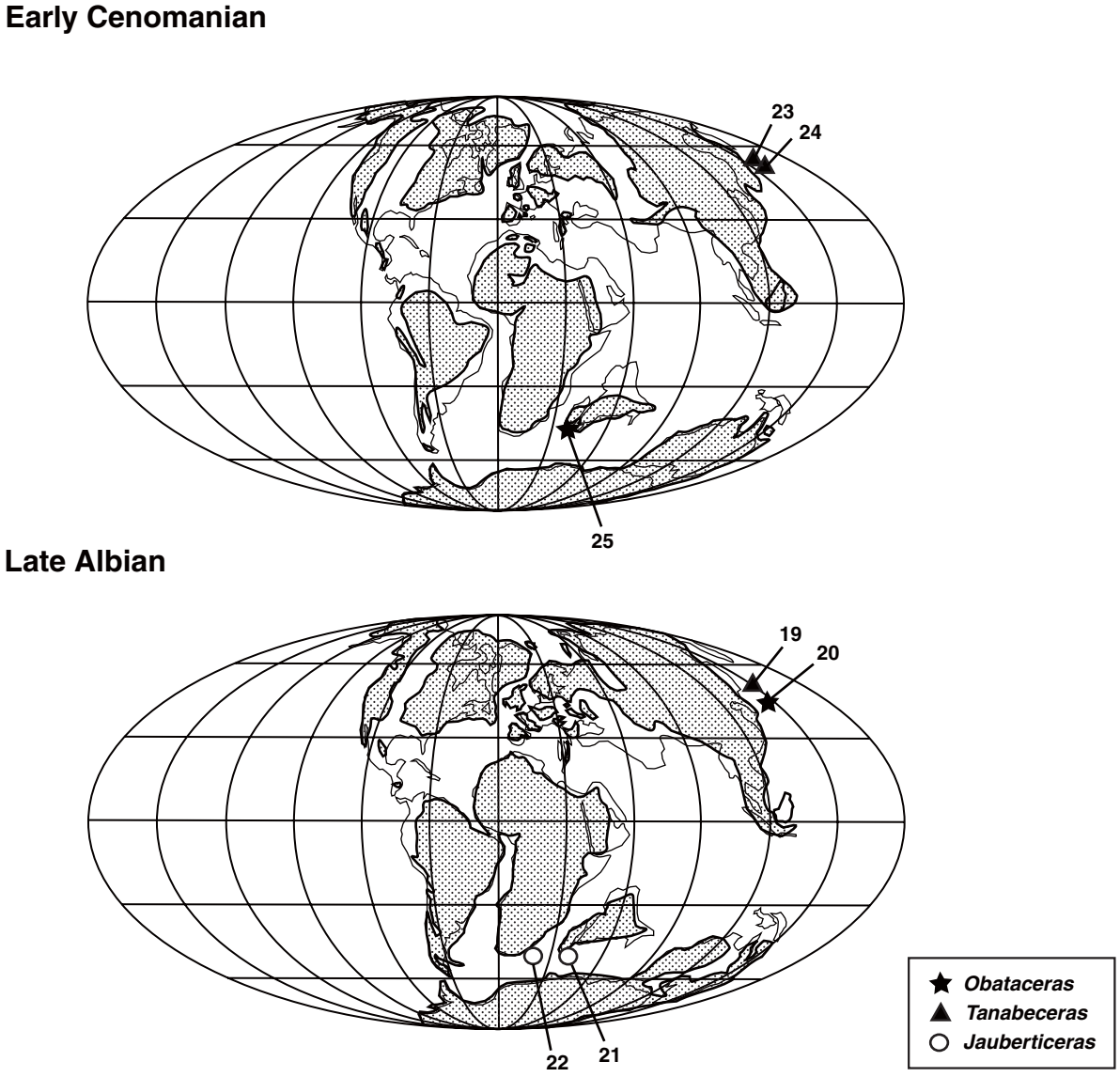


**Figure 6.** Paleogeographical distribution of the Gabbioceratinae during Late Albian to Early Cenomanian time. Paleomaps from Smith *et al*. (1994). **19,** *Tanabeceras pombetsense* sp. nov.; **20,** *Obataceras manjiense* sp. nov.; **21,** *Jauberticeras collignoni* Murphy, 1967a; **22,** *J. collignoni*, Kennedy and Klinger (1977); **23,** *T. yezoense* (Shigeta, 1996); **24,** *T. mikasaense* (Shigeta, 1996); **25,** *O. beraketense* (Collignon, 1964).

Northwest Pacific during Late Aptian to Early Albian time. They most likely extended their geographical distribution from the Mediterranean area into this region during Middle to Late Albian time.

During Early Cenomanian time, the distribution of *Obataceras* was probably restricted to Madagascar (Collignon, 1964); in contrast, *Tanabeceras* flourished in the Northwest Pacific until Middle Cenomanian time (Shigeta, 1996; Hayakawa and Nishino, 1999). It is well known that the Early Cenomanian ammonoid fauna of Hokkaido contains many endemic genera and species restricted to Hokkaido and Sakhalin (Matsumoto, 1943, 1955, 1984, 1991, 1995; Matsumoto *et al*., 1972a, 1972b, 2004; Shigeta *et al*., 2010), which suggests that the Northwest Pacific region was biogeographically separated from other regions during Early Cenomanian time. Although the cause of the extinction of *Tanabeceras* in other regions is unknown, its survival and evolution in the Northwest Pacific province may have been due to the biogeographical separation that occurred during Early

Cenomanian time.

Iba and Sano (2007, 2008) have documented the step by step demise of the Tethyan biota during latest Aptian to latest Albian time in the Northwest Pacific, and they have also discussed the existence of a "vicariance event", which separated the North Pacific region from the Tethyan biotic realm. Although it is unclear whether the "endemism" episode that occurred during Early Cenomanian time was one of the chain episodes of the "Albian vicariance event", these events may have resulted in the establishment of the North Pacific biotic province during the Late Cretaceous (Jeletzky, 1971).

In addition, our detailed observation provisionally reveals that the some characters, such as sutures, pattern of apertural margins, and whorl-section shapes, are keys for the taxonomy of the Gabbioceratinae. By a close analysis of various species belonging to this subfamily using these characters, their generic assignments could be revised and reconstructed in the near future.

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