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The genus *Hourcquia* (Ammonoidea, Pseudotissotiidae) from the Upper Cretaceous of Hokkaido, Japan: biostratigraphic and biogeographic implications

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Abstract. Stratigraphic and ontogenetic descriptions of three species of *Hourcquia* from the Cretaceous Yezo Supergroup of Hokkaido, Japan are given for the first time. *H. ingens*, *H. hataii* and *H. kawashitai* occur in the *Inoceramus teshioensis* Zone of the upper Turonian. *Hourcquia* evolved and radiated in not only the Tethyan and adjacent areas but also the Northwest Pacific region for a short period in the late Turonian.

Key words: Ammonoid, Hokkaido, *Hourcquia*, late Turonian, Yezo Supergroup

Introduction

The genus *Hourcquia* Collignon, 1965 of the family Pseudotissotiidae is characterized by having trapezoidal whorl sections with a rounded keel, coarse ribs, and umbilical and ventrolateral tubercles. Species of the genus are known to occur from the upper Turonian of Madagascar (Collignon, 1965), Venezuela (Renz, 1982), New Mexico, and Texas (Anonymous, 1981). These areas belong to the Tethyan and surrounding realms.

Distribution of the present genus extends also to the northwest Pacific region. Five species of *Hourcquia* are known from the Cretaceous Yezo Supergroup of Hokkaido, Japan (Hashimoto, 1973; Matsumoto and Obata, 1982; Matsumoto and Toshimitsu, 1984; Toshimitsu and Maiya, 1986) and Sakhalin, Russia (Matsumoto, 1970). However, no detailed analysis has been undertaken of their exact stratigraphic occurrences and variations of shell growth. Further work based on better material is desirable for elucidating the ontogeny, biostratigraphy and biogeography of the genus.

Recently, we collected several well-preserved specimens referable to *Hourcquia* from the Cretaceous Yezo Supergroup in the Ikushumbetsu, Miruto and Haboro areas, Hokkaido (Figure 1). In this paper, we describe three species of the genus and discuss their biostratigraphic and biogeographic implications.

Note on stratigraphy

The Cretaceous Yezo Supergroup consists of clastic deposits in a forearc basin. The supergroup is widely distributed in the median zone of Hokkaido (Figure 1) and is divided into four groups, the Lower Yezo, Middle Yezo, Upper Yezo and Hakobuchi groups in ascending order (Okada, 1983).

Ikushumbetsu and Miruto areas

The Middle and Upper Yezo groups, ranging from the Albian to Santonian stages, are exposed along the Ikushumbetsu and Horomui rivers and their tributaries. The Middle Yezo Group is subdivided into the lower-lying 'Main Part' (Matsuno *et al.*, 1964) and the Mikasa Formation (Matsumoto, 1951). The former consists of well-bedded sandstone or laminated mudstone with sandstone intercalations. The latter consists mainly of sandstone exhibiting hummocky cross-stratification; it is subdivided into four units, Ta of sandstone, Tb of sandstone to muddy sandstone, Tc of mudstone, and Td of sandstone to muddy sandstone, in ascending order (Matsuno *et al.*, 1964). The Upper Yezo Group consists mainly of sandy mudstone in the lower part and homogenous fine-grained mudstone in the

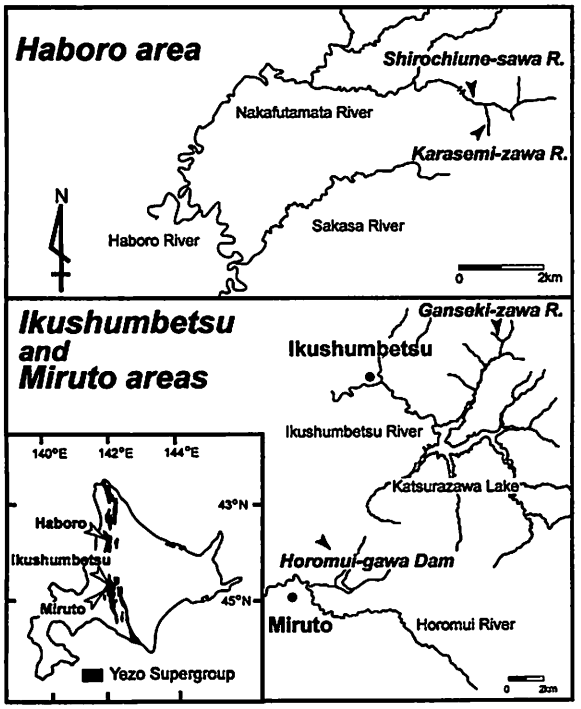

Figure 1. Maps of the Haboro and Ikushumbetsu-Miruto areas showing the localities of the *Hourcquia* species examined.

upper part. The group conformably overlies the Mikasa Formation, although the lithologic boundaries are diachronous (Ando, 1990).

The specimen assigned to *Hourcquia ingens* was obtained from the lower part of the Upper Yezo Group along the Ganseki-zawa, a stream of the Ikushumbetsu River (Figure 1). This part consists mainly of intensively bioturbated sandy mudstone with intercalations of discontinuous sandstone beds, interpreted as distal storm-sheets on the outer shelf. That specimen is associated with *Subprionocyclus minimus* and *Inoceramus teshioensis* (Figure 2), which are diagnostic fossils of the upper part of the upper Turonian (see Toshimitsu *et al.*, 1995).

The specimen assigned to *Hourcquia kawashitai* was found in the unit Td of the Mikasa Formation, composed of muddy bioturbated sandstone of inner-shelf type, near the Horomui-gawa Dam of the Miruto area. Ando (1990) refers the stratigraphic level of the locality to the upper Turonian.

Haboro area

The Middle and Upper Yezo groups, ranging from the middle Turonian to lower Campanian stages, are exposed in the upper reaches of the Haboro River. The Shirochi Formation of the Middle Yezo Group consists of mudstone with intercalations of thin turbidite-sandstone beds (Toshimitsu, 1985). The Upper Yezo Group conformably overlies the Shirochi Formation and consists mainly of mudstone in the lower part and mudstone with intercalations of thin sandstone in the middle part, while the upper part coarsens upward, beginning with mudstone and ending with cross-bedded sandstone (Toshimitsu, 1985).

The specimens determined as *Hourcquia hataii* were extracted from calcareous concretions in float along the Shirochiune-sawa and Karasemi-zawa valleys. The Shirochi Formation of offshore mudstone is distributed in this area and correlated with the *Inoceramus teshioensis* Zone of the upper Turonian (Toshimitsu and Maiya, 1986). Those specimens were found associated with *Subprionocyclus neptuni* and *Inoceramus teshioensis* in the concretions.

Repository of specimens.—The specimens described and figured herein are reposited in the National Science Museum, Tokyo with prefix of NSM PM and in the Institute of Geoscience, University of Tsukuba (formerly the Institute of Geology and Mineralogy, Tokyo University of Education) with prefix of TKU.

Abbreviations.—D = shell diameter; NSM PCL = National Science Museum, Paleontological Collection Locality.

Systematic descriptions

Superfamily Acanthoceratoidea Grossouvre, 1894
Family Pseudotissotiidae Hyatt, 1903
Subfamily Hourcquiinae Renz, 1982
Genus ***Hourcquia*** Collignon, 1965

Type species.— Hourcquia mirabilis Collignon, 1965.

Hourcquia ingens Collignon, 1965

Figures 3a-d, 4, 5

Hourcquia ingens Collignon, 1965, p. 80, pl. 412, figs. 1704-1706, pl. 413, fig. 1708; Matsumoto and Obata, 1982, p. 79, pl. 4, fig. 2a-c.

Hourcquia ingens var. *antsakoazatensis* Collignon, 1965, p. 82, pl. 413, figs. 1707, 1710.

Type.—Holotype is the original of Collignon (1965, p. 80, pl. 412, fig. 1704), from the Masiaposa area, Madagascar.

Material.—One specimen, NSM PM16159. Shell moderately large, 110 mm in D at preserved last septum, and consists of only phragmocone.

Locality. —NSM PCL 4-15-3 [= Loc. 319 in Futakami (1986)]: a cliff along Ganseki-zawa, a tributary of the Kamiichino-sawa River in the Ikushumbetsu area, Hokkaido (Figure 1).

Description.—Coiling moderately involute, with fairly narrow and deep umbilicus, rounded umbilical shoulder, and gently convex to nearly vertical umbilical wall. Shell surface ornamented, more distinctively on inner whorls, with prorsiradiate ribs tuberculated at umbilical and ventrolateral shoulders, springing in pairs from umbilical tubercles and intercalated shorter ones. Whorl cross-section subtrapezoidal on inner whorls and subtriangular on outer preserved whorl, with maximum breadth at umbilical tubercles; rounded keel on fastigate venter, obtuse ventrolateral shoulder. Lateral lobe of suture line asymmetrically divided and deeply incised (Figure 5).

Comparison. — The immature shell described as *Hourcquia ingens* by Matsumoto and Obata (1982, pl. 4, fig. 2a-c) from Hokkaido is more involute than our specimen

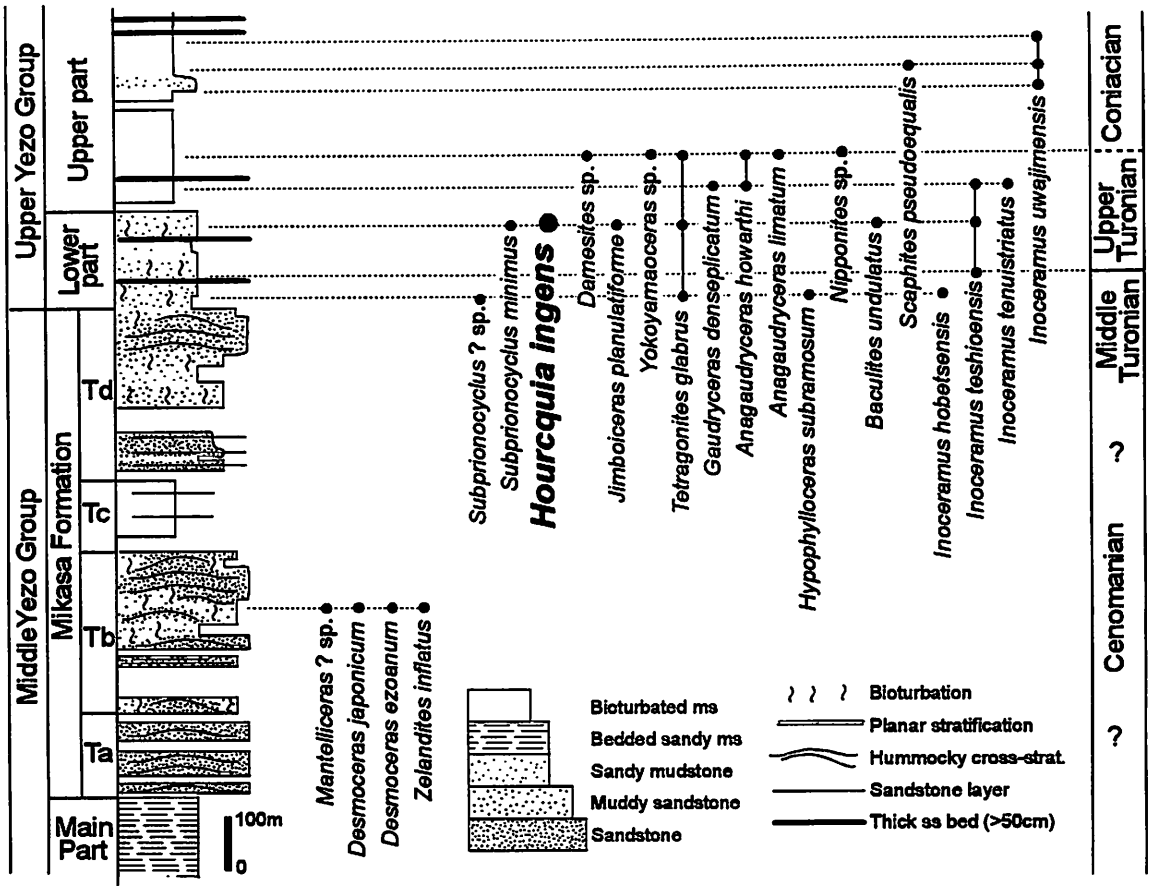

Figure 2. Columnar section and stratigraphic distribution of ammonoids and inoceramids along the Ganseki-zawa Valley, Ikushumbetsu. *Hourcquia ingens* Collignon occurs from the lower part of the Upper Yezo Group, in association with *Subprionocyclus minimus* (Hayasaka and Fukada), an index ammonite of the uppermost part of the upper Turonian in Japan.

NSM PM16159. The specimens from Madagascar display wide variation in the width of the umbilicus during the immature growth-stage (Collignon, 1965, figs. 1705, 1706, 1708, 1710). Both specimens from Japan are included in the range of variation for the species.

Hourcqia ingens closely resembles *Hourcquia moralesi* Renz (1982, p. 104, pl. 34, fig. 2) from the upper Turonian of Venezuela in having a subtriangular whorl section and bifurcated, intercalated and projected ribs. The latter is, however, distinguished from the former in retaining the ornamentation until a late growth-stage.

Occurrence.—Upper Turonian, *Coilopoceras requieni-Romaniceras deveriai* Zone in Madagascar. Upper part of the upper Turonian, *Subprionocyclus minimus* Subzone of *Inoceramus teshioensis* Zone in Hokkaido, Japan.

Hourcquia hataii Hashimoto, 1973

Figure 6a–j, 7, 8

Hourquia hataii Hashimoto, 1973, p. 316, pl. 35, text-fig. 2.

Type.—Holotype (TKU30492), by monotypy, is the specimen figured by Hashimoto (1973, pl. 35) from the Nigorikawa River (Loc. 6373114p) in the Teshio area, northern Hokkaido.

Material.—Two specimens extracted from calcareous concretions in float along the Shirochiune-sawa Valley and its small tributary, the Karasemi-zawa Valley, in the Haboro area, Hokkaido are used in the following description: NSM PM16161, from the same place as Loc. RH2096 in Toshimitsu (1985), consists mainly of phragmocone of 70 mm in D at depressed apertual part; NSM PM16162, from the lower course of the Karasemi-zawa Valley, 30 mm in D at compressed apertual part.

Description.—Shell displays large ontogenetic variation (Figures 6a–j). In initial growth-stage (D < 5 mm), shells involute with depressed whorl section. Immature (5 < D < 50 mm), shells evolute with, firstly, compressed whorl section and less ornamentation on shell surface, and, later, subtrapezoidal whorl section, rounded keel, bifurcated and intercalated ribs, and ventral and umbilical bullae. At later growth-stage (D > 50 mm), shell involute with steep umbilical wall; whorl cross-section then subtrapezoidal with strong ventrolateral and umbilical tubercles and rounded broad keel.

Initial chamber elliptical in median section (Figure 7),

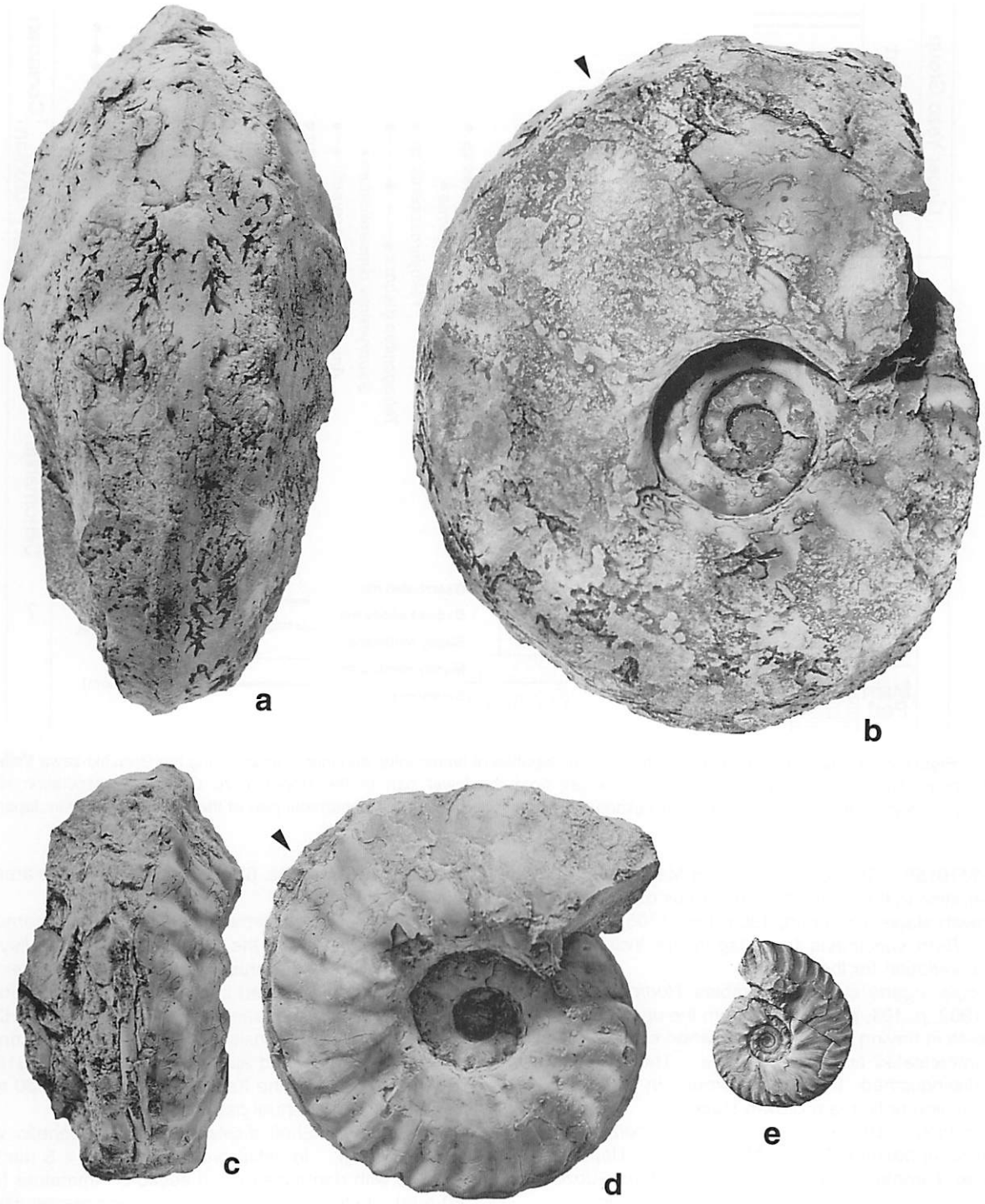

Figure 3. **a–d.** *Hourcquia ingens* Collignon, NSM PM16159, from NSM PCL 4–15–3 [= the locality 319 in Futakami (1986)], Ikushumbetsu, ×1.0. **c, d.** Inner whorls of a and b. Note the change of shell shape and ornamentation through growth. Dimensions for each growth-stage observed at the solid arrows. b; D (shell-diameter) = 104.0 mm, U (umbilical-diameter) = 25.1 mm, B (whorl-breadth) = 53.6 mm, H (whorl-height) = 47.5 mm; d; D = 65.5mm, U = 16.8 mm, H = 27.0 mm. **e.** *Subprinocyclus minimus* (Hayasaka and Fukada), NSM PM16163, from NSM PCL 4–15–3, Ikushumbetsu, ×1.2.

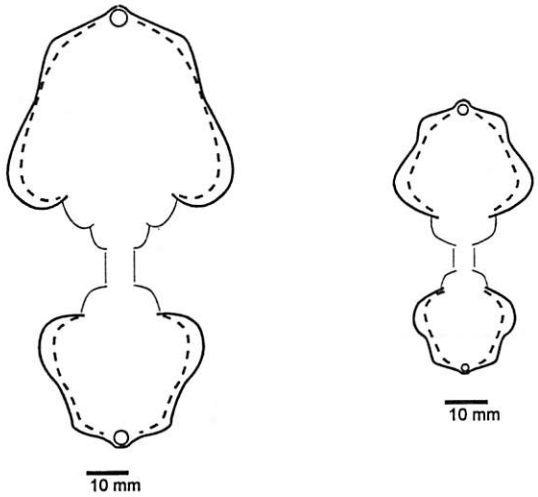

Figure 4. Median cross sections of *Hourcquia ingens* Collignon, NSM PM16159 showing the ontogenetic change of whorl-shape (right to left). The dashed line shows the intercostal whorl cross-section.

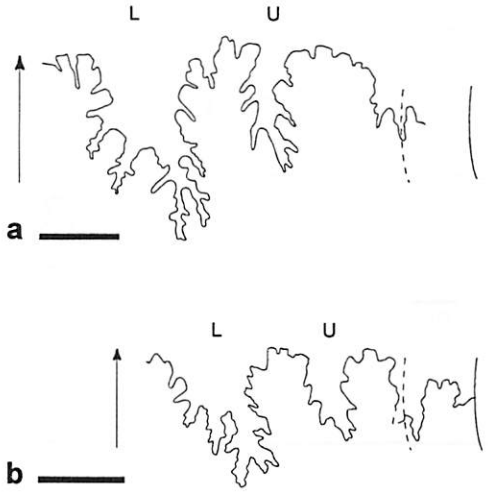

Figure 5. Suture line of *Hourcquia ingens* Collignon, NSM PM16159. **a.** Whorl-height = 24.4 mm. **b.** Whorl-height = 21.3 mm. Scale bars = 5.0 mm. L; lateral lobe, U; umbilical lobe.

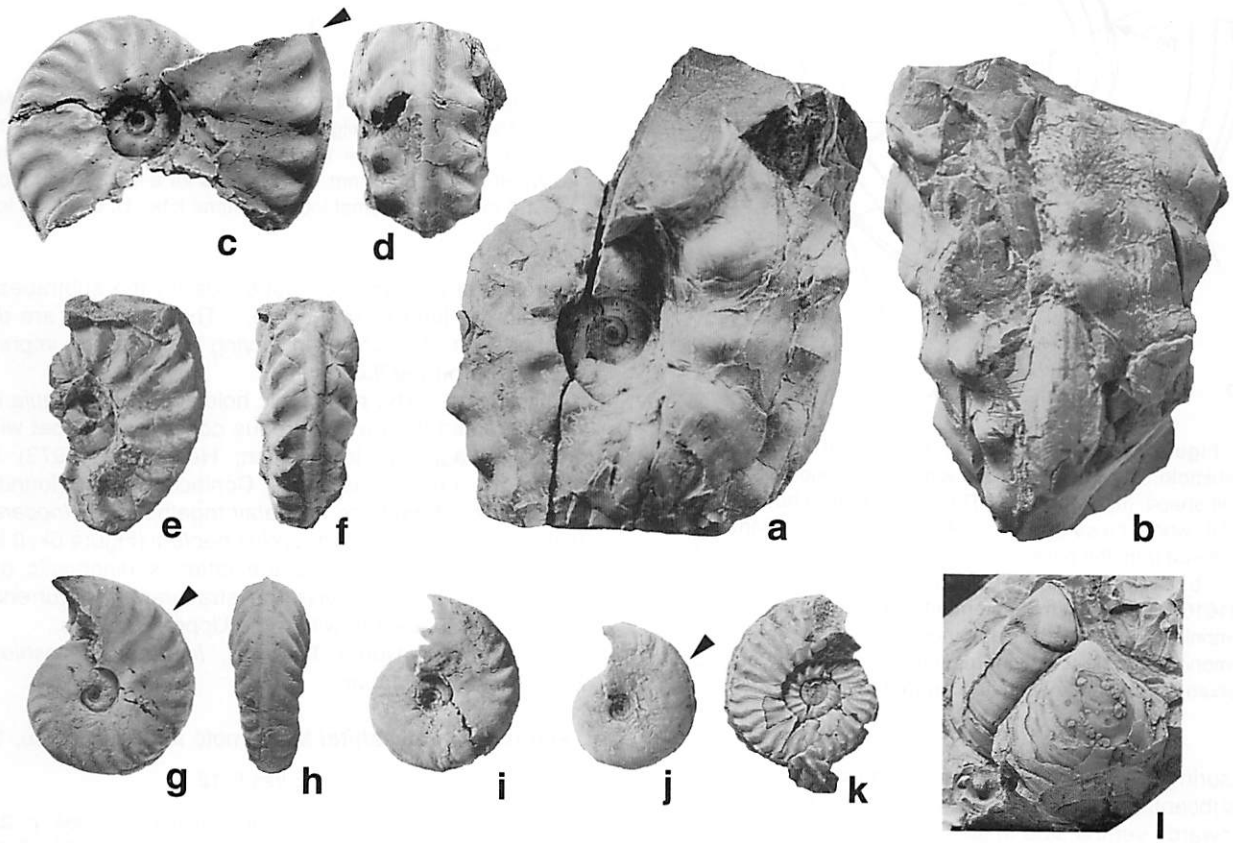

Figure 6. **a–j.** *Hourcquia hataii* Hashimoto. **a, b.** NSM PM16161, from the Shirochiune-sawa River, ×1.0. **c, d.** Inner whorls of a and b [NSM PM16161], ×1.0. **e, f.** NSM PM16162, from the Karasemi-zawa River, ×1.0. **g, h.** Inner whorls of a and b [NSM PM16161], ×1.0. **i, j.** Inner whorls of a and b [NSM PM16161], ×1.2. Note the change of shell-shape and ornamentation throughout growth. Dimensions for each growth-stage observed at the solid arrows. c; D = 43.0 mm, U = 8.5 mm, B = 20.2 mm, H = 20.2 mm: g; D = 23.4 mm, U = 5.7 mm, B = 9.2 mm, H = 10.6 mm: j; D = 12.7 mm, U = 2.7 mm, B = 5.8 mm, H = 6.0 mm. **k.** *Subprionocyclus neptuni* (Geinitz), NSM PM16164, associated with NSM PM16162, ×1.2. **l.** *Inoceramus teshioensis* Nagao and Matsumoto, NSM PM16165, associated with NSM PM16161, ×1.2.

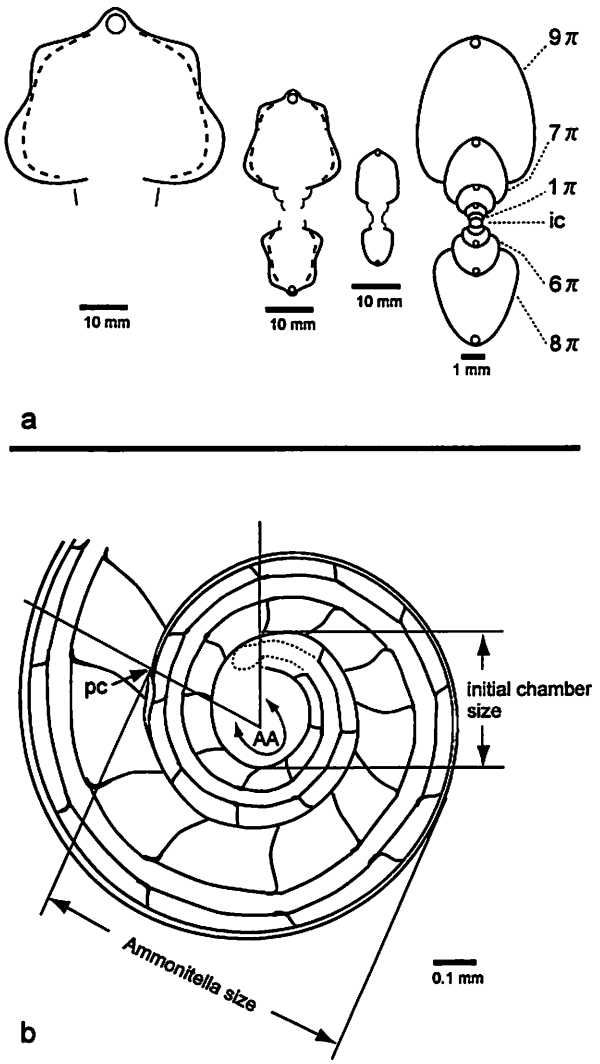

Figure 7. **a.** Median cross sections of *Hourcquia hataii* Hashimoto, NSM PM16161 showing the ontogenetic change in whorl-shape (right to left). The dashed line shows the intercostal whorl cross-section. Angles for whorl-diameter are measured from the base of the caecum (see b). ic; initial chamber. **b.** Early internal shell structure of *Hourcquia hataii*, NSM PM16161 showing measurements of initial chamber size, ammonitella size, and ammnonitella angle (AA). The ammonitella angle is defined as the angle from the base of the caecum to the primary constriction (pc).

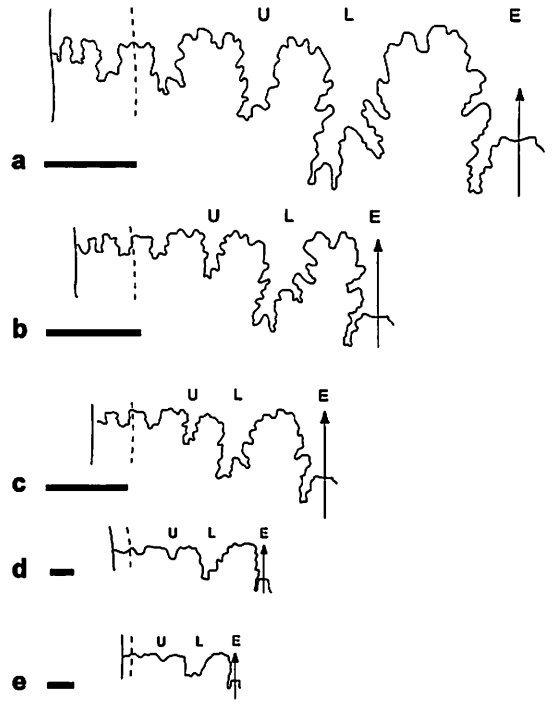

Figure 8. Suture line of *Hourcquia hataii* Hashimoto, NSM PM16161. **a.** Whorl-height = 20.5 mm. **b.** Whorl-height = 14.1 mm. **c.** Whorl-height = 10.3 mm. **d.** Whorl-height = 5.7 mm. **e.** Whorl-height = 4.0 mm. Scale bars for a–c = 5.0 mm, for d, e = 1.0 mm. E; external lobe, L; lateral lobe, U; umbilical lobe.

measuring 0.46 mm in diameter. Siphuncular tube occupying subcentral position in first whorl and subsequently moving towards ventral side in second whorl. Ammonitella size and angle in median section 0.78 mm and 303° respectively. Lateral lobe of suture line asymmetrically divided and deeply incised (Figure 8).

Comparison. — *Hourcquia hataii* closely resembles *Hourcquia mirabilis* from Madagascar (Collignon 1965, p. 77, fig. 1703) and *H. krausei*, monotypic, from Venezuela (Renz 1982, p. 104, pl. 34, fig. 1) in respect of the strong ventrolateral and umbilical tubercles on the subtrapezoidal whorl in the later growth-stage. The latter two are distinguished from the former in having a concavely impressed spiral band on the flank.

Discussion.—The monotypic holotype of *Hourcquia hataii* was extracted from a calcareous concretion in float without any age-diagnostic information; Hashimoto (1973) interpreted the horizon as being Coniacian. We found two specimens referable to *H. hataii* together with *Inoceramus teshioensis* and *Subprionocyclus neptuni* (Figure 6k, l) in the same concretions. Since the latter is diagnostic of the Upper Turonian, we revise the stratigraphic occurrence of the present species to within the Upper Turonian.

Occurrence.—Upper Turonian, *Inoceramus teshioensis* Zone, Hokkaido, Japan.

Hourcquia kawashitai Matsumoto and Toshimitsu, 1984

Figures 9-12

Hourquia kawashitai Matsumoto and Toshimitsu, 1984, p. 233, pl. 32, figs. 1, 2; pl. 33, figs. 1-3; pl. 34, fig. 2, text-figs. 2, 3.

Type. — Holotype, YKC.57 - 6 - 20 - E, Y. Kawashita's Collection, is the original of Matsumoto and Toshimitsu (1984, pl. 32, fig. 1), from the Karasemi-zawa Valley in the Haboro area, northwestern Hokkaido (Figure 1).

Material.—One specimen, NSM PM16160. Immature

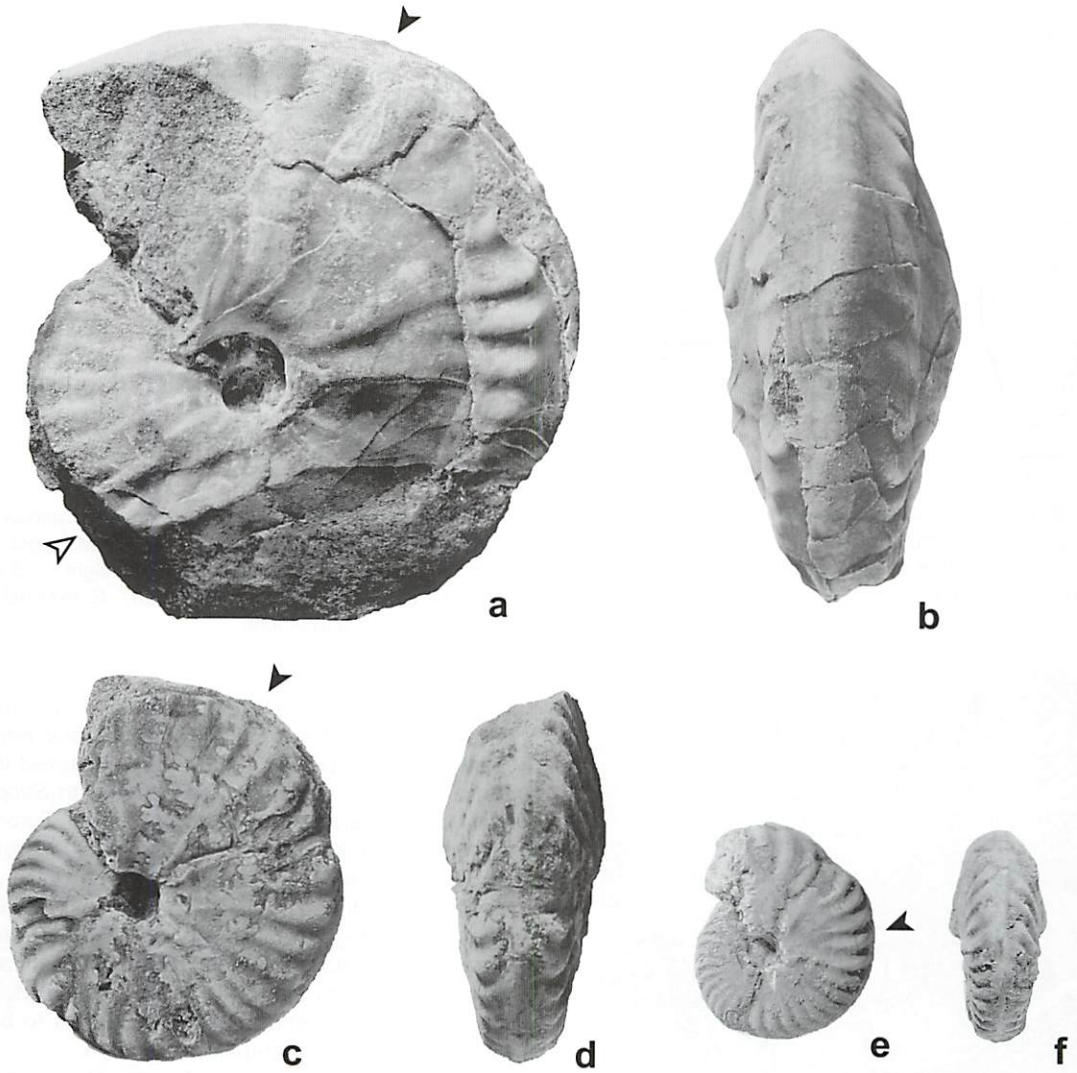

Figure 9. *Hourcquia kawashitai* Matsumoto and Toshimitsu, NSM PM16160, from NSM PCL 4-14-15, Miruto, ×1.0. **c-f.** Inner whorls of a and b. Dimensions for each growth stage observed at the solid arrows. a; D = 81.3 mm, U = 9.2 mm, B = 28.5 mm, H = 40.5 mm: c; D = 49.7 mm, U = 4.9 mm, B = 19.0 mm, H = 25.0 mm: e; D = 25.1 mm, U = 2.9 mm, B = 9.8 mm, H = 13.1 mm. The white arrow shows the location of the last suture-line.

shell, 82 mm in D, and consists of phragmocone and long body chamber occupying about 270° in spiral length, without complete aperture.

Locality.—NSM PCL 4-14-15: a cliff about 2 km north of the Horomui-gawa Dam in the Miruto area, Hokkaido (Figure 1).

Description.—Coiling very involute, with narrow and deep umbilicus, rounded umbilical shoulder and nearly vertical umbilical wall. Shell surface ornamented with prorsiradiate ribs tuberculated at umbilical and ventrolateral shoulders, springing in pairs from umbilical tubercles and with intercalated shorter ones. Ribs weaker on flank. Whorl cross-section high subtrigonal with maximum breadth at umbilical tubercles, rounded keel on roof-shaped venter, obtuse ventrolateral shoulder.

Initial chamber elliptical in median section, measuring 0.42 mm in diameter. Caecum subelliptical in lateral view (Figure 11). Prosiphon not preserved. Siphuncular tube occupies subcentral position in first whorl and gradually moves toward ventral side in second whorl. Ammonitella size and angle in median section, 0.89 mm and 310°, respectively. Lateral lobe of suture line asymmetrically divided and deeply incised (Figure 12).

Comparison.—Although the specimen NSM PM16159 is an immature shell, the shape and ornament are essentially the same as those of the inner whorl of *Hourcquia kawashitai* (Matsumoto and Toshimitsu, 1984; pl.32, fig.2).

Occurrence.—Upper Turonian, *Inoceramus teshioensis*

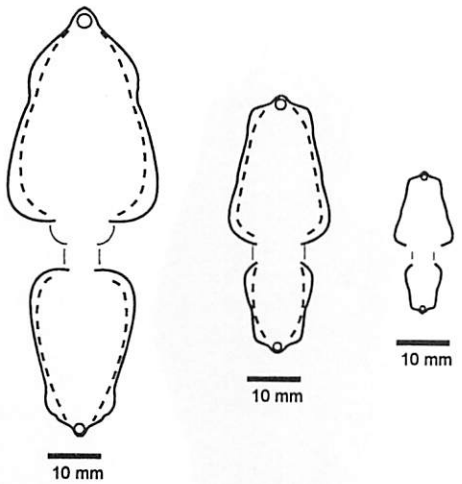

Figure 10. Median cross sections of *Hourcquia kawashitai* Matsumoto and Toshimitsu, NSM PM16160 showing the ontogenetic change in whorl-shape (right to left). The dashed line shows the intercostal whorl cross-section.

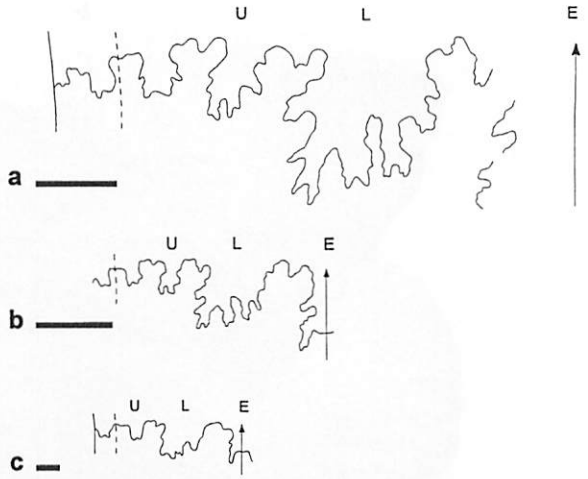

Figure 12. Suture line of *Hourcquia kawashitai* Matsumoto and Toshimitsu, NSM PM16160. **a.** Whorl height = 28.6 mm. **b.** Whorl height = 14.0 mm. **c.** Whorl height = 9.3 mm. Scale bars for a, b = 5.0 mm, for c = 1.0 mm. E; external lobe, L; lateral lobe, U; umbilical lobe.

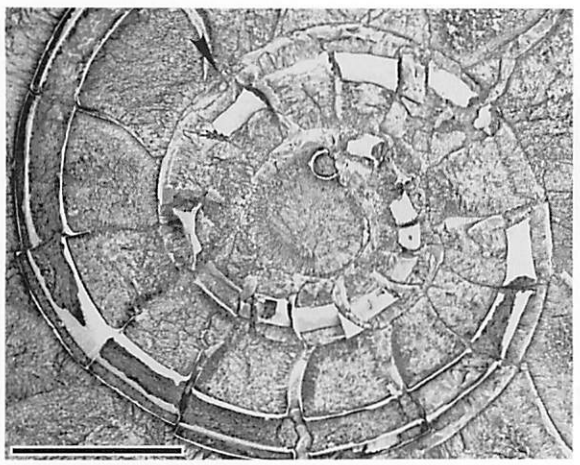

Figure 11. SEM micrograph of the early internal shell structure of *Hourcquia kawashitai* Matsumoto and Toshimitsu, NSM PM16160, in median section. The arrow shows the primary constriction. Scale bar = 0.5 mm. See Figure 7-B for measurements of initial chamber size, ammonitella size, and ammnonitella angle.

Zone in Hokkaido, Japan.

Discussion

Five species of *Hourcuia*, *H. mirabilis*, *H. ingens*, *H. pacifica*, *H. hatai* and *H. kawashitai*, have been described up to now from the Cretaceous of Hokkaido and Sakhalin. Almost all species were not collected *in situ* but from calcareous concretions in float without specific stratigraphic evidence. Previous authors thought that the biostratigraphic horizon of *H. hataii* was the Coniacian, that of *H. pacifica* was the upper Turonian to Coniacian, and that of the other three species was the upper Turonian. In this paper, we have determined the precise biostratigraphic horizons of the following three species. *H. ingens* occurred in the upper part of the upper Turonian associated with *Subprionocyclus minimus*, *H. hataii* occurred in the Upper Turonian with *S. neptuni*, and *H. kawashitai* was also obtained from the upper Turonian. In the Tethyan and adjacent regions, *Hourcquia* radiated only during the late Turonian; *H. mirabilis* and *H. ingens* in Madagascar (Collignon, 1965), *H. krausi* and *H. moralesi* in Venezuela (Renz, 1982), *H.* cf. *mirabilis* in New Mexico and Trans-Pecos Texas (Anonymous, 1981). In consequence the genus *Hourcquia* seems to be useful for inter-regional biostratigraphic correlation.

In Hokkaido and Sakhalin, it is generally considered that the ammonoid fauna is characteristic of the North Pacific bio-province, different from both the Tethyan and Boreal provinces, during the post-Albian. However, the occurrence of *Hourcquia* species in the Yezo Supergroup, including two pandemic ones, *H. mirabilis* and *H. ingens* and three endemic ones, *H. pacifica*, *H. hataii*, and *H. kawashitai*, demonstrates that this genus evolved and radiated in not only the Tethyan and adjacent regions but also possibly in the northwest Pacific region for a short period in the late Turonian. In a similar manner, the Tethyan vascoceratids entered into the Yezo forearc basin for a short period in the early Turonian (Matsumoto, 1973; Matsumoto, 1978; Matsumoto and Muramoto, 1978). The oxygen isotope evidence suggests two cycles of rapid warming during earliest Turonian and middle to late Turonian time (Jenkyns *et al.*, 1994; Clarke and Jenkyns, 1999). The extended distributions of *Hourcquia* and vascoceratids seem to have been influenced by episodic global climatic optimums.

Acknowledgments

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