

Original Article

# Discovery of a stage-diagnostic inoceramid bivalve from the Upper Cretaceous part of the Hakobuchi Formation, Yezo Group in the Oyubari area, Hokkaido

Tomohiro Nishimura<sup>1,2\*</sup> and Hisao Ando<sup>3</sup>

<sup>1</sup>Hobetsu Museum, 80-6 Hobetsu, Mukawa Town, Hokkaido 054-0211, Japan

<sup>2</sup>Hokkaido University Museum, Kita 10, Nishi 8, Kita-ku, Sapporo, Hokkaido 060-0810, Japan

<sup>3</sup>Faculty of Dinosaur Paleontology, Fukui Prefectural University, 4-1-1 Kenjojima, Matsuoka, Eiheiji Town, Fukui 910-1195, Japan

\*Corresponding author: T. Nishimura, [tnishimura@town.mukawa.lg.jp](mailto:tnishimura@town.mukawa.lg.jp)

**Abstract.** A stage-diagnostic inoceramid bivalve, *Sphenoceramus nagaoui* (Matsumoto and Ueda, 1962), which occurred from the lower part of the Hakobuchi Formation, Yezo Group, Oyubari area, Hokkaido, northern Japan, is briefly described for the interregional stratigraphic correlation. This specimen was found in the “Hard Sandstone” rock unit of the lower part of the Hakobuchi Formation, Hakobuchi Gorge section, Oyubari area. Because *S. nagaoui* is indicative of the stage, and is known from the southernly adjacent Hobetsu and Biratori areas. The discovery leads to an exact biostratigraphic correlation of the lower part of the Hakobuchi Formation with the uppermost Santonian to lower middle Campanian deposits in various areas in Hokkaido and Sakhalin.

**Key words:** biostratigraphy, Hakobuchi Formation, Late Cretaceous, Oyubari, *Sphenoceramus*

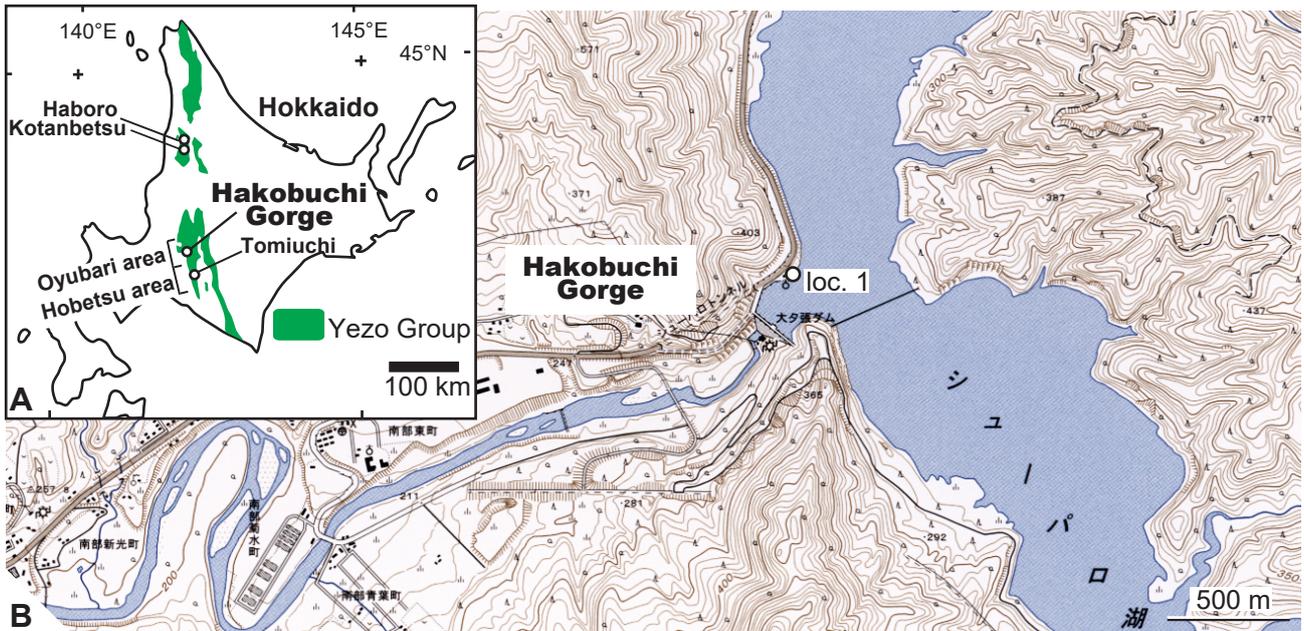
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## Introduction

The Upper Cretaceous to Paleogene Hakobuchi Formation, the uppermost lithostratigraphic unit in the Yezo Group (Figure 1A), is distributed in the Ishikari Coal Field district, namely the Ashibetsu, Mikasa, Oyubari, and Hobetsu areas in central to southern Hokkaido (Matsumoto, 1954; Ando, 1993; Takashima *et al.*, 2004). In the Hakobuchi Formation of the Hobetsu area, rich molluscan fossils such as ammonoids and inoceramids commonly occur from several horizons, and some of them were treated as Late Cretaceous age-diagnostic fossils in the northwest Pacific province (e.g., Matsumoto, 1977; Matsumoto *et al.*, 1993; Toshimitsu *et al.*, 1995; Yazykova, 2004; Shigeta *et al.*, 2010, Shigeta and Nishimura, 2013, Jagt-Yazykova, 2011). Furthermore, marine reptile fossils, such as mosasaurs and turtles, and terrestrial dinosaurs occasionally occur from the Hakobuchi Formation (Suzuki, 1985; Hirayama and Chitoku, 1996; Sakurai *et al.*, 1999; Konishi *et al.*, 2016; Kobayashi *et al.*, 2019).

These vertebrates are significant for understanding the paleoecosystem of the northwest Pacific province and the eastern margin of the Asian Continent.

The Hakobuchi Formation was first described as “Hakobuti Sandstone” by Imai (1924) in the Hakobuchi Gorge section, Oyubari area (Figure 1). The stratotype of the Hakobuchi Formation is interpreted as Hakobuchi Gorge section (Chitoku, 1986; Ando, 2003). Compared with the Hobetsu area, macrofossils are quite rare in the Hakobuchi Formation in the Oyubari area except for plant fossils (Endo, 1925; Okubo and Kimura, 1989). In 1993, the junior author HA found a stage-diagnostic inoceramid fossil from the stratotype section of the Hakobuchi Formation (Figures 1B, 2, 3) before construction of the new Yubari Shuparo Dam in 2015, which is located on the downstream side of the old Oyubari Dam. Now the fossil site is submerged. The present paper describes the inoceramid specimen repositied in the Hobetsu Museum since 2024 and its geological significance.



**Figure 1.** Map of the Hakobuchi Gorge section in the Oyubari area. **A.** Distribution of Yezo Group in Hokkaido. **B.** Locality of an incoceramid specimen. This map is based on the Topographic Map 25,000 "Shuparo-ko" published by the Geographical Survey Institute (2008). The locality is the same as loc. 1 of Nishimura and Komatsu (2022). This exposure was submerged beneath the reservoir lake of the newly constructed large Yubari Shuparo Dam, located downstream of the Oyubari Dam in 2015.

### Notes on stratigraphy

The Cretaceous to Paleogene Yezo Group in the Oyubari area is subdivided into eight formations: Soashibetsugawa, Shuparogawa, Maruyama, Hikagenosawa, Saku, Kashima, and Hakobuchi formations in ascending order (Takashima *et al.*, 2004). The uppermost unit of the Yezo Group, Hakobuchi Formation, was conventionally ranked as the group (e.g., Matsumoto, 1954; Nagao *et al.*, 1954; Fujii, 1958), but it was demoted into the formation rank by Takashima *et al.* (2004), considering detailed wide area stratigraphic correlations in central Hokkaido.

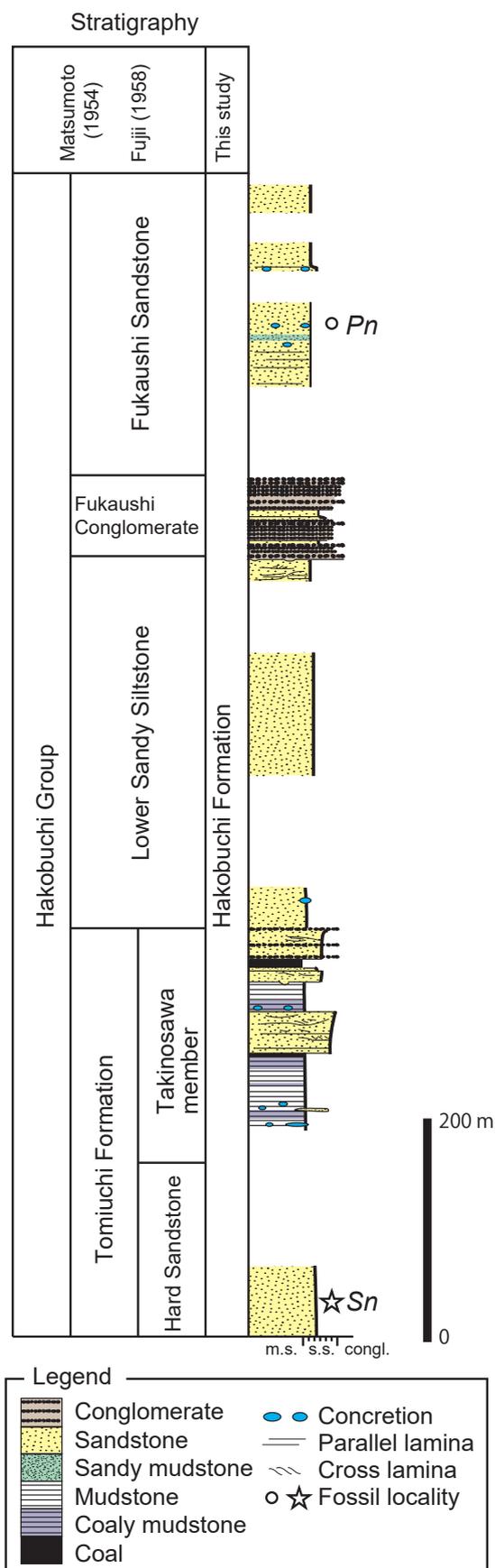
The Hakobuchi Formation extends in an NNW-SSE direction along the western margin of the distribution of the Yezo Group in the Oyubari area, and continues southward into the Hobetsu area. It dips steeply or vertically and occasionally overturned in westward upsection, reflecting the large-scale geologic structure (anticline). Along the Hakobuchi Gorge section, the Hakobuchi Formation is widely and continuously distributed (Figure 1), conformably overlying the Kashima Formation eastward, and unconformably underlying the Paleogene Noborikawa Formation, Ishikari Group westward. These strata form an

overturned monoclinical structure, whereas striking N40-50° westward and dipping overturned 40-50° eastward (Ando, 2003, fig. 5; Ando *et al.*, 2007, figs. 8, 9; Nishimura and Komatsu, 2022, fig. 1).

The Hakobuchi Formation in the stratotype section is subdivided into eight lithostratigraphic units by Matsumoto (1954) and Fujii (1958): 1) Basal Sandstone and Conglomerate, 2) Tuffaceous Beds, 3) Hard Sandstone, 4) Takinosawa Member, 5) Lower Sandy Siltstone, 6) Fukaushi Conglomerate, 7) Fukaushi Sandstone, and 8) Sanushupe [=Sanushube] Sandstone in ascending order. The lower four units, from the Basal Sandstone and Conglomerate (1) to the Takinosawa Member (4), were treated as the "Tomiuchi Formation" by Matsumoto (1954) and Fujii (1958). On the other hand, Ando *et al.* (2007, figs. 8, 9) subdivided into twelve depositional sequences (DS), DS1 to DS12, based on sequence stratigraphy.

### Biostratigraphic correlation

In general, stage-diagnostic fossils quite rarely occur in the Hakobuchi Formation of the Oyubari area. Two specimens of ammonoid *Canadoceras kossmati* occurred from just below and at the base of the



**Figure 2.** Geological columnar section in the Hakobuchi Gorge section of the Hakobuchi Formation, Yezo Group in the Oyubari area and fossil occurrences. *Pn*, *Periplomya nagai*; *Sn*, *Sphenoceramus nagai*.

formation (Saito *et al.*, 1998) in the northern Oyubari area. *Canadoceras kossmati* indicates the lower middle Campanian, bearing *Sphenoceramus schmidt* to the upper Campanian (Matsumoto, 1954; Poyarkova, 1987; Saito *et al.*, 1998; Shigeta, 2019). The “early morphotype” of *Canadoceras kossmati* occurs from the lower Campanian *Sphenoceramus schmidt* Zone (Saito *et al.*, 1998). Several studies of the 2010s interpreted this *Canadoceras* horizon as regards the lower middle Campanian (Shigeta *et al.*, 2016, 2019; Shigeta and Tsutsumi, 2018).

The Campanian to Maastrichtian bivalve *Periplomya nagai* Ichikawa and Maeda, 1958 was reported from the 7) Fukaushi Sandstone rock unit (Figure 2; Nishimura and Komatsu, 2022). In the uppermost part of the Hakobuchi Formation, 8) Sanushupe [=Sanushube] Sandstone rock unit, late Paleocene dinoflagellates such as *Alisocysta margarita*, *A. circumtabulata*, and *Fibradinium annetorpense* are briefly reported in an oral presentation (Suzuki *et al.*, 1997).

We basically followed the biostratigraphic scheme of the Toshimitsu *et al.* (1995), and the revised Campanian subdivision by Shigeta *et al.* (2016, 2019).

### Paleontological description

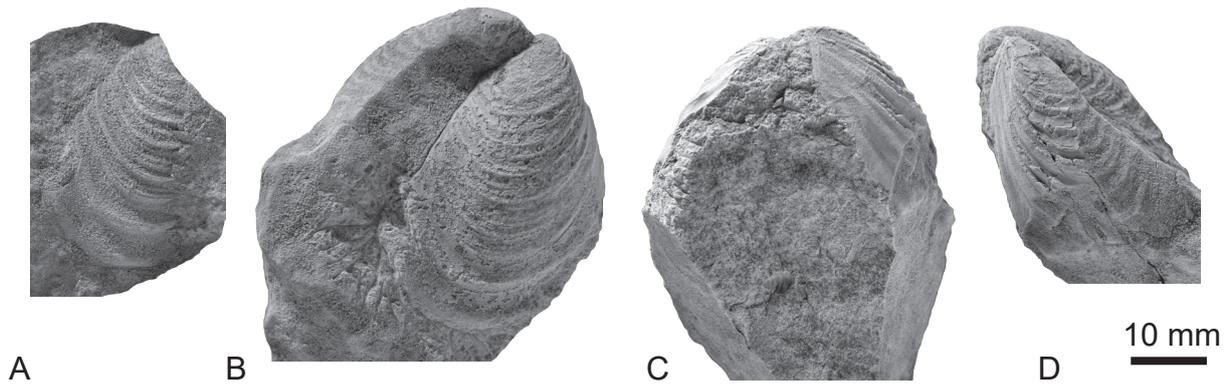
Family Inoceramidae Giebel, 1852

Genus *Sphenoceramus* Böhm, 1915

*Sphenoceramus nagai* (Matsumoto and Ueda, 1962)

Figure 3

- 1914, *Inoceramus labatus* Goldfuss, Sokolow, p.37–39, 75–76, pl. 4, figs. 4, 5, pl. 5, fig. 2.
- 1940, *Inoceramus orientalis* var. *ambiguus* Nagao and Matsumoto, p. 37, pl. 15, figs. 3–4; pl. 17, figs. 1–2.
- 1960, *Inoceramus orientalis* var. *ambiguus*, Amano, p. 9, pl. 1, figs. 1–3, 6, 8, 10.
- 1962, *Inoceramus orientalis nagai*, nom. nov. Matsumoto and Ueda, in Ueda, 1962, p. 167–169, pl. 23, figs. 1–5.
- 1965, *Inoceramus nagai* var. *modica* Zonova, p. 192–193, pl. 1, figs. 1–4.
- 1974, *Inoceramus orientalis nagai* Matsumoto and Ueda, 1962, Pergament, p. 179, 180, pl. 43, fig. 4.
- 1974, *Inoceramus orientalis vaugs* Pergament, p. 182–185, pl. 43, fig. 5, pl. 44, figs. 2–5.
- 1976, *Inoceramus orientalis nagai* Matsumoto and Ueda, 1962, Noda and Matsumoto, 1976, no. 45–269, fig. 7.
- 1988, *Sphenoceramus nagai* (Matsumoto and Ueda, 1962), Noda, 1988, p.147–150, pl. 1, figs. 7a–c.



**Figure 3.** An inoceramid bivalve *Sphenoceramus nagaoi* (Matsumoto and Ueda, 1962) from Hard Sandstone rock unit of the lower part of the Hakobuchi Formation along the Hakobuchi Gorge section, Oyubari area, Hokkaido. HMG-2623 (registered and stored at Hobetsu Museum). **A.** A rubber cast of a part of the right valve. **B.** Right valve. **C.** Anterior view of articulated valves. **D.** Left valve that deformed in the antero-posterior direction.

*Type.*—HK3808 (Hokkaido University Museum), from the *Anapachydiscus* bed of the Upper Yezo Group (= the Kashima Formation in recent scheme) at Osachinai, Biratori Town, Hokkaido, was designated as the lectotype by Matsumoto and Ueda (1962).

*Material.*—HMG-2623

*Description.*—A single individual with both valves is available. The inner mold and external mold of the right valve are preserved. Most of the calcite shells are dissolved. The right valve is mostly well preserved, except for the posterior wing. The left valve is deformed in the anteroposterior direction.

The shell is inequilateral in shape, higher than long, and is 35 mm in height. The shell is moderately convex, and the anterior part is slightly steeply inclined to the commissure area. Major concentric ribs are developed in a whole growth stage of the specimen. Double rib is also observed in the outer mold and/or the rubber cast of the right valve (Figure 3A). The shallow radial depression along the posterior margin is not developed.

*Remarks.*—Specimens described by Nagao and Matsumoto (1940, p. 37–40) have a shallow radial depression along the posterior margin as *Inoceramus orientalis* var. *ambiguous* (= *Sphenoceramus nagaoi*), but the shallow radial depression was sometimes described as very indistinct or hardly discernible (Nagao

and Matsumoto, 1940, p. 38). The shallow depression is also hardly discernible or not developed in HMG-2623.

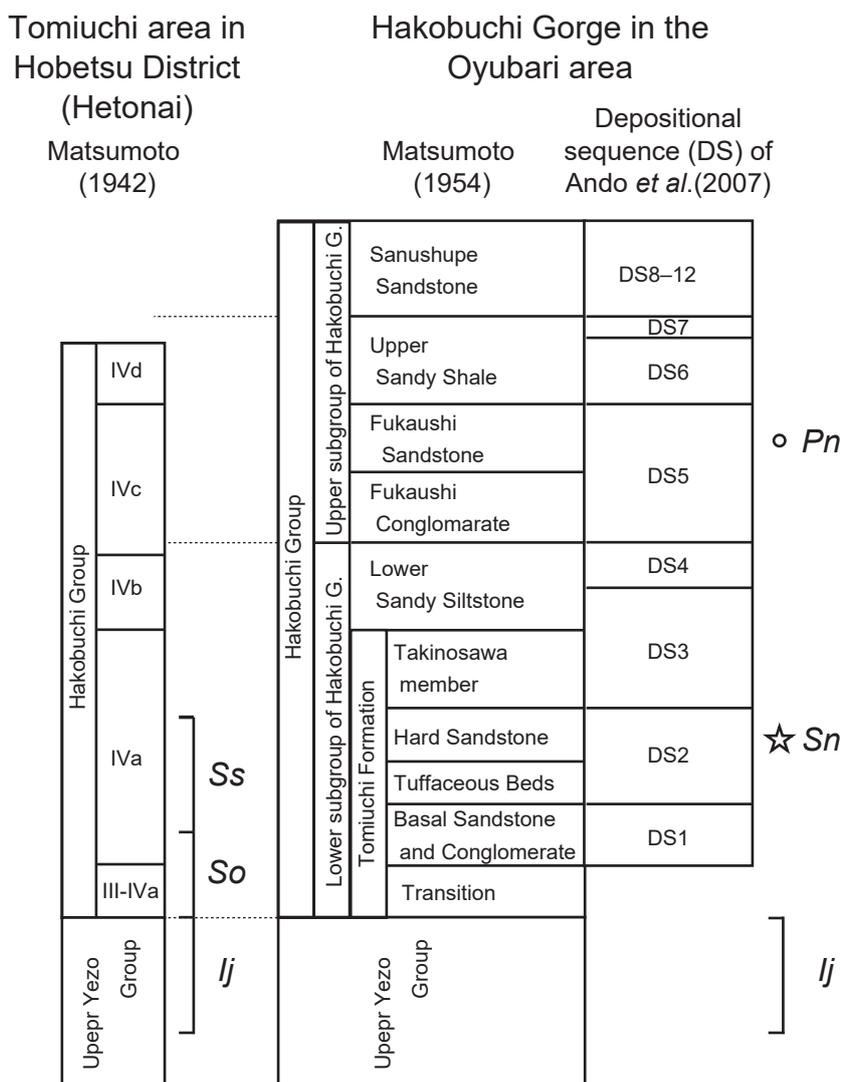
The *Sphenoceramus orientalis* Zone was correlated to be the lower Campanian (e.g., Toshimitsu *et al.*, 1995), while it is treated as the lower middle Campanian in Shigeta *et al.* (2016, 2019) and Shigeta and Tsutsumi (2018).

*Sphenoceramus nagaoi* occurs in both *Inoceramus (Platyceramus) japonicus* and *Sphenoceramus orientalis* zones (Noda and Matsumoto, 1976). FAD (first appearance datum) of *S. nagaoi* is just below the lower Campanian *I. (P.) japonicus* Zone in the Haboro and Kotanbetsu areas of Hokkaido (Toshimitsu, 1985; Wani and Hirano, 2000), and is correlated to the uppermost Santonian.

*Occurrence.*—Uppermost Santonian to lower middle Campanian in Japan and Sakhalin.

### Discussion

The occurrence of the Santonian to middle Campanian *Sphenoceramus nagaoi* (Matsumoto and Ueda, 1962), ranging from the Hard Sandstone rock unit of the “Tomiuchi Formation” (Figure 2; Matsumoto, 1954; Fujii, 1958), or the upper part of DS2 of the Hakobuchi Formation (Ando, 2003, fig. 5; Ando *et al.*, 2007, figs. 8, 9), is significant because of quite rare occurrences of macrofossils in the Hakobuchi



**Figure 4.** Comparison of lithostratigraphic divisions between the Tomiuchi and Hakobuchi Gorge sections of upper part of the Yezo Group and fossil occurrences. *Ij*, *Inoceramus (Platyceramus) japonicus*; *Pn*, *Periplomya nagaoi*; *So*, *Sphenoceramus orientalis*; *Sn*, *S. nagaoi*; *Ss*, *Sphenoceramus schmidti*.

Formation of the Oyubari area. According to Ando *et al.* (2007), DS1 and DS2 are regarded as shallow-marine sediments under inner shelf to upper shoreface environments, and both show coarsening (shallowing) upward facies succession.

Recently, Kubomi and Nagata (2024) described lithostratigraphical and petrographical observations on white to gray acid tuff about 28 m thick of the Tuffaceous bed of the “Tomiuchi Formation” (Fujii, 1958), or the lower part of DS2 (Ando *et al.*, 2007). They reported the zircon U-Pb radiometric age of 79.8±0.8 Ma for the tuff sample (Kubomi *et al.* 2025). The radiometric age is concordant with the biostratigraphic correlation for *S. nagaoi* described above, and also for *Canadoceras kossmati* (Saito *et al.*,

1998). This series of evidence suggests that the lower part of the Hakobuchi Formation, especially shallow-marine DS1 and DS2 underlying a fluvial to shallow-marine facies succession of DS3 with a basal erosional sequence boundary (unconformity), can be regarded as the upper lower to lower middle Campanian.

Although the upper middle and upper Campanian and further subsequent index fossils have not yet been obtained from the middle-upper Hakobuchi Formation in the Oyubari area, the lower middle Campanian *Sphenoceramus orientalis* and lower middle Campanian *S. schmidti* occur from the Tomiuchi section of the Hobetsu area, located 25 km south of the Hakobuchi Gorge section (Figures 1, 4; Matsumoto, 1942; Tanaka, 1960). However, the stage-diagnostic fossils for the

upper Campanian are not found in either area. The lower Maastrichtian inoceramids and ammonoids commonly occur from the upper Hakobuchi Formation in the Hobetsu area (Matsumoto *et al.*, 1993; Shigeta *et al.*, 2010; Shigeta and Nishimura, 2013). On the other hand, the lowest Campanian *Inoceramus* (*Platyceramus*) *japonicus* Nagao and Matsumoto, 1940 occurs from the Kashima Formation (previously described as “Upper Yezo Group”) conformably underlying the Hakobuchi Formation in both the Oyubari and Hobetsu areas (Matsumoto, 1942; Hirano *et al.*, 1990; Kubomi and Nagata, 2025; Nishimura, 2025).

Therefore, the uppermost part of the Kashima Formation to the lower part of the Hakobuchi Formation are biostratigraphically correlative to the lowest to lower middle Campanian in both Oyubari and Hobetsu areas. Their detailed stratigraphic correlation will be necessary in terms of sedimentary facies and sequence stratigraphic analyses, and radiometric dating as future research topics.

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#### Author contributions

H.A. collected fossils. T.N. conducted the taxonomic study. Both authors contributed to the geological study and the writing of the paper.

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#### (要 旨)

北海道大夕張地域に分布する最上部白亜系～古第三系暁新統蝦夷層群函淵層下部からイノセラムス科二枚貝の *Sphenoceras nagaio* (Matsumoto and Ueda, 1962) を発見した. この標本は函淵層の模式層で, 現在は夕張シューパロダムに水没している函淵峡谷の上流側の露頭から産した. 大夕張地域から最上部サントニアン階～中部カンパニアン階を示す *Sphenoceras nagaio* が産出したことは, 函淵層下部の堆積時代について, 南方の穂別地域と対比可能な層準が追加され, 層序対比に制約を与える.