Early Jurassic mollusks from the Kuruma Group around Mt. Kikuishi on the Tsugami Shindō Trail, Itoigawa, Niigata, central Japan

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Abstract

Mt. Kikuishi (1,209 m) is one of the peaks on the Tsugami Shindō Trail. The name was coined in reference to the ammonoids (*Kikuishi*) discovered here by the late Dr. Ken Ono who lead the creation of the trail in the 1960's. The geology on the trail around the Mt. Kikuishi fossil locality has not been studied in detail yet. We carried out geological research and fossil collection on 20 September and 23–24 October in 2021. Careful searching for fossils in the Teradani Formation exposed around the trail made a successful finding of many molluscan fossils including bivalves, gastropods and ammonoids which include *Canavaria* sp. The significance of the occurrence of these molluscan fossils is pointed out.

Keywords: ammonoid, *Canavaria*, Early Jurassic, Kuruma Group, Mt. Kikuishi.

Introduction

The Tsugami Shindō Trail (27 km in total length) runs from the Oyashirazu Cliffs on the coast of the Japan Sea to Fukiage-no-Col, 0.5 km north of Mt. Asahi (2,418 m). Mt. Kikuishi (1,209 m) is one of the peaks on the trail (Fig. 1). The name was coined in reference to the ammonoids (*Kikuishi*) discovered here by the late Dr. Ken Ono who lead the creation of the trail in the 1960's. The ammonoid specimens collected by him are hosted in the Fossa Magna Museum of Itoigawa City (Fig. 2). The year 2021 was the 50th anniversary of the

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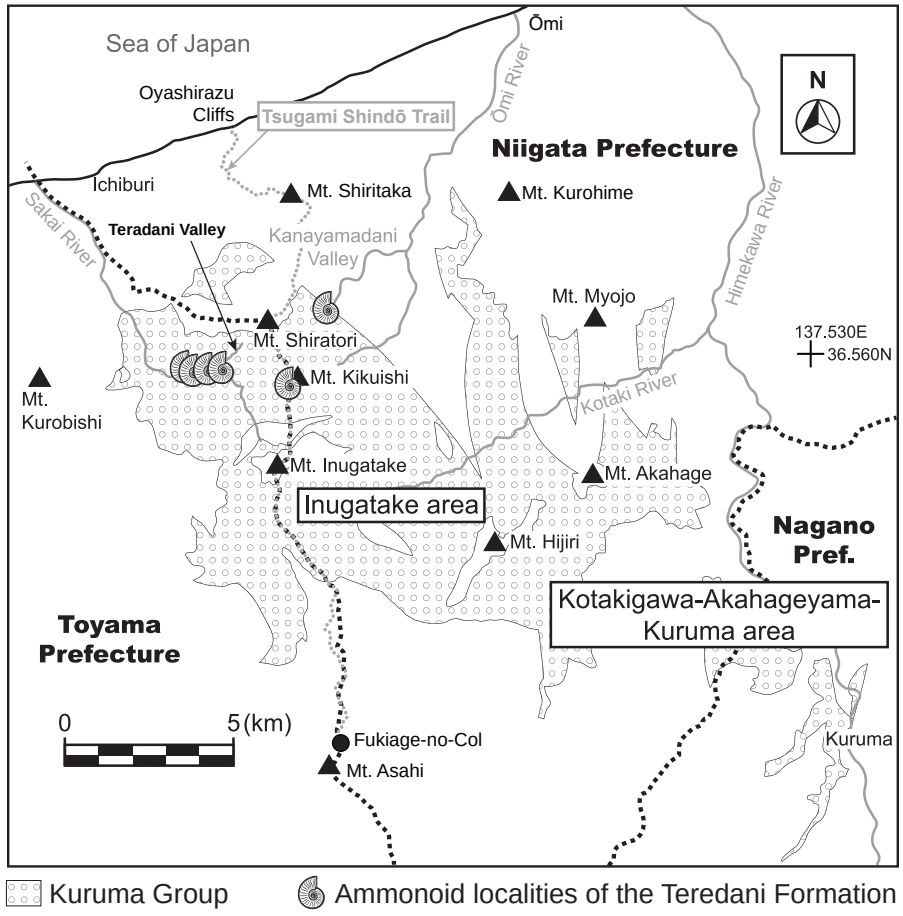

Fig. 1. Index map of the Tsugami Shindō Trail and distribution of the Kuruma Group with ammonoid localities.

opening of the Tsugami Shindō Trail. A commemorative exhibition was held at the museum and the ammonoid specimen (Fig. 2) was presented at the exhibition hall. The ammonoid specimen is believed to come from the Teradani Formation of which the type locality is around the Teradani Valley, 2.5 km west of Mt. Kikuishi (Fig. 1). The Teradani Formation is a shallow marine sequence belonging to the Kuruma Group, a representative of the Lower Jurassic in East Asia.

The year 2021 was another memorable year not only for the trail but also for Jurassic ammonoid and Kuruma Group research. The Pliensbachian ammonoid *Amaltheus orientalis* Nakada, Goto, Meister and Matsuoka was described as a new species from the type locality of the Teradani Formation (Nakada et al., 2021). This new Early Jurassic ammonoid was the first to be recorded in Japan in 50 years since Hirano (1971) described a few new species from the Toyora Group in Yamaguchi Prefecture, southwest Japan. This new ammonoid is the first amaltheid species newly recognized in East Asia. The Kuruma Group is an

Fig. 2. Ammonoid specimen (FMM4868) collected near Mt. Kikuishi by Dr. K. Ono. Scale bar is 1 cm.

important geological entity which includes geochronological and paleobiogeographical significance. The geology around the Mt. Kikuishi fossil locality has not been studied in detail yet. We carried out geological research and fossil collection on 20 September and 23–24 October in 2021 with support of the Tsugami Mountain Organization.

A flash report on our research was presented at the 171st Regular Meeting of the Palaeontological Society of Japan (Matsuoka et al., 2022). This article reports findings from our field research around Mt. Kikuishi and points out the significance of the occurrence of molluscan fossils.

Geological outline of the Kuruma Group

The Kuruma Group comprises Lower Jurassic terrestrial and shallow marine sediments exposed widely in eastern Toyama, western Niigata, and northern Nagano prefectures, central Japan (Fig. 1). The distribution of the group is divided into the Inugatake area in the west and the Kotakigawa-Akahageyama-Kuruma area in the East. The most complete succession is observable in the Inugatake area where the group is subdivided into the Jogodani, Kitamatadani, Negoya, Teradani, Shinatani, Otakidani and Mizukamidani formations in ascending order (Kobayashi et al., 1957) (Fig. 3). Later, the Mizukamidani Formation came to be regarded as a part of the Lower Cretaceous Tetori Group (e.g., Takizawa, 1984; Board of Education of Toyama Prefecture, 2003; Sakai et al., 2012; Takeuchi

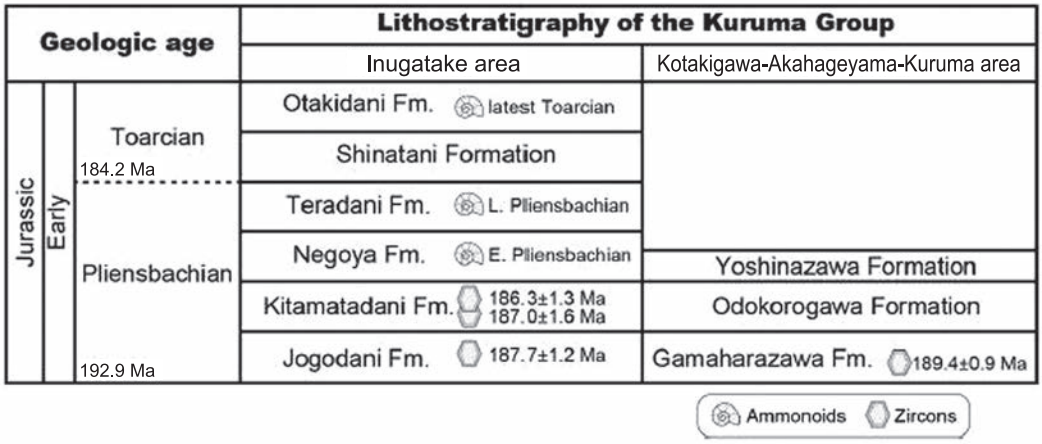

Fig. 3. Lithostratigraphy of the Kuruma Group with major age assignments by ammonoids and zircon U–Pb dating in previous studies. The numerical ages are based on Gradstein et al. (2021). The ammonoid occurrences are from Sato (1956, 1992) and Nakada et al. (2021); the zircon U–Pb age data are from Takeuchi et al. (2017b).

et al., 2017a). In the Kotakigawa-Akahageyama-Kuruma area, the group is subdivided into the Gamaharazawa, Odokorogawa, and Yoshinazawa formations in ascending order (Shiraishi, 1992; Nagamori et al., 2010; Takeuchi et al., 2015) (Fig. 3).

The Kuruma Group consists chiefly of sandstones, mudstones and conglomerates, and is characterized by alternation of marine and non-marine sediments (Kobayashi et al., 1957; Nagamori et al., 2010; Takeuchi et al., 2017a). The group has yielded a variety of fossil taxa including ammonoids (Sato, 1955, 1956, 1992; Nakada et al., 2021), bivalves (Hayami, 1957a, b, c, d, e, 1958a, b, 1962; Goto, 1983; Ibaraki et al., 2017), belemnites (Iba et al., 2015), brachiopods (Hasegawa and Goto, 1990), crinoids (Goto, 1994), turtles (Sonoda et al., 2015), sea reptiles (Tanimoto and Okura, 1989), dinosaur footprints (Hatakeyama, 1995; The Academic Research Group of Dinosaur Fossil Footprints of Otari Village, 2000) and land plants (Yagi, 1918; Oishi, 1931a, b; Kimura and Tsujii, 1980a, b, 1981, 1982, 1983, 1984; Kimura et al., 1988; Terada, 2013; Terada et al., 2017).

Among the above-mentioned fossils, geochronologically important ones are early Pliensbachian ammonoid (*Eoderoceras*) from the Negoya Formation, late Pliensbachian ammonoids (*Amaltheus, Canavaria*) from the Teradani Formation and latest Toarcian ammonoids (*Grammoceras, Hammatoceras*) from the Otakidani Formation (Sato, 1956, 1992). Recently Nakada et al. (2021) clarified the ammonoid succession in three sections in the upper stream area of the Sakaigawa River including the Teradani Valley, the type locality of the Teradani Formation. Zircon U–Pb ages from 186.3 ± 1.3 Ma to 189.4 ± 0.9 Ma, indicating early Pliensbachian in age (Gradstein et al., 2021), were obtained from sandstone, tuffaceous sandstone and vitric tuff in the Jogodani, Kitamatadani and Gamaharazawa formations (Takeuchi et al., 2017b), which are concordant with the age assignments by ammonoids from the Kuruma Group (Fig. 3).

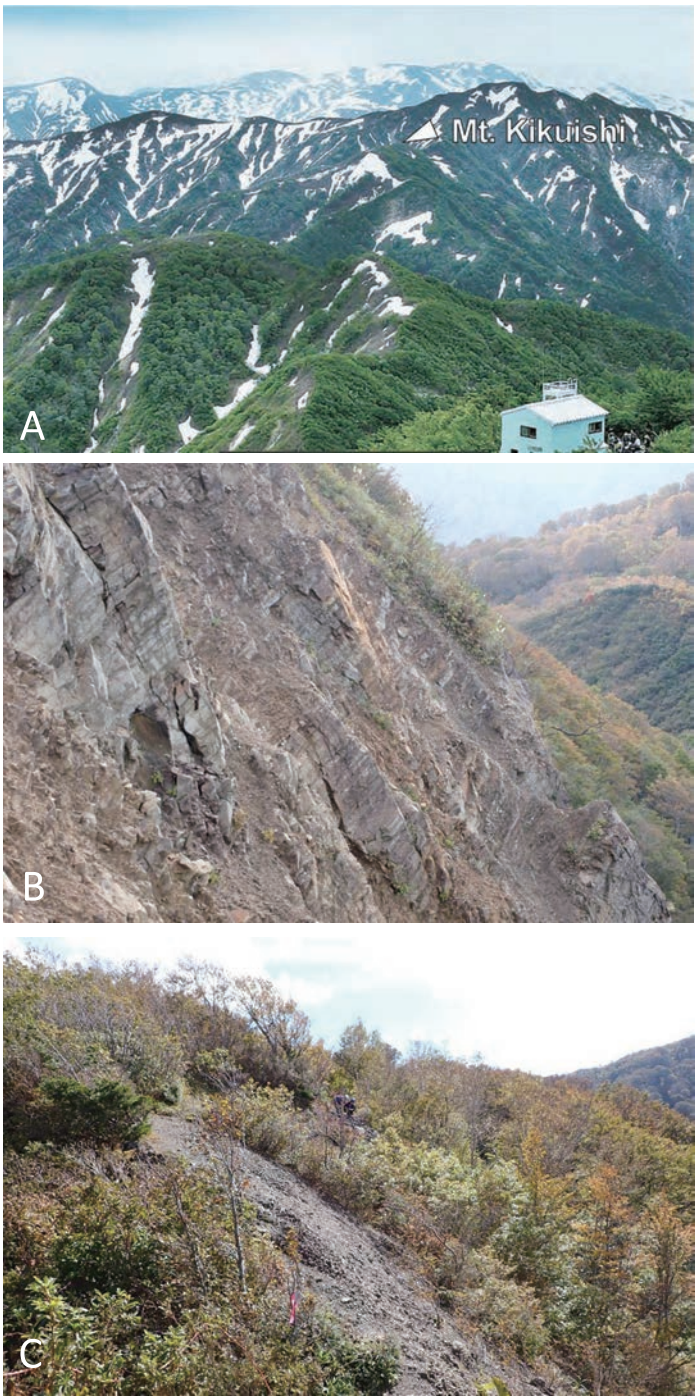

Fig. 4. Landscape and outcrop photographs of the Kuruma Group on the Tsugami Shindō Trail. A: Panoramic view of the Tsugami Shindō Trail from Mt. Shiratori to the south; B: Steep escarpment composed of alternating beds of sandstone and mudstone belonging to the Shinatani Formation of the Kuruma Group, southwest side of Mt. Shimokomagatake; C: Outcrop of the Teradani Formation of the Kuruma Group on the ridgeway of the Tsugami Shindō Trail, north of Mt. Kikuishi.

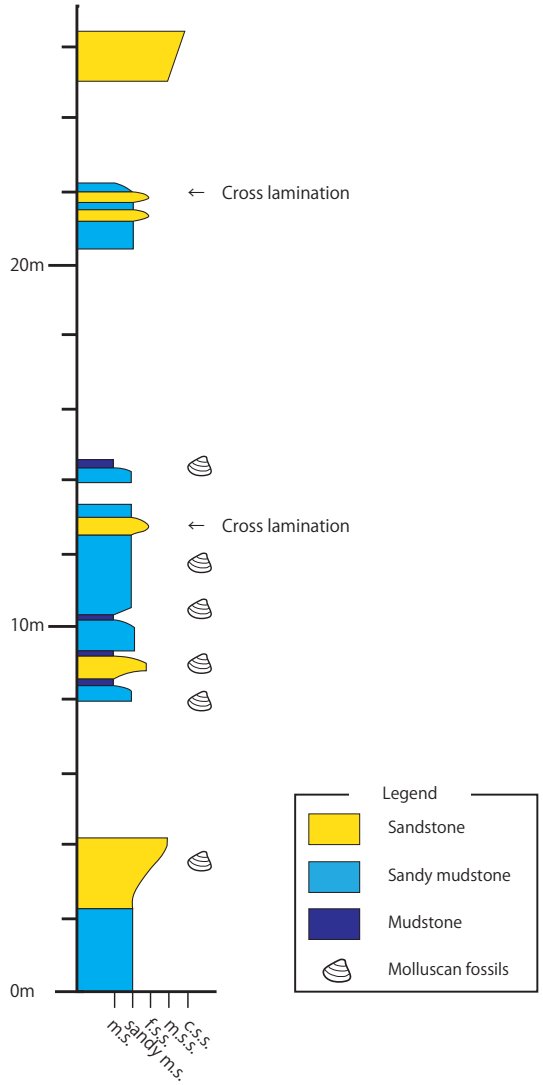

Fig. 5. Columnar section of the Teradani Formation of the Kuruma Group along the ridgeway, including the outcrop shown in Fig. 4-C, north of Mt. Kikuishi.

The Kuruma Group on the Tsugami Shindō Trail and fossil occurrences

The Kuruma Group on the Tsugami Shindō Trail is exposed between Mt. Shiratori and Mt. Inugatake (Fig. 4-A). A steep escarpment (Fig. 4-B) composed of alternating beds of sandstone and mudstone is situated on the southwest side of Mt. Shimokomagatake (1,241 m), located between Mt. Shiratori and Mt. Kikuishi. The alternating beds belong to the Shinatani Formation which conformably overlies the Teradani Formation. The boundary between the Teradani and Shinatani formations is located at a point in the southern slope of

Fig. 6. Molluscan fossils from the Teradani Formation of the Kuruma Group around Mt. Kikuishi on the Tsugami Shindō Trail. A–C: Specimens collected on 20 September in 2021 by S. Tsurumoto (A, B) and S. Ino (C), D–E: Specimens collected on 24 October in 2021 by A. Matsuoka. A: ammonoid, B: bivalve, C: gastropod, D: ammonoids, E: bivalves. Scale bars in A–C are 1 cm.

Mt. Shimokomagatake. Mudstone-dominated beds are sporadically exposed south of the boundary. Better outcrops of the Teradani Formation are exposed on the ridgeway and western slope of the Tsugami Shindō Trail ca. 50 m north of Mt. Kikuishi (Fig. 4-C). A columnar section of the outcrops along the ridgeway is depicted in Fig. 5. Beds in the section are composed mainly of sandy mudstone associated with sandstone and mudstone. Six fossil-bearing horizons are recognized in the stratigraphic section. The majority of fossils found in the outcrops is bivalve.

Fossil findings were performed in the west slope of the ridgeway on 20 September and 24 October in 2021. Careful searching for fossils on floating stones in the slope made a successful finding of many molluscan fossils including bivalves, gastropods and ammonoids (Fig. 6). The most abundant fossils collected are bivalves followed by gastropods. Four specimens of ammonoids have a rather complete shell (Fig. 6-A, D). Some of them are tentatively assigned to *Canavaria* sp., a common genus in the Teradani Formation. The fossil specimens are stored at the Science Museum in the Faculty of Science, Niigata University. They will be registered and hosted at the Fossa Magna Museum after paleontological research.

Concluding remarks

In our 2021 field research we have successfully discovered ammonoid specimens from the Teradani Formation of the Kuruma Group north of Mt. Kikuishi. Some of them can be assigned to *Canavaria* sp. in our preliminary identification. The *Canavaria* assemblage zone is the upper zone among the three successive ammonoid assemblage zones established in the Teradani Formation (Nakada et al., 2021). The exposures that yielded ammonoids obtained in our research can be attributed to the *Canavaria* assemblage zone, corresponding to the latest Pliensbachian. In previous study, some *Amaltheus* ammonoids (*A. stokesi* (Sowerby) and *A. margaritatus* de Montfort) were obtained from Mt. Kikuishi (Sato, 1955; Nakada et al., 2021). Therefore, we expect to discover other zone-diagnostic ammonoid species of the genus *Amaltheus* in future research.

In terms of paleobiogeography, it has been pointed out that the genus *Amaltheus* is a typical Boreal ammonoid while the genus *Canavaria* is a Tethyan one (Sato, 1956, 1992; Kobayashi et al., 1957; Nakada et al., 2021). It is important to elucidate how ammonoid faunas change in a continuous sequence because ammonoids are key taxa to give both geological ages and paleogeographic information. The succession exposed north of Mt. Kikuishi (Fig. 5) has a potential to trace not only ammonoid faunal change but also bivalve and gastropod faunal changes.

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