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SHORT NOTES

Permian orthoconic cephalopods of the Ochiai Formation in the Southern Kitakami Mountains, Northeast Japan

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Introduction and geologic setting

Middle to Upper Permian strata in the Southern Kitakami Mountains, Northeast Japan, contain a relatively diverse orthoconic cephalopod assemblage. Although they were the subject of investigations by Hayasaka (1924), Shimizu and Obata (1936), Ouchi (1971) and Koizumi (1975), information from the Southern Kitakami Mountains has been ignored in modern cephalopod taxonomy owing to a lack of adequate illustrations and descriptions. Knowledge of Middle to Late Permian orthoconic cephalopods is very limited and comes mainly from the Peri-Gondwana region that includes Iran (e.g., Teichert and Kummel, 1973), Oman (Niko *et al.*, 1996), the Salt Range (Waagen, 1879), Timor (Haniel, 1915), and the South China region (e.g., Zhao *et al.*, 1978). Revision of the Kitakami fauna, therefore, may be of phylogenetic and paleobiogeographic importance. In view of this, the present study focuses on orthocerid species from the Kamiyasse area, Miyagi Prefecture, and an adjoining area to the north in Iwate Prefecture (Figure 1). The repository for these specimens is the University Museum of the University of Tokyo (UMUT).

In an earlier geologic study, Tazawa (1973) investigated the Kamiyasse area, and elucidated the detailed lithostratigraphy of the Permian deposits as the Sakamotozawa, Kanokura and Toyoma series. With the exception of the lowest, carbonate-rich strata assigned to the Nakadaira Formation, most of these series were synthesized and assigned in the subsequent works of Ehiro (1974, 1977) to the Ochiai Formation (Onuki, 1969), from which the present cephalopod specimens were collected. The Ochiai Formation is divisible into three members: the Toyazawa Member (Ehiro, 1977), consisting of sandstone interbedded with calcareous shale and impure limestone layers, represents the middle part of the formation, whereas the unnamed lower and upper members are mainly massive shale with minor amounts of conglomerate, sandstone and limestone.

Systematic paleontology

Order Orthocerida Kuhn, 1940
Superfamily Orthoceratoidea M'Coy, 1844
Family Brachycycloceratidae Furnish, Glenister and Hansman, 1962
Genus ***Brachycycloceras*** Miller, Dunbar and Condra, 1933

Type species. — *Brachycycloceras normale* Miller, Dunbar and Condra, 1933.

Brachycycloceras sp.

Figure 2.1, 2.2

Description.—Single, deformed orthocone, 56 mm in length, consisting of annulated, apical phragmocone with gently curved (exogastric?) apical shell; shell expansion rapid for orthoceratids. Prominent annulations form rounded to bluntly pointed crests and deep interspaces that appear as rounded concavities in longitudinal profile; annulations quite oblique, slope toward dorsal (?) side. Except for weak dorsal (?) sinus, sutures run roughly parallel to annulations.

Discussion.—No siphuncular structure is preserved in this specimen. However, its rapidly expanded shell with

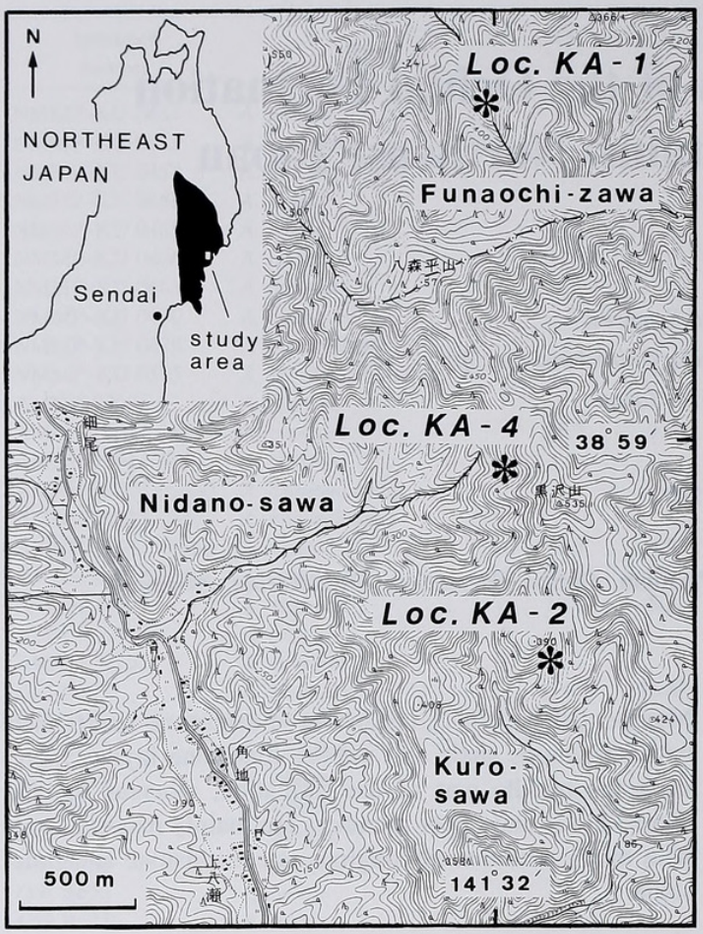

Figure 1. Index map of fossil localities in the Southern Kitakami Mountains (inset), using the 1:25,000 map of "Shishiori" published by the Geographical Survey Institution.

gently curved apical part and strongly prominent annulations warrant generic assignment to *Brachycycloceras*. In addition to *Brachycycloceras* sp. from the Early Permian of western Australia (Teichert, 1951) and *B. rustaqense* Niko, Pillevuit and Nishida, 1996, from the Wordian (Middle Permian in a three-fold division) of the central Oman Mountains, this discovery represents the third Permian occurrence of the genus.

Material examined and occurrence.—UMUT PM 28065. This specimen was recovered as float from shale in the Funaochi-zawa Valley at locality KA-1 (Figure 1). Judging from the lithofacies of the matrix, the geology around this locality, and the associated ammonoid fauna, it was probably derived from the middle–upper portion (Roadian–Wordian; Middle Permian) of the lower member of the Ochiai Formation.

Family Geisonoceratidae Zhuravleva, 1959
cf. Geisonoceratid, genus and species uncertain

Figure 2.4, 2.7

Discussion.—A deformed body chamber of an orthoconic shell, 115 mm in length, is available for this study. This specimen is tentatively considered to be a geisonoceratid, because of the characteristic ornamentation of its transverse ridges that indicates asymmetrical (steep side towards aperture) longitudinal profiles, and because of the absence of a shell constriction. Similar ornamentation is also known to occur in some Carboniferous bactritoids, such as *Ctenobactrites isogramma* (Meek, 1871; Sturgeon *et al.*, 1997, pl. 1-1, figs. 8–11, pl. 1-42, fig. 3) and *Bactrites peytonensis* Mapes (1979, pl. 8, figs. 7, 11), although characteristic dorsal carina and/or well-developed wrinkle-layer of ornamented bactritoids are not recognized in this specimen.

Material examined and occurrence.—UMUT PM 28066. This specimen was recovered as float in talus deposits of shale located on a tributary of the Kuro-sawa Valley (locality KA-2), where the upper member is exclusively distributed. Based on ammonoids collected near this locality, Ehiro and Araki (1997) inferred a late Capitanian (Middle Permian) age for the cephalopod-bearing shale of the lower part of the upper member of the Ochiai Formation.

Superfamily Pseudorthoceratoidea Flower and Caster, 1935
Family Pseudorthoceratidae Flower and Caster, 1935
Subfamily Spyroceratinae Shimizu and Obata, 1935
Genus ***Lopingoceras*** Shimanskiy in Ruzhentsev, 1962

Type species.—*Orthoceras lopingense* Stoyanow, 1909.

Other included species.—*Lopingoceras acutanolatum* Zhao, Liang and Zheng, 1978; *L.* cf. *acutanolatum* (this report); *L. bicinctum* (Abich, 1878); *L. cyclophorum* (Waagen, 1879); *L. guangdeense* Zhao, Liang and Zheng, 1978; *L. hayasakai* Niko and Ozawa, 1997; *L. margaritatum* (Abich, 1878); *L. maubesiense* (Haniel, 1915); *L.* ? *obliqueannulatum* (Waagen, 1879); *L.* sp. (Teichert *et al.*, 1973), and *L.* sp. (Zheng, 1984).

Range.—Known from the late Gzhelian (Late Carboniferous)–early Asselian (Early Permian) boundary through the Changhsingian (Late Permian).

Diagnosis.—Early juvenile shell gently curved, nonannulated with transverse surface lirae. See Shimanskiy in Ruzhentsev (1962, p. 90) for diagnosis of adult shell, which we accept.

Discussion.—The distinction between *Lopingoceras* and the Early Carboniferous genus *Cycloceras* (M'Coy, 1844; type and only reliably included species, *Orthoceras laevigatum* M'Coy, 1844, see Histon, 1991, and BZN 50, 1993, opinion 1720) has long been plagued by an inadequate description of the latter's type species. Except for differences in age range, the former differs from the latter only in the shape of annulations, i.e., *Cycloceras* having

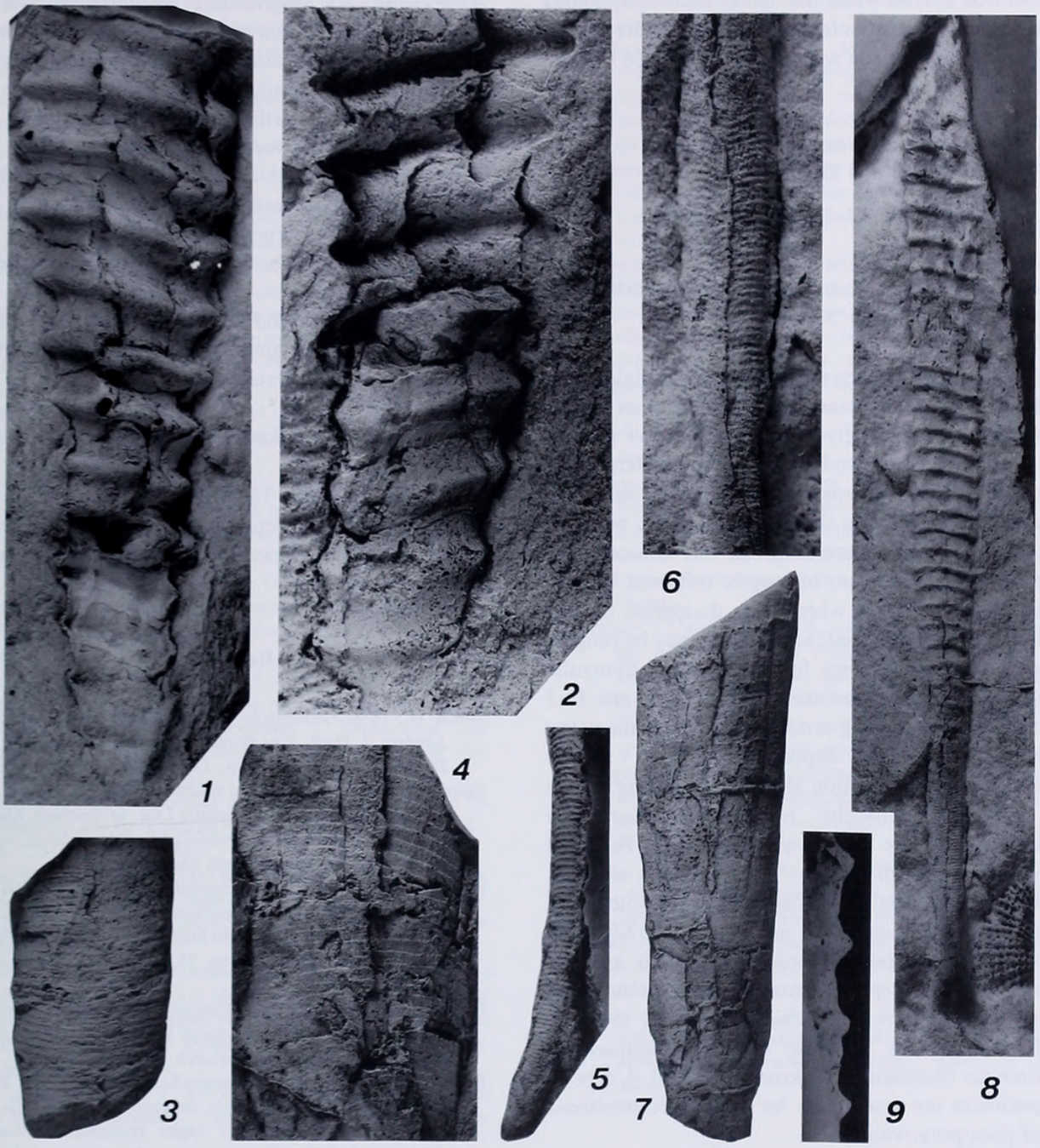

Figure 2. **1**, **2**. *Brachycycloceras* sp., UMUT PM 23065. **1**, lateral view of silicone rubber cast, venter on left (?), ×2; **2**, external mold with steinkern of apical shell, note gently curved shell and sutures, venter on right (?), ×3. **3**. Orthocerid, superfamily, family, genus and species uncertain, UMUT PM 28068, side view, ×2. **4**, **7**. Cf. geisonoceratid, genus and species uncertain, UMUT PM 28066. **4**, details of surface ornamentation, silicone rubber cast, ×2; **7**, steinkern, side view, ×1. **5**, **6**, **8**, **9**. *Lopingoceras* cf. *acutanolatum* Zhao, Liang and Zheng, 1978, UMUT PM 28067, silicone rubber cast. **5**, details of early juvenile shell, ×4; **6**, details of ornamentation of nonannulated part, ×5; **8**, side view, ×2; **9**, details of annulations, note triangular longitudinal profiles, ×5.

contiguous annulations with equally rounded crests and interspaces, whereas in *Lopingoceras* the annulations are more or less distant in spacing and have triangular profiles. Whether these external differences are of supraspecific rank seems questionable in modern taxonomy. The Kitakami material described herein includes the first known example of an early juvenile shell of *Lopingoceras*, whose characters add to the generic concept. The taxonomic

problem will be solved when the apical shell morphology and internal structure of *Cycloceras laevigatum* are known well enough for comparison with the newly refined diagnosis of *Lopingoceras*.

Lopingoceras cf. ***acutanolatum*** Zhao, Liang and Zheng, 1978

Figure 2.5, 2.6, 2.8, 2.9

Compare with.—
Lopingoceras acutanolatum Zhao, Liang and Zheng, 1978, p. 63, 64, pl. 31, figs. 11, 12, pl. 33, figs. 3, 4.

Description.—This species represented by a single external mold of gradually expanded shell, 65 mm in length, whose adoral part is strongly deformed, with no internal structure preserved; adoral end attains approximately 4 mm (reconstructed as circular cross section) in shell diameter. Nonannulated early juvenile shell gently curved, with circular cross section and transverse lirae; this nonannulated part, approximately 21.5 mm in length, followed by monotonously annulated shell where lirae disappear; embryonic shell may be cone-shaped; annulations may be roughly transverse with wide spacing for genus, with triangular longitudinal profiles and pointed crests; there are 1–2 annulations in corresponding reconstructed shell diameter; interspaces probably weakly depressed.

Discussion.—The annulation shape and spacing of the present specimen strongly resemble *Lopingoceras acutanolatum* from the Wuchiapingian (Late Permian) Laoshan Shale in South China. Nevertheless, since *L. acutanolatum* is described from fragmentary specimens and its apical shell morphology is unknown, the Kitakami specimen is only provisionally assigned to this species. Comparison between *Lopingoceras* cf. *acutanolatum* and figured specimens from the Ochiai Formation cited as *Lopingoceras* ? sp. by Koizumi (1975) is impossible. Judging from his illustrations (Koizumi, 1975, pl. 4, figs. 4, 5), the specimens are inadequate for systematic treatment because of poor preservation.

Material examined and occurrence.—UMUT PM 28067. This specimen was collected from a float block of shale in the riverbed of the Nidano-sawa Valley at locality KA-4. The exact stratigraphic horizon from which this block was derived is unknown, but it is highly likely that this block came from the middle part of the Toyazawa Member of the Ochiai Formation, based on its lithofacies and collected locality. Thus, this specimen is considered to be of Wordian (or Capitanian) age.

Superfamily, family, genus and species uncertain

Figure 2.3

Discussion.—A fragmentary specimen of a deformed orthoconic shell, 22 mm in length, shows transverse lirae that consist of alternating strongly prominent and less prominent ridges. Similar ornamentation occurs in several post-Carboniferous orthocerid genera; such as the orthoceratid *Trematoceras* (Eichwald, 1851), the geisonoceratid *Pseudotemperoceras* (Stschastlivtseva, 1986), and the pseudorthoceratid *Dolorthoceras* (Miller, 1931). No internal structures are preserved in the present specimen, so it cannot be identified even to the superfamily level.

Material examined and occurrence.—UMUT PM 28068. Same as the specimen above assigned to cf. geisonoceratid, genus and species uncertain.

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