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Gaudryceras izumiense Matsumoto and Morozumi, a Maastrichtian ammonoid from Hokkaido and Alaska and its biostratigraphic implications

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Abstract. ***Gaudryceras izumiense*** **Matsumoto and Morozumi, 1980, an ammonoid of early Maastrichtian age, occurs frequently in the Izumi Group in the Izumi Mountains, Southwest Japan. Described herein are two specimens referable to this species that were recently collected from the Hakobuchi Formation of the Yezo Group in the Hobetsu area, Hokkaido and from the Matanuska Formation in the southern Talkeetna Mountains, Alaska. In the past, a precise biostratigraphic correlation of the uppermost Cretaceous in the North Pacific realm has been difficult because of the lack of common zonal-index taxa, but the discovery of *G. izumiense* in Hokkaido and Alaska has made it possible to correlate lower Maastrichtian strata in these localities with coeval strata in Southwest Japan. Gaudryceratid ammonoids are fairly abundant in the uppermost Cretaceous of the North Pacific realm, and consequently, they are ideal taxa for the establishment of a precise biostratigraphic correlation framework for the uppermost Cretaceous in this vast area.**

Key words: Alaska, ammonoid, Cretaceous, *Gaudryceras izumiense*, Hokkaido

Introduction

The biostratigraphic zonation scheme established for the Japanese Upper Campanian-Maastrichtian is based mainly on ammonoids from the Izumi Group of Southwest Japan (Toshimitsu *et al.*, 1995a, b). Although various horizons of the Izumi Group contain rich ammonoid faunas (Matsumoto and Morozumi, 1980; Morozumi, 1985), most zonal-index ammonoids are endemic species restricted to Southwest Japan. Because of this lack of common zonal-index taxa, a precise biostratigraphic correlation between the Izumi Group and other Cretaceous deposits in the North Pacific realm remained obscure. Nevertheless, the recent discovery of *Pravitoceras sigmoidale* Yabe, 1902 from Hokkaido has resulted in a much more precise biostratigraphic correlation between the Izumi and Yezo groups (Matsunaga *et al.*, 2008).

Gaudryceras izumiense Matsumoto and Morozumi, 1980, the taxon described herein, occurs frequently in the lower Maastrichtian in the Izumi Mountains, but it has never been reported from contemporaneous deposits of other regions. We have recently discovered specimens referable to *G. izumiense* in the Hobetsu area, Hokkaido and in the southern Talkeetna Mountains, Alaska. These specimens are described in this paper and we then discuss the biostratigraphic correlation of lower Maastrichtian strata in these regions of the North Pacific realm.

Notes on stratigraphy

Hobetsu area, Hokkaido

The Yezo Group represents a thick clastic sequence deposited in a forearc basin along the eastern margin of the paleo-Asian continent during Aptian to Paleocene time, and it is widely distributed in the central region of Hokkaido and Sakhalin (Matsumoto, 1954; Vereshchagin, 1977; Okada, 1983; Takashima *et al.*, 2004; Shigeta and Maeda, 2005). On Hokkaido the Hakobuchi Formation, the uppermost part of the group, consists mainly of sandstone and is well exposed along the Mukawa River near Tomiuchi Village, Hobetsu area, south-central Hokkaido.

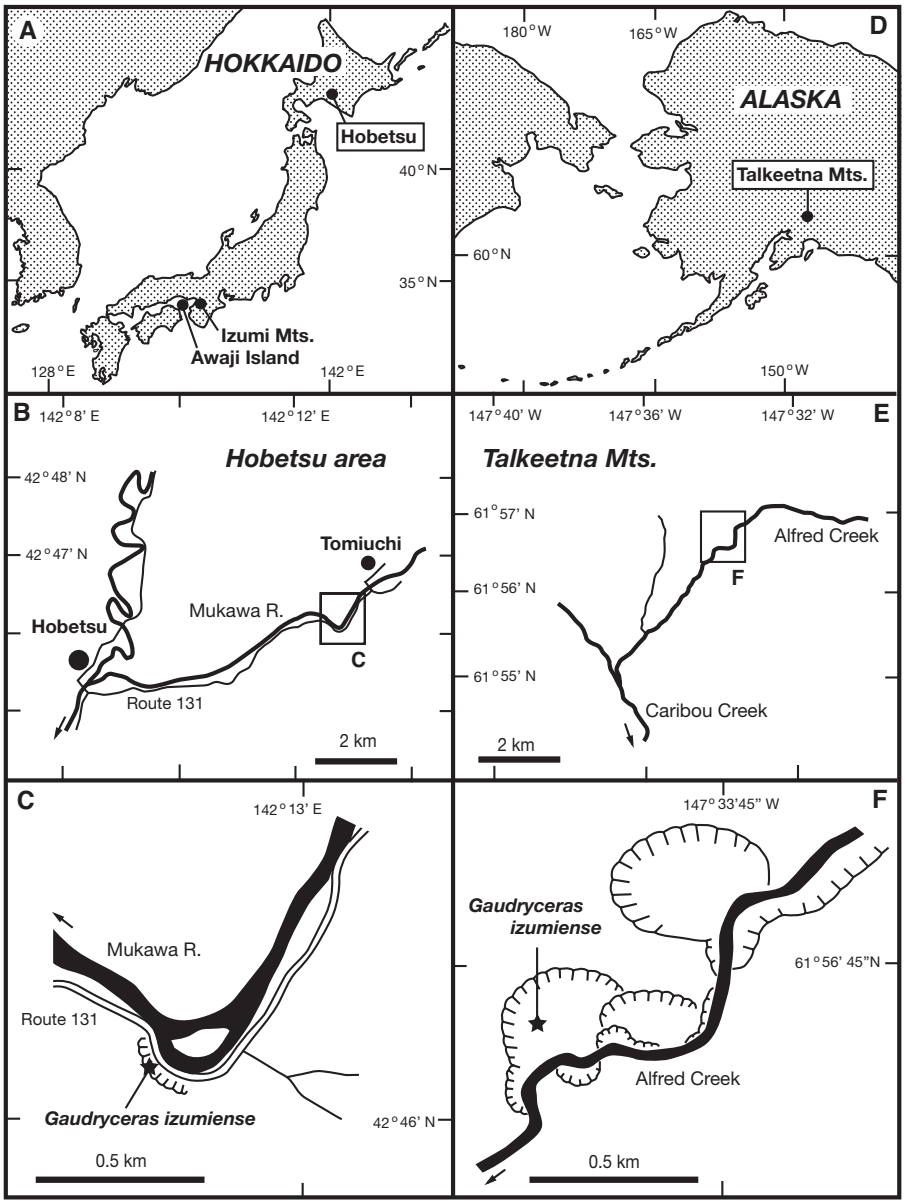

Figure 1. Index maps showing the localities from which *Gaudryceras izumiense* Matsumoto and Morozumi, 1980 was collected. **A–C**. Hobetsu area, Hokkaido. **D–F**. southern Talkeetna Mountains, Alaska.

Matsumoto (1942) divided it into the four following lithologic units, in ascending order: IVa (=Tomiuchi Formation by Matsumoto, 1954), sandstone in association with conglomerate, sandy mudstone and coal beds; IVb, sandy mudstone; IVc (=Fukaushi Formation by Matsumoto, 1954), sandstone with intercalations of conglomerate and sandy mudstone beds; and IVd, sandy mudstone. *Sphenoceramus schmidti* (Michael, 1899), a Campanian index species, has been found in the middle part of Unit IVa (Tanaka, 1960), and *Nostoceras hetonaiense* Matsumoto, 1977 and *Pachydiscus japonicus* Matsumoto, 1947 are indicative of the lower Maastrichtian in Unit IVb (Matsumoto, 1947, 1954, 1977; Tanaka, 1960). *P. kobayashii* (Shimizu, 1935), *P. gracilis* Matsumoto, 1979, *Gaudryceras venustum* Matsumoto, 1984 and *S. hetonaianus* (Matsumoto, 1952) have been reported from the upper part of Unit IVc (=IVc5 of Matsumoto, 1954) near Kiusu Village, 6.5 km northwest of Tomiuchi Town, in the Hobetsu area (Matsumoto, 1979, 1984; Matsumoto and Toshimitsu, 1992, 1995; Matsumoto *et al.*, 1993). A specimen assignable to *G. izumiense* has been obtained from the upper part of Unit IVc (=IVc4 of Matsumoto, 1954) near Tomiuchi Village, Hobetsu area (Figure 1).

Figure 2. *Gaudryceras izumiense* Matsumoto and Morozumi, 1980, HMG-1541, from the Hobetsu area, Hokkaido. **A**. Left lateral view. Black arrow indicates position of last septum. **B**. Apertural view.

Southern Talkeetna Mountains, Alaska

Upper Cretaceous deposits are widely distributed throughout southern Alaska, and the upper part of the Matanuska Formation that is exposed in the Matanuska Valley-Talkeetna Mountains is interpreted as having been deposited in a forearc basin during Campanian to Maastrichtian time (Trop, 2008). Well preserved macrofossils are abundant at various horizons, and two fossil zones were established by Jones (1963), namely, the *Sphenoceramus schmidti* Zone (Campanian) and the *Pachydiscus kamishakensis* Zone (Campanian-Maastrichtian) in ascending order. A specimen referable to *Gaudryceras izumiense* was obtained from exposures of the *P. kamishakensis* Zone in the uppermost part of the Matanuska Formation along Alfred Creek in the southern Talkeetna Mountains (Figure 1).

Paleontological description

Morphological terms in the systematic description are those used in the *Treatise on Invertebrate Paleontology* (Moore, 1957). Quantifiers used to describe the shape of the ammonoid shell replicate those proposed by Matsumoto

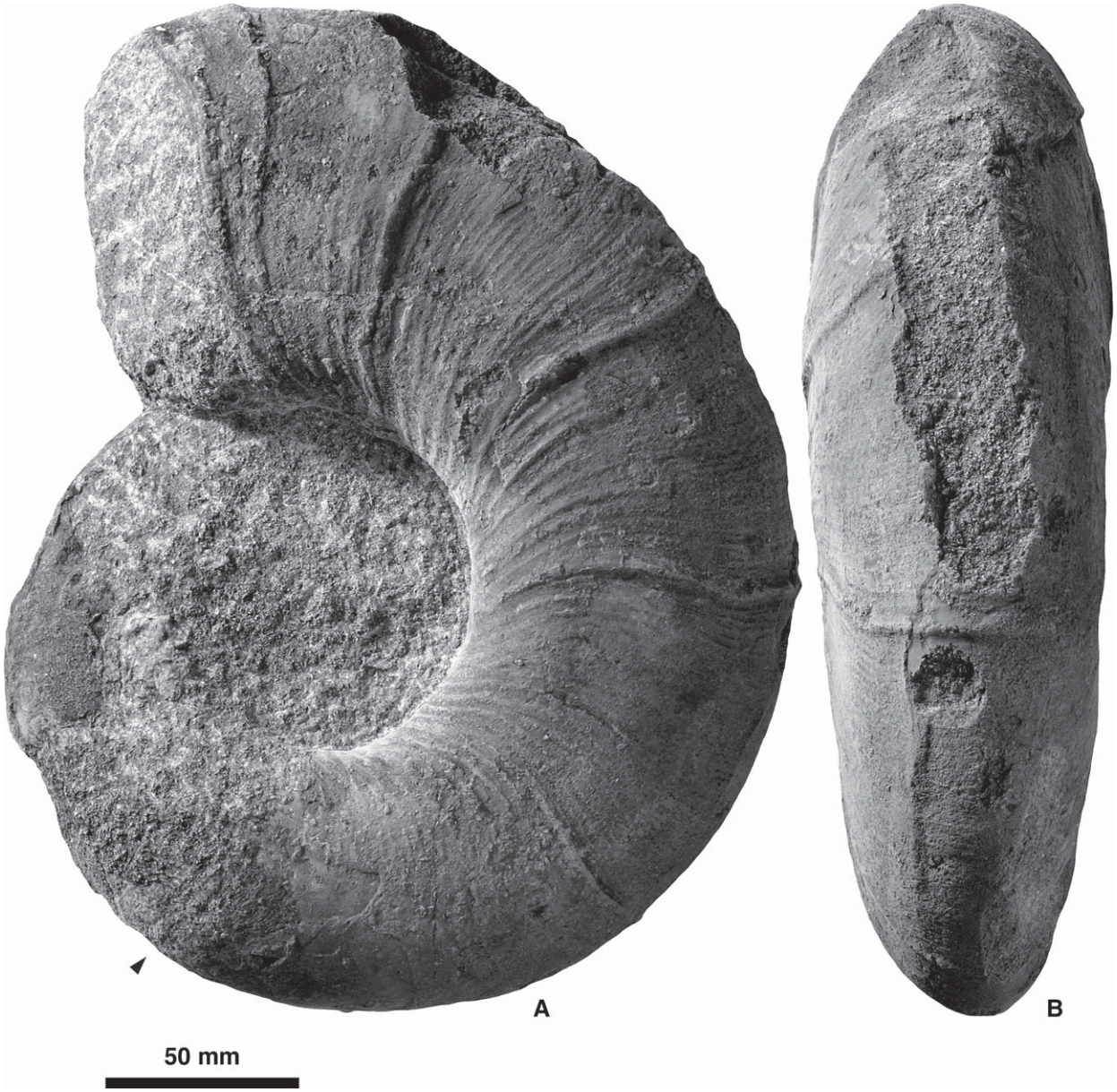

Figure 3. *Gaudryceras izumiense* Matsumoto and Morozumi, 1980, HMG-1541, from the Hobetsu area, Hokkaido. **A**. Right lateral view. Black arrow indicates position of last septum. **B**. Ventral view.

(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.

Institution abbreviations.— HMG=Hobetsu Museum, Mukawa, Hokkaido; OMNH=Osaka Museum of Natural History, Osaka; NSM=National Museum of Nature and Science, Tokyo.

Superfamily Tetragonitoidea Hyatt, 1900
Family Gaudryceratidae Spath, 1927

Subfamily Gaudryceratinae Spath, 1927
Genus ***Gaudryceras*** de Grossouvre, 1894

Type species.— *Ammonites mitis* von Hauer, 1866.

Gaudryceras izumiense Matsumoto and Morozumi, 1980

Figures 2–5

Gaudryceras tenuiliratum Yabe. Kobayashi, 1931, p. 639, pl. 10.
Gaudryceras izumiense Matsumoto and Morozumi, 1980, p. 12, pl. 11, fig. 1a-c, pl. 12, fig. 1a-c, pl. 13, fig. 1a, b.

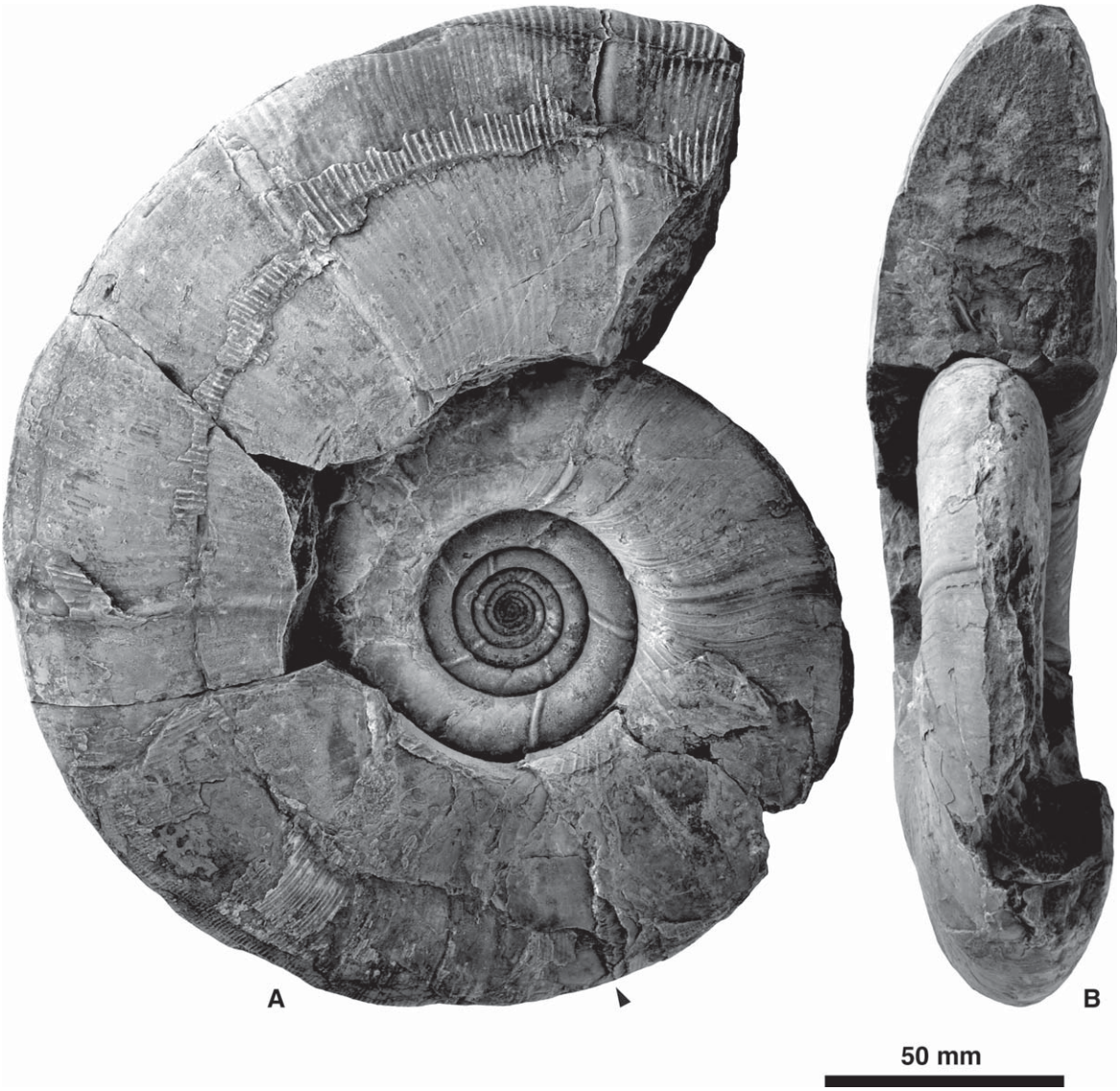

Figure 4. *Gaudryceras izumiense* Matsumoto and Morozumi, 1980, NSM PM23443, southern Talkeetna Mountains, Alaska. **A**. Left lateral view. Black arrow indicates position of last septum. **B**. Apertural view.

Gaudryceras venustum Matsumoto, 1984, p. 5, pl. 3, figs. 1, 2; Matsumoto and Toshimitsu, 1995, p. 2, pls. 1–8.

Holotype.—OMNH.M1125, figured by Matsumoto and Morozumi (1980, p. 13, pl. 11, fig. 1a–c), from the Maastrichtian Azenotani Formation of the Izumi Group at a roadside cliff about 800 m west of Sobura (Loc. 7), Kaizuka City, Osaka Prefecture, Japan.

Material examined.—HMG-1541 (Figures 2, 3), measuring 260 cm in diameter, was collected from greenish gray, medium-grained massive sandstone of the upper part of Unit IVc (=IVc4 of Matsumoto, 1954) at Loc. H14 of Matsumoto (1942, pl. XVII) (42°46′14″N, 142°12′28″E), 1.7 km southwest of Tomiuchi Village, Hobetsu area. This specimen consists of a partly preserved phragmocone as well as a completely preserved body chamber, which begins at about 150 to 160 mm in diameter and occupies two-thirds of the outer whorl.

NSM PM23443 (Figures 4, 5), measuring 210 cm in diameter, together with a specimen of *Pachydiscus kamishakensis* Jones, 1963, was extracted from a calcareous concretion embedded in dark gray, intensely bioturbated mudstone of the uppermost part of the Matanuska Formation exposed along Alfred Creek in the southern Talkeetna Mountains (61°56′39″N, 147°34′2″W). NSM PM23443 consists of the phragmocone and a majority of the body chamber,

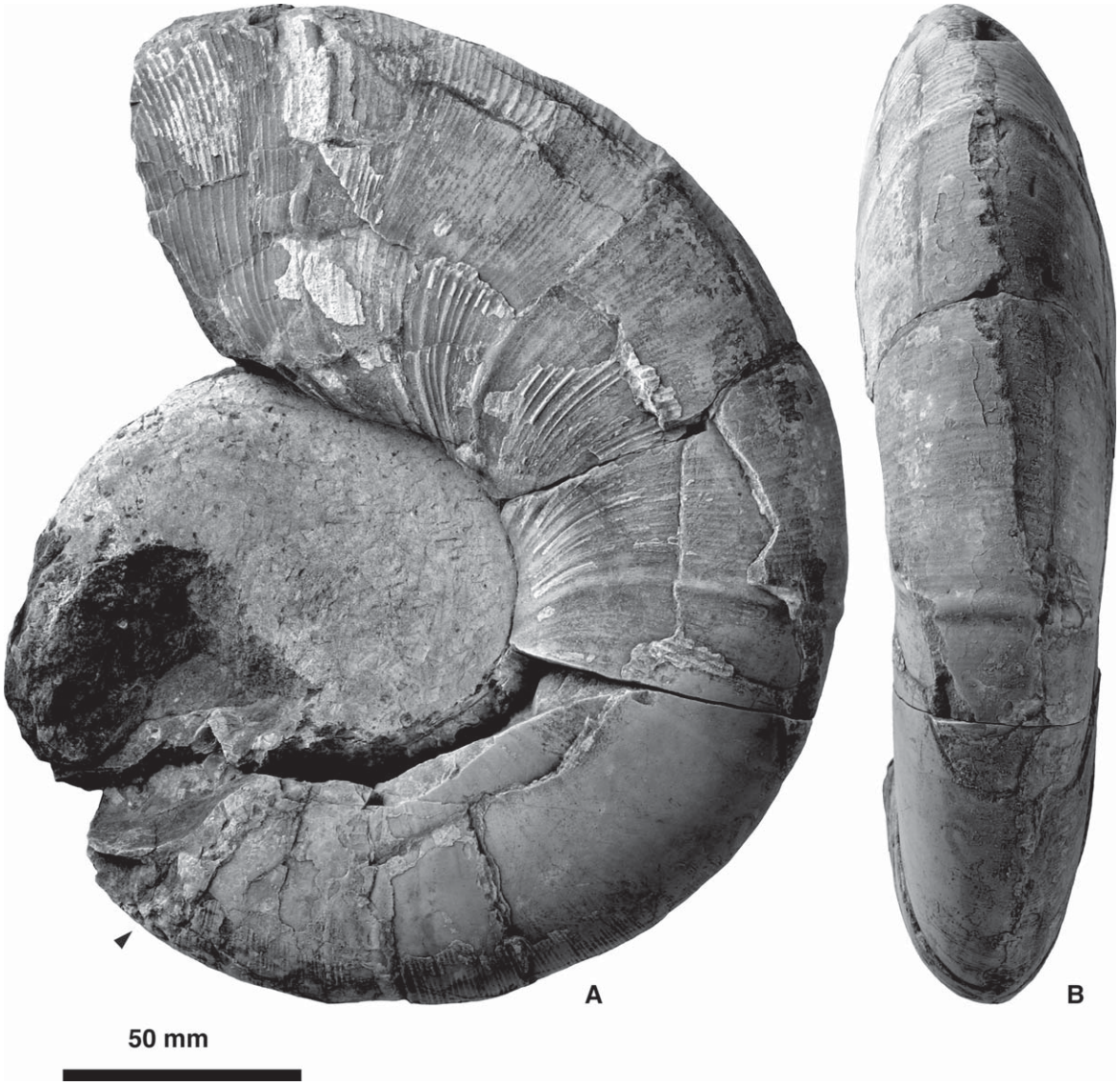

Figure 5. *Gaudryceras izumiense* Matsumoto and Morozumi, 1980, NSM PM23443, southern Talkeetna Mountains, Alaska. **A**. Right lateral view. Black arrow indicates position of last septum. **B**. Ventral view.

which begins at 131.4 mm in diameter and occupies nearly two-thirds of the outer whorl.

Description.—Very evolute, fairly compressed shell with arched venter, indistinct ventral shoulders and gently convex flanks forming a subelliptical whorl section with maximum whorl width at mid-flank. Umbilicus moderately wide with moderately high, vertical wall and rounded shoulders. Ornamentation on phragmocone consists of very fine, dense, slightly sinuous lirae, which arise at umbilical seam and pass over venter in a broad convex arch. Intercalation of lirae occurs on umbilical shoulder and lower flank. Each whorl has variable close or distant, rounded, collar-like or fold-like ribs, running parallel to lirae, and each rib is immediately followed by a shallow constriction. Lirae gradually develop into slightly more distant, narrowly raised ribs, which increase in strength as diameter increases. On body chamber, ribs become much coarser and more distant, and collar-like ribs become more frequent. Suture line only partly exposed on NSM PM23443, but large, incised, bifid saddles of typical gaudryceratid type are visible.

Measurements.—Taken at D=260 mm of HMG-1541, U=86 mm, H=104 mm, W=85 mm, U/D=0.33, W/H=0.82, and at D=210 mm of NSM PM23443, U=70 mm, H=80 mm, W=60 mm, U/D=0.33, W/H=0.75.

Occurrence.—The described specimen from Hokkaido came from the *Sphenoceramus hetonaianus* Zone (lower

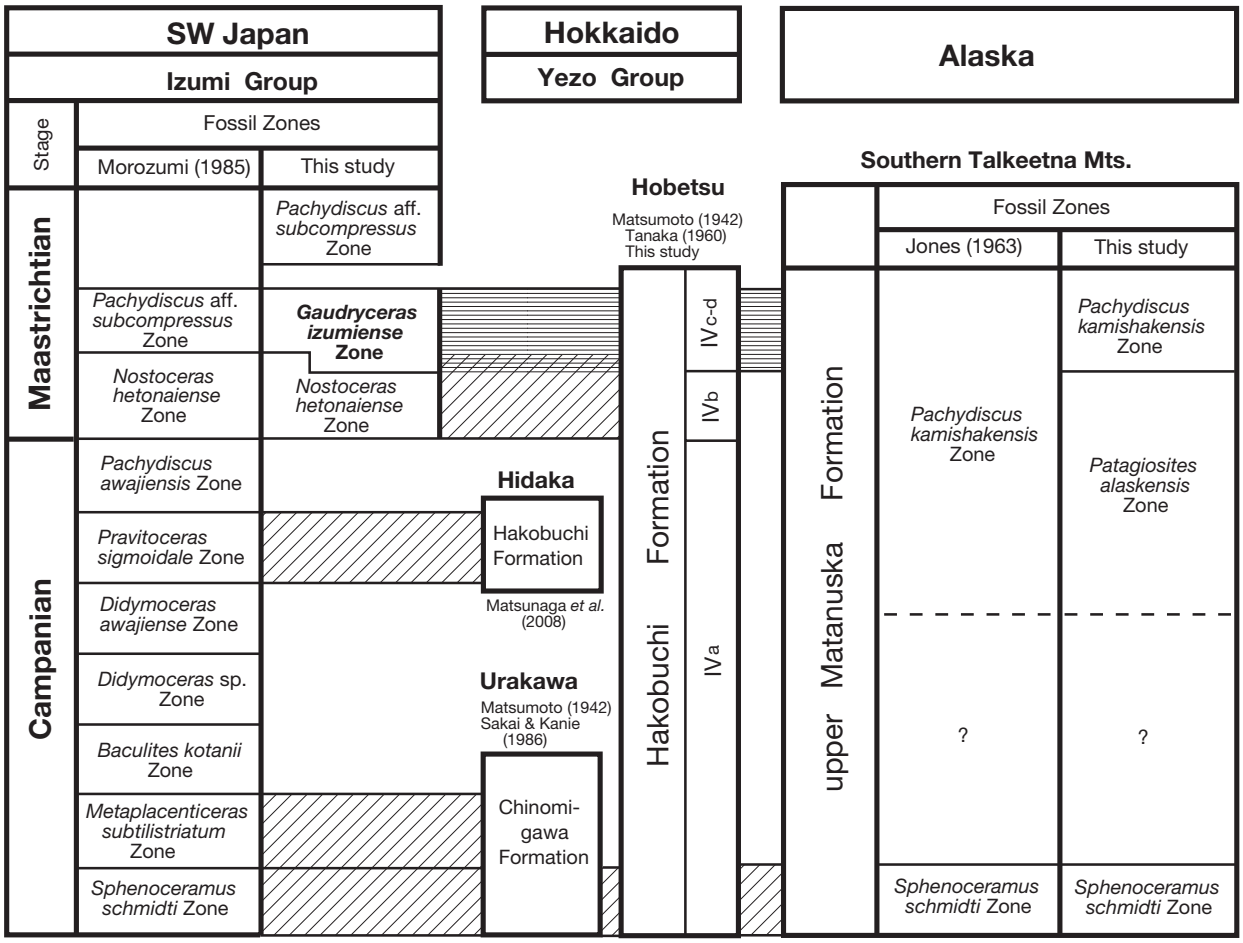

Figure 6. Diagram showing biostratigraphic correlation between Campanian-Maastrichtian deposits in Southwest Japan (left), Hokkaido (center) and Alaska (right). The lower Maastrichtian *Gaudryceras izumiense* Zone was first recognized in these three areas of the North Pacific realm.

Maastrichtian, Toshimitsu *et al.*, 1995a, b) of the Hakobuchi Formation, Hobetsu area, and the specimen from Alaska came from the *Pachydiscus kamishakensis* Zone (Jones, 1963) of the Matanuska Formation, Talkeetna Mountains. This species also occurs frequently in the Izumi Group in the Izumi Mountains (lower Maastrichtian), Southwest Japan (Matsumoto and Morozumi, 1980).

Discussion.—Gaudryceras izumiense is morphologically very close to *G. venustum*. Although the shell surface of the holotype of *G. venustum*, as well as the surfaces of other specimens described by Matsumoto and Toshimitsu (1995), is abraded, which partly obscures its ornamentation, the basic pattern of ornamentation is very similar to that of *G. izumiense*. Both taxa were collected from nearly the same horizon in Unit VIc of the Hakobuchi Formation in the Hobetsu area. The specimen described here, HMG-1541, exhibits ornamentation characteristic of *G. izumiense* on one lateral side (Figure 3), but the other side (Figure 2) is abraded and appears very similar to *G. venustum*. These lines of evidence suggest that both taxa are conspecific.

Discussion

The *Gaudryceras izumiense* Zone, proposed by Toshimitsu *et al*. (1995), includes the following ammonoid species that cooccur in the Izumi Mountains (Matsumoto and Morozumi, 1980): *Pachydiscus kobayashii*, *Canadoceras tanii* Matsumoto and Morozumi, 1980, *Nostoceras* aff. *hetonaiense* and *Baculites regina* Obata and Matsumoto, 1963 in the lower part and *P*. aff. *flexuosus* Matsumoto, 1979, *P*. cf. *gracilis*, and *N*. aff. *kernense* (Anderson, 1958) in the upper part. *G. izumiense* rarely occurs in the lower part of the zone, but is abundant in the upper part.

Morozumi (1985) assigned the lower part of the *Gaudryceras izumiense* bearing beds in the Izumi Mountains to the upper portion of the *Nostoceras hetonaiense* Zone. This correlation is supported by the occurrence of *G. izumiense* just above the uppermost horizon of the *N. hetonaiense* Zone of

the Hakobuchi Group in the Hobetsu area, Hokkaido as described in this paper. According to the magnetostratigraphy on Awaji Island (Kodama, 1990), the *N. hetonaiense* Zone is correlated with the lowest Maastrichtian.

Morozumi (1985) placed the *Pachydiscus* aff. *subcompressus* Zone just above the *Nostoceras hetonaiense* Zone, but both zones are cut by a fault on Awaji Island. Subsequently, he assigned the upper part of the *Gaudryceras izumiense* bearing beds in the Izumi Mountains to the *P*. aff. *subcompressus* Zone. In addition to the zonal-index species, *P*. aff. *subcompressus* Matsumoto, 1954, the zone also contains *Anagaudryceras matsumotoi* Morozumi, 1985, *Zelandites* cf. *varuna* (Forbes, 1846), *Gaudryceras makarovense* Shigeta and Maeda, 2005, and "*Inoceramus*" *awajiensis* Matsumoto, 1952 (Morozumi, 1985). Morozumi (1985) described a specimen from this zone as *G. izumiense*, but Maeda *et al*. (2005) later referred the specimen to *G. makarovense*. Similar assemblages are known from the uppermost part of the Yezo Group in Hokkaido (Ando *et al.*, 2001) and Sakhalin (Shigeta and Maeda, 2005) as well as from the Senpohshi Formation of the Nemuro Group in eastern Hokkaido (Naruse *et al.*, 2000; Nifuku *et al.*, 2009). Magnetostratigraphic studies of the Senpohshi Formation strongly suggest that the "*Inoceramus*" *awajiensis* bearing beds are correlatable with polarity chron C31n of the upper Maastrichtian (Nifuku *et al.*, 2009). Therefore, the *P*. aff. *subcompressus* Zone has been tentatively placed within the upper Maastrichtian, but this assignment implies a large stratigraphic gap between the *N. hetonaiense* Zone and the *P*. aff. *subcompressus* Zone on Awaji Island. The *G. izumiense* Zone overlaps the *N. hetonaiense* Zone, but does not share any ammonoid species with the *P*. aff. *subcompressus* Zone. These lines of evidence suggest that the *G. izumiense* Zone should be placed below the *P*. aff. *subcompressus* Zone with a probable large stratigraphic gap (Figure 6).

In the past, the biostratigraphic correlation of uppermost Cretaceous strata of the Izumi and Yezo groups has been less than precise because of the poor development of fossiliferous mudstone facies and the intermittent occurrence of fossils in the uppermost part of the Yezo Group, due to the dominance of coarse-grained sediments. Consequently, only four fossil zones, the *Sphenoceramus schmidti*, *Metaplacenticeras subtilistriatum*, *Pravitoceras sigmoidale* and *Nostoceras hetonaiense* zones, in ascending order, were common to both groups (Figure 6). The recent discovery of *Gaudryceras izumiense* in the Yezo Group is a significant step toward a much more precise biostratigraphic correlation between the groups. In addition, the common occurrence of *Pachydiscus kobayashii* and *P. gracilis* strongly suggests that the Yezo and Izumi groups shared a similar ammonoid fauna during the early Maastrichtian.

The newly discovered specimen of *Gaudryceras izumiense* from the Alfred Creek area in the southern Talkeetna Mountains has also shed light on the age delineation of these chronologically poorly defined beds in Alaska. Jones (1963) recognized two fossil zones in the upper part of the Matanuska Formation in southern Alaska, the lower *Sphenoceramus schmidti* Zone and the upper *Pachydiscus kamishakensis* Zone. However, his faunal list (Table 1 in Jones, 1963) clearly shows that the *P. kamishakensis* Zone includes two different ammonoid assemblages; one characterized by *P. kamishakensis*, *Desmophyllites phyllimorphum* (Kossmat, 1898) and *Didymoceras* aff. *hornbyense* (Whiteaves, 1895), and the other by *Patagiosites alaskensis* Jones, 1963 and *Damesites hetonaiensis* Matsumoto, 1954. Therefore, the *P. kamishakensis* Zone of Jones (1963) can be subdivided into two taxon-range zones, namely, the *P. kamishakensis* and *Pat. alaskensis* zones. Unfortunately, the stratigraphic relationship between them was not documented by Jones (1963).

The occurrence of *Gaudryceras izumiense* in the upper Matanuska Formation suggests that the *Pachydiscus kamishakensis* Zone is correlatable to the *G. izumiense* Zone of early Maastrichtian age of the Izumi Group. *Canadoceras tanii*, described from the Izumi Group by Matsumoto and Morozumi (1980), is very similar to *P. kamishakensis* in having indistinct umbilical bullae, gently flexuous ribs and intercalated ribs, and more likely, it is conspecific with the latter. The specimen described as *Nostoceras* aff. *kernense* by Matsumoto and Morozumi (1980, pl. 14, fig. 2) is somewhat similar to the specimen described as *Didymoceras* aff. *hornbyense* by Jones (1963, pl. 23, fig. 1). These facts also support the above correlation. In addition, the common accompanying fossils suggest that the Izumi Group and the Matanuska Formation may have shared a similar fauna during early Maastrichtian time.

Damesites hetonaiensis is a typical ammonoid species in the *Nostoceras hetonaiense* Zone of earliest Maastrichtian age in the Yezo Group (Matsumoto, 1954), and it also occurs with *Patagiosites alaskensis* in Alaska (Jones, 1963). The specimens described under *D*. cf. *sugata* (Forbes, 1846) by Haggart *et al*. (2009) from the uppermost Campanian of the Queen Charlotte Islands, British Columbia, Canada, are probably identical to *D. hetonaiensis*. In summary the *Pat. alaskensis* Zone underlies the *Pachydiscus kamishakensis* Zone in Alaska and is correlatable to the *N. hetonaiense* Zone of either the lowest Maastrichtian or the uppermost Campanian in the North Pacific realm. This correlation is likely supported by the cooccurrence of *Pat. alaskensis* and *Pravitoceras sigmoidale* in the Yezo Group in the Hidaka area, southern-central Hokkaido (Matsunaga *et al.*, 2008).

Concluding remarks

Until now, biostratigraphic correlation of the uppermost Cretaceous in the North Pacific realm has been less than precise, but the recent discovery of *Gaudryceras izumiense* in

Hokkaido and Alaska has made it possible to correlate lower Maastrichtian strata in these areas with coeval strata in Southwest Japan. In addition, cooccurring fossils suggest that a similar fauna may have existed in these areas of the North Pacific realm during early Maastrichtian time.

Gaudryceratid ammonoids are fairly abundant in the uppermost Cretaceous in the North Pacific realm, and thus they are ideal taxa for precise biostratigraphic correlation of uppermost Cretaceous strata in this particular realm.

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