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Article

Carboniferous and Permian conodont fossils from bedded chert in Otori, Iwaizumi Town, Iwate Prefecture, with a review of previously reported conodonts from the North Kitakami Belt

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MUTO Shun, TAKAHASHI Satoshi and MURAYAMA Masafumi (2025) Carboniferous and Permian conodont fossils from bedded chert in Otori, Iwaizumi Town, Iwate Prefecture, with a review of previously reported conodonts from the North Kitakami Belt. *Bulletin of the Geological Survey of Japan*, vol. 76 (1/2), p. 1–29, 9 figs and 1 table.

Abstract: Conodont biostratigraphy of pelagic deep-sea sequences in the Jurassic accretionary complex of Japan offers a globally correlative timescale for these rare sedimentary records. The northern Kitakami Mountains provide potential for conodont biostratigraphic research of the deep-sea sedimentary rocks, especially for the Paleozoic interval where zonal schemes remain incomplete. Herein, we report conodont fossils from a deep-sea section named the Otori section in Iwaizumi Town, Iwate Prefecture. Conodonts were visualized using microfocus X-ray computed tomography. We identified *Mesogondolella clarki*, *Mesogondolella* aff. *donbassica*, *Mesogondolella* cf. *bisselli*, *Mesogondolella* cf. *idahoensis*, *Jinogondolella* cf. *palmata*, *Jinogondolella postserrata*, *Sweetognathus iranicus*, *Jinogondolella altudaensis* and *Jinogondolella xuanhanensis*. These conodonts indicate the Moscovian (middle Pennsylvanian, Carboniferous) to the Capitanian (upper Guadalupian, Permian). We also compiled and reviewed previous reports of conodont occurrences in the northern Kitakami Mountains. While previous reports have recognized late Carboniferous to Triassic ages based on conodonts, a majority of the Permian ages are not attestable due to the lack of taxonomic descriptions and illustrations.

Keywords: Artinskian, Capitanian, Jurassic accretionary complex, Kado District, Kungurian, North Kitakami–Oshima Belt, Moscovian, Sakmarian, Wordian, X-ray micro-CT

1. Introduction

Conodont fossils played a major role in geological studies of the Jurassic accretionary complexes in Japan. Conodonts, along with radiolarians, provided biostratigraphic evidence that fragments of late Paleozoic and early Mesozoic material formed in the pelagic area of Panthalassa were accreted to the continental margin of proto-Japan during the Jurassic (Matsuda and Isozaki, 1991). Pelagic deep-sea strata in the accretionary complexes are valuable records of the abyssal plain that is now lost (Fig. 1A). Conodonts are used as age indicators in studies of palaeoenvironmental records preserved in the deep-sea strata (Isozaki, 1997; Takahashi *et al.*, 2009; Nishikane *et al.*, 2014; Muto *et al.*, 2020; Tomimatsu *et al.*, 2020; Muto, 2021).

Triassic conodont biostratigraphy of deep-sea sections has been intensely studied mainly in Southwest Japan (Isozaki and Matsuda, 1980; Yao *et al.*, 1980; Tanaka, 1980; Yamashita *et al.*, 2018; Muto *et al.*, 2019). Consequently, conodont biozonation is constructed for most of the Triassic. On the other hand, Paleozoic deep-sea sections are less studied (see Fig. 1B for the loction of study areas mentioned below). Yao *et al.* (2001) described two upper Permian sections corresponding to the upper Wuchiapingian and Changhsingian stages in Gifu and Shiga prefectures. Nishikane *et al.* (2011, 2014) studied the Guadalupian–Lopingian boundary in the Gifu study section of Yao *et al.* (2001). Kusunoki *et al.* (2004) studied a long-ranging section covering the uppermost Carboniferous and entire Permian in Kyoto Prefecture.

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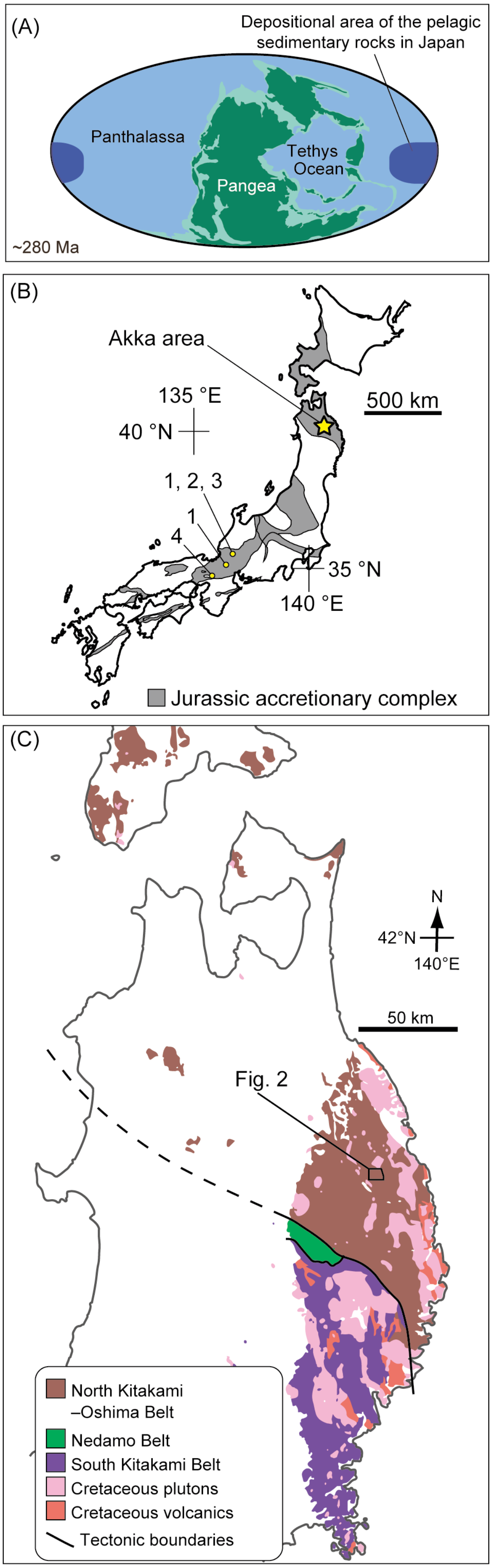

Fig. 1 (A) Palaeogeography of the late Carboniferous–middle Permian interval, represented by the Kungurian (by Laya *et al.*, 2013). (B) Distribution of the Jurassic accretionary complex in the Japanese Islands (after Isozaki *et al.*, 2010). The location of areas targeted in this study and previous studies are shown. 1: Yao *et al.* (2001). 2: Nishikane *et al.* (2011). 3: Nishikane *et al.* (2014). 4: Kusunoki *et al.* (2004). Akka area: Yamakita *et al.* (2008); Ehiro *et al.* (2008); Muto *et al.* (2023b); this study. (C) Geology of the basement rocks of northern the Tohoku Region (modified from Geological Survey of Japan, AIST, 2020).

Yamakita *et al.* (2008) and Ehiro *et al.* (2008) drew attention to the Paleozoic deep-sea record in the northern Kitakami Mountains in Northeast Japan, in contrast to the above studies from Southwest Japan. These studies briefly reported on conodonts across the Carboniferous–Permian boundary in the Akka area in Iwate Prefecture, which includes the target area of the present study. Muto *et al.* (2023b) studied the boundary in detail and detected the successive appearance of globally useful zonal marker species. Thus, the northern Kitakami Mountains present a great potential for studies of conodont biostratigraphy of pelagic deep-sea sedimentary rocks.

In this study, we report Carboniferous and Permian conodonts from a section in the Akka area in the northern Kitakami Mountains, Northeast Japan, reported by Ehiro *et al.* (2008). The section is herein named the Otori section. The conodont occurrence of this study was introduced by Muto *et al.* (2022) in a conference, but illustrations of the specimens are published for the first time. This study also provides notes on previous reports of conodonts from the North Kitakami Belt, aiming to present an updated basis of conodont information in this region.

2. Geological outline

The Otori section is a pelagic deep-sea section in the upper reaches of the Akka River in Iwaizumi Town, Iwate Prefecture. Rocks distributed in this area belong to the Jurassic accretionary complex in the northeastern zone of the North Kitakami–Oshima Belt (e.g., Isozaki and Maruyama, 1991; Ehiro *et al.*, 2008; Fig. 1B, C). Based on surveys for the 1: 50,000 geological map of the Kado District for the Quadrangle Series of the Geological Survey of Japan, AIST, the Jurassic accretionary complex of the area is divided into three units with distinct lithofacies; the Otori, Seki and Takayashiki units in tectonically descending order (Takahashi *et al.*, 2016; Muto *et al.*, 2023a; Fig. 2). The Otori section belongs to the structurally lower part of the Otori Unit (the Okoshizawa Subunit) which is composed of stacked sheets of chert and siliceous mudstone (Muto *et al.*, 2023a; Fig. 2). The Otori Unit is composed of upper Carboniferous to Lower Jurassic pelagic deep-sea sedimentary rocks (mostly chert) (Toyohara *et al.*, 1980; Murai *et al.*, 1985; Ehiro *et al.*, 2008; Takahashi *et al.*, 2016; Muto *et al.*, 2023a, b, c) and

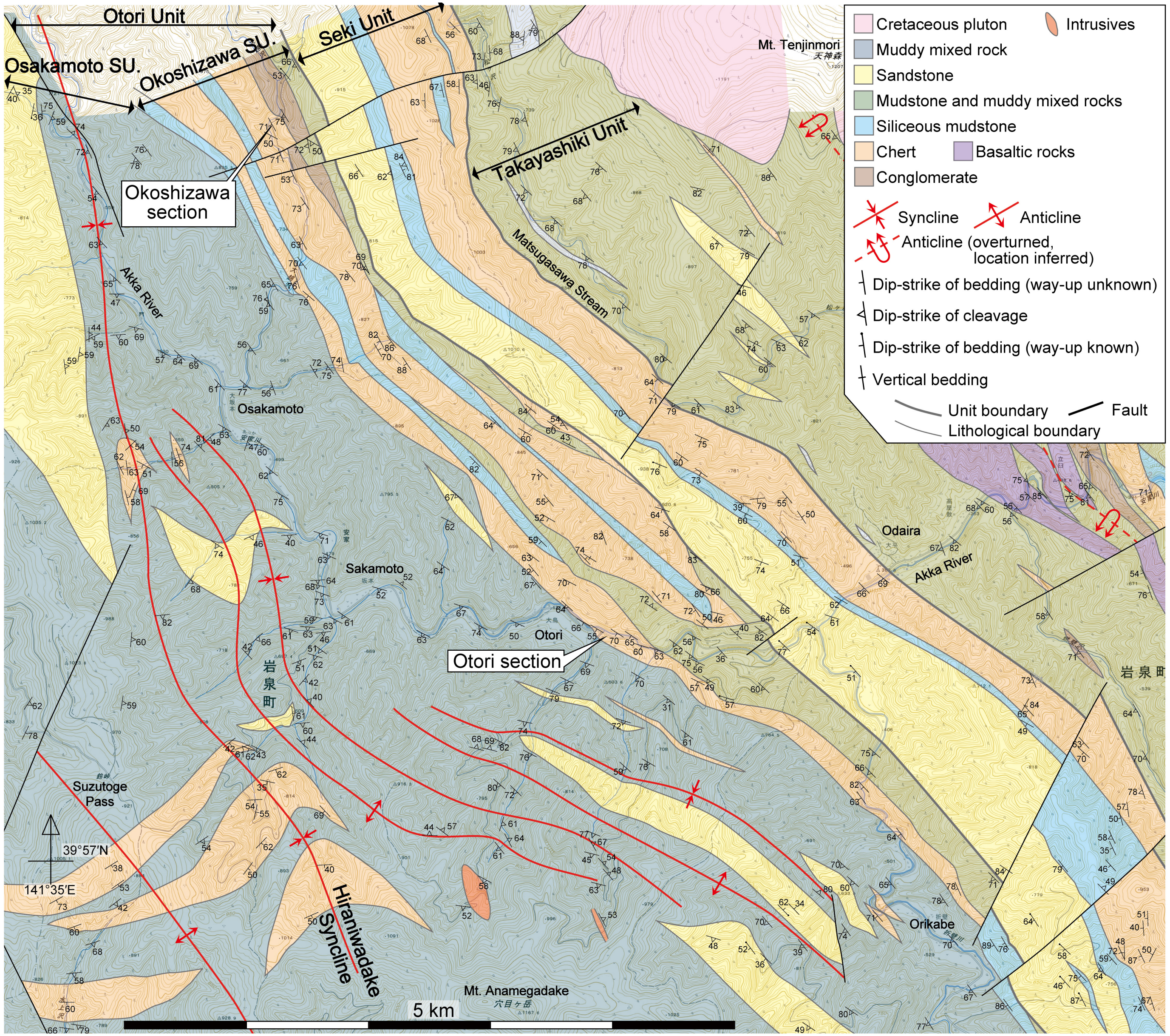

Fig. 2 The geology of the North Kitakami Belt in the upper reaches of the Akka River (updated from Muto *et al*., 2023a). SU: subunit.

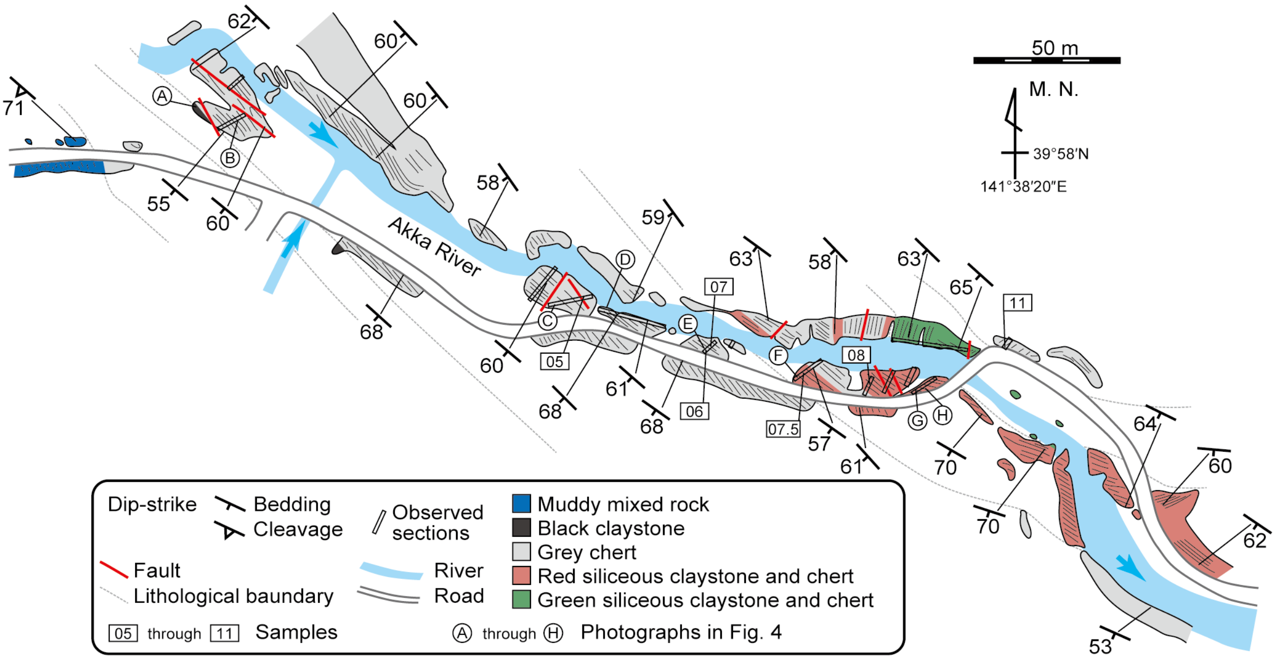

Fig. 3 Geological sketch map of the Otori section. M. N.: Magnetic north. Sample numbers correspond to the last two or three digits after 191213-.

Middle Jurassic hemipelagic to trench-fill sedimentary rocks (Suzuki *et al.*, 2007b; Ehiro *et al.*, 2008; Muto *et al.*, 2023a). Chert of the Otori Unit is accompanied by green and red siliceous claystone in the upper Carboniferous to lower Permian interval (Ehiro *et al.*, 2008; Muto *et al.*, 2023a, b) and black carbonaceous claystone and grey siliceous claystone at the Permian–Triassic boundary (Takahashi *et al.*, 2009; Muto *et al.*, 2023c).

The Otori section represents the Paleozoic portion of the pelagic deep-sea sedimentary rocks of the Otori Unit. The lithofacies is in ascending order grey bedded chert, green siliceous claystone, red siliceous claystone interbedded with reddish or greyish chert and grey bedded chert (Figs. 3–5). The total thickness is apparently ~90 m, but true stratigraphic thickness is unknown due to faults and folds. The green siliceous claystone is composed of 5–20 cm thick beds that are partly poorly defined. The interval of red siliceous claystone and reddish or greyish chert is composed of beds that are mostly 2–10 cm thick (Fig. 4F–H). The colour of the rocks have considerable lateral variation, changing between red to reddish purple or red to grey in the same bed. Single bed thickness and pattern of bedding in the grey bedded chert in the upper part of the Otori section show minor stratigraphic changes. The lower to middle part that include horizons yielding Guadalupian (middle Permian) conodonts have very thin clay partings mostly less than a few millimetres in thickness between individual chert beds (Fig. 4C–E). In this part, single bed thickness varies from 1–5 cm in thin-bedded parts (Fig. 4E) to around 20 cm in thick-bedded parts (Fig. 4C) and some intervals have poorly parted beds (Fig. 4D). In contrast, the upper part of the grey bedded chert tends to have thicker clay partings, and chert beds interbedded with 1–3 cm thick clayey beds that appear as yellowish bands on the outcrop surface are common (Fig. 4B). Single bed thickness is mostly 2–5 cm in the upper part of the grey bedded chert. At the top of the section is black carbonaceous claystone, which is lithostratigraphically correlated to the Permian–Triassic boundary (Fig. 4A).

3. Methods

Conodonts were found on cleaved surfaces of sampled rocks (Fig. 6) and scanned by an X-ray microscope using the method established by Muto *et al.* (2021b). Rock pieces containing well-preserved specimens

(→ p. 5)

Fig. 4 Outcrop photographs of the Otori section. (A) The Permian–Triassic boundary between grey bedded chert (below) and black carbonaceous claystone (above). The two lithofacies are in contact with a slip plane and the exact boundary may be lost. (B) Lopingian (?) grey bedded chert with thick clayey layers. (C) Guadalupian (?) grey thick bedded chert. (D) Guadalupian grey bedded chert. (E) Guadalupian grey bedded chert. (F) Cisuralian reddish grey siliceous claystone with a thick white chert interbed. (G) Cisuralian red and reddish purple red siliceous claystone with white chert interbeds. (H) Cisuralian greyish red siliceous claystone. Scale bars are 20 cm. The hammer in A and G are 30 cm long.


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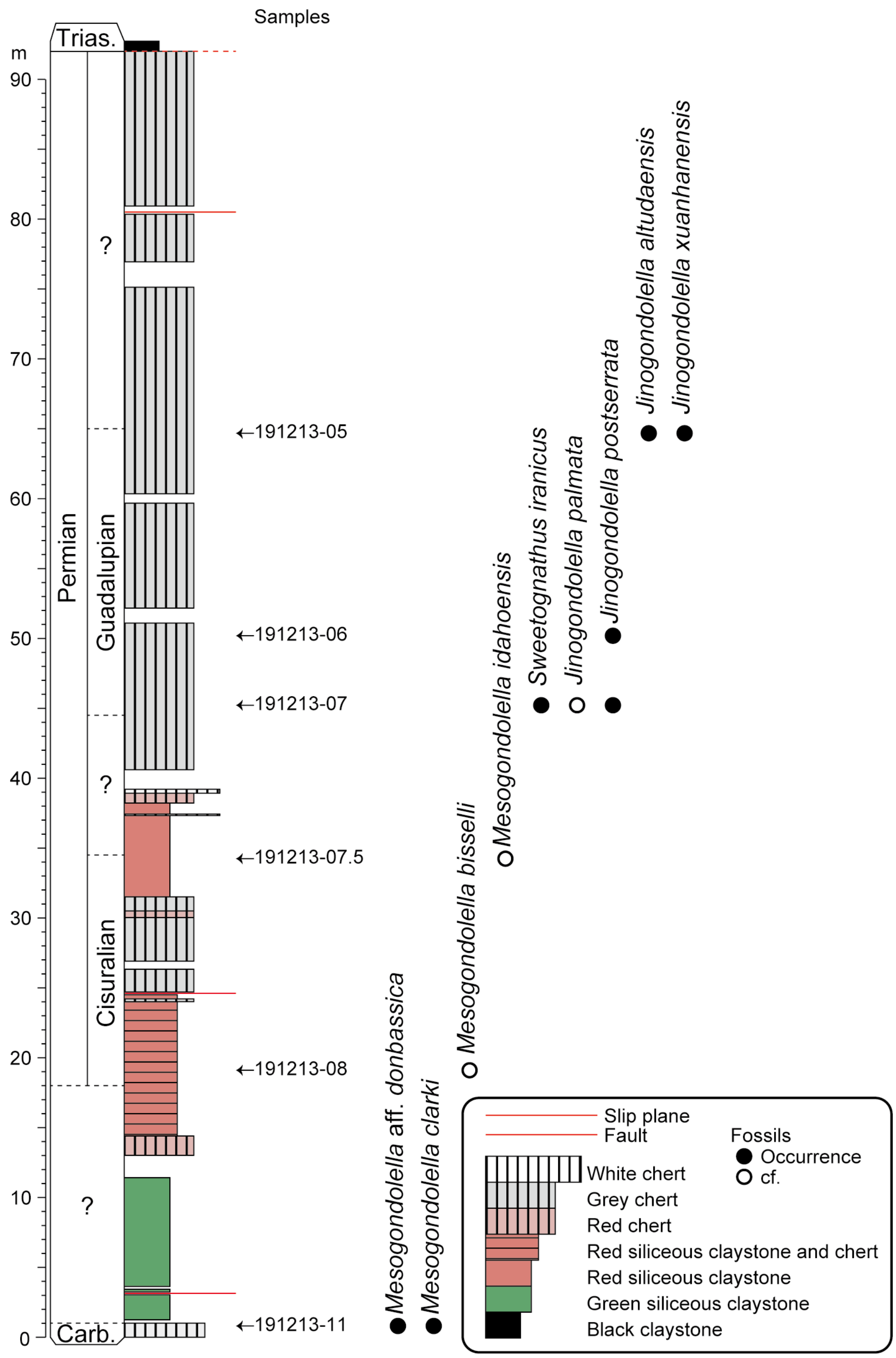


Fig. 5 Lithostratigraphy and conodont occurrence of the Otori section. Carb.: Carboniferous; Trias.: Triassic.

were selected and trimmed down to blocks of a few millimetres. The specimens on the rock pieces were enclosed in a "hedge" of concrete mortar to avoid effects of surface refraction of X-rays, glued onto the end of a pencil lead and scanned using a ZEISS Xradia 410 versa X-ray microscope equipped with a L8121-03 SEL X-ray source of Hamamatsu Photonics K.K. at the Marine Core Research Institute, Kochi University. Tomographic sections obtained by Xradia 410 versa were processed using Amira Software (Thermo Fisher Scientific). For details, see Muto *et al.* (2021b).

4. Conodont occurrence and age assignment of the Otori section

We obtained conodonts from six horizons in the Otori

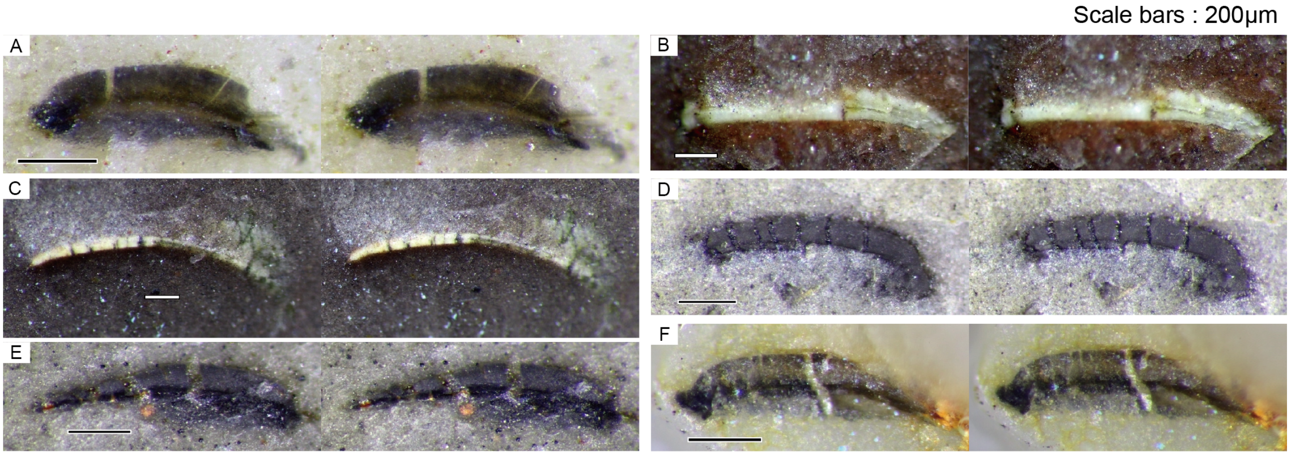


Fig. 6 Parallel-viewing stereoscopic photographs of representative conodont specimens from different rock types. (A) Grey chert, 191213-11, not in Fig. 7. (B) Red siliceous claystone, 191213-08, same specimen as Fig. 7S. (C) Red siliceous claystone, 191213-07.5, same specimen as Fig. 7R. (D) Grey chert, 191213-07, same specimen as Fig. 7N. (E) Grey chert, 191213-06, not in Fig. 7. (F) Grey chert, 191213-05, same specimen as Fig. 7G. Scale bars are 200 μm.

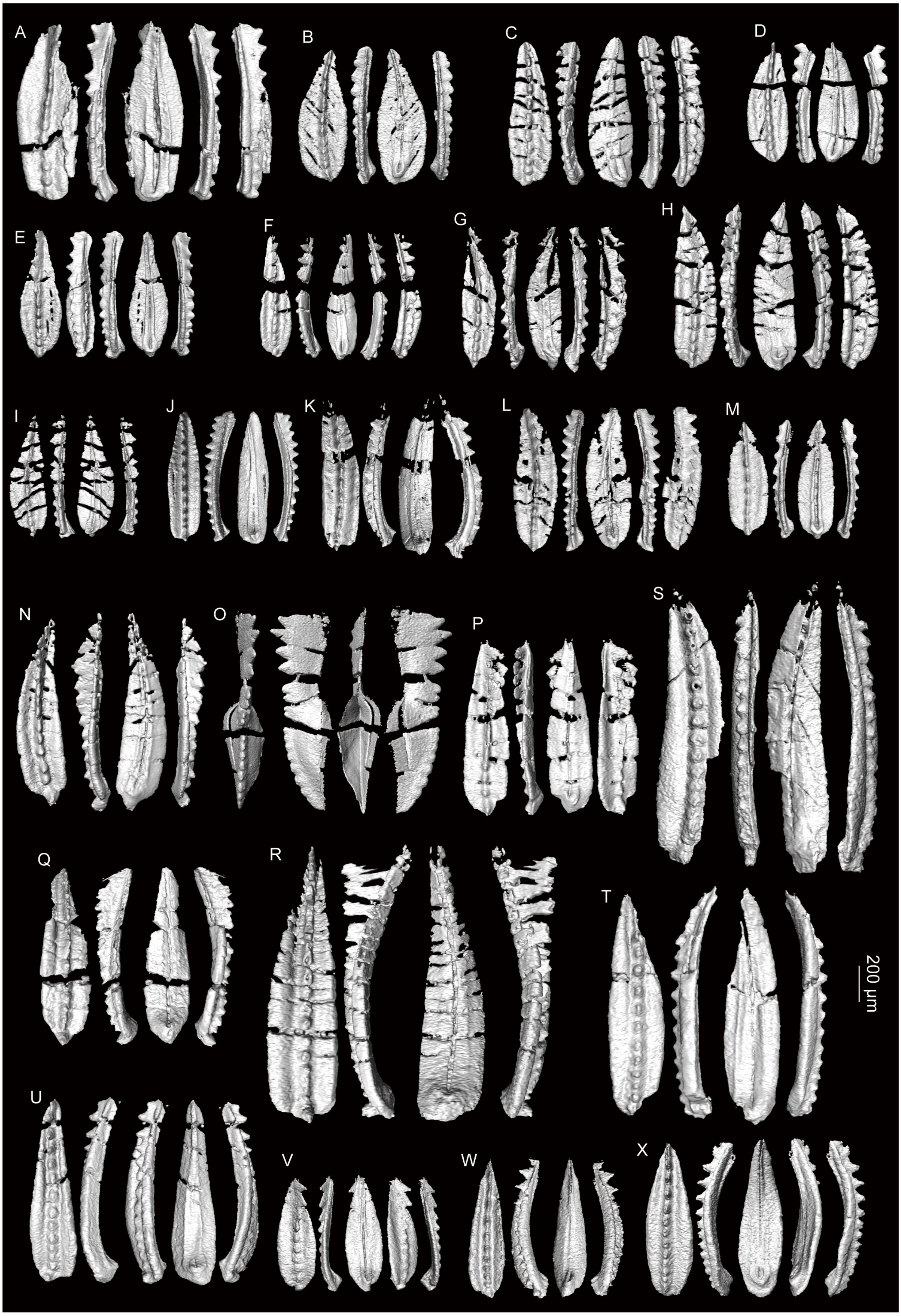
section (Figs. 5, 7). The basal part of the section (Sample 191213-11) yielded *Mesogondolella clarki* (Koike) and *Mesogondolella* aff. *donbassica* (Kossenko). The former has been shown from a similar horizon of the Otori section by Ehiro *et al.* (2008). *Mesogondolella clarki* is a widespread Moscovian (middle Pennsylvanian) species known from pelagic Panthalassa (Koike, 1967; Muto *et al.*, 2023b), the Donets Basin (Nemyrovska, 2011; 2017a) and South China (Wang and Qi, 2003; Qi *et al.*, 2014, 2016). *Mesogondolella donbassica* is known from the Moscovian of the Donets Basin (Nemyrovska *et al.*, 1999), Novaya Zemlya (Sobolev and Nakrem, 1996) and South China (Wang and Qi, 2003).

The lower part of the reddish siliceous claystone and chert interval (Sample 191213-08) yielded specimens comparable to *Mesogondolella bisselli* (Clark and Behnken). This species is known from the Sakmarian to Artinskian of pelagic Panthalassa (Igo, 1981; Igo and Hisada, 1986), South China (Wang and Wang, 1981), Novaya Zemlya (Sobolev and Nakrem, 1996), Urals (Chernykh, 2005) and western USA (Clark and Behnken, 1971; Behnken, 1975). The upper part of the reddish siliceous claystone and chert interval (Sample 191213-07.5) yielded specimens comparable to *Mesogondolella idahoensis* (Youngquist *et al.*, 1951). This species is an indicator of the Kungurian (late Cisuralian) and has a wide distribution occurring from Panthalassa (Igo, 1981; Muto *et al.*, 2021a), South China (Zhang *et al.*, 2010), Spitsbergen (Szaniawski and Malkowski, 1979) and western USA (e.g., Youngquist *et al.*, 1951; Behnken, 1975; Lambert *et al.*, 2007).

We obtained conodonts from two horizons in the lower part of the grey bedded chert. The lower horizon (Sample 191213-07) contained *Sweetognathus iranicus* Kozur *et al.*, *Jinogondolella* cf. *palmata* Nestell and Wardlaw and *Jinogondolella postserrata* (Behnken), while the higher horizon (Sample 191213-06) yielded *J. postserrata*. *Jinogondolella palmata* and *J. postserrata* respectively occur from the Wordian (middle Guadalupian) to lowermost Capitanian (upper Guadalupian) and the Capitanian in western USA (Wardlaw and Nestell, 2015) and South China (Sun *et al.*, 2017). *Sweetognathus iranicus* was originally reported from the Capitanian of Iran (Kozur *et al.*, 1975). It was later found from the Wordian of the Salt Range (Wardlaw and Mei, 1998) and the Kungurian of South China (Sun *et al.*, 2017).

The middle part of the grey bedded chert (Sample 191213-05) yielded *Jinogondolella altudaensis* (Kozur) and *Jinogondolella xuanhanensis* (Mei and Wardlaw in Mei *et al.*, 1994a). These species are known from Panthalassa (Nishikane *et al.*, 2011, 2014), western USA (e.g., Wardlaw, 2000; Wardlaw and Nestell, 2010; Lambert *et al.*, 2010) and South China (Mei *et al.*, 1994a, b; Sun *et al.*, 2017), and cooccur in the Capitanian.

Based on the above, the confirmed age of the Otori section spans from the Moscovian of the Pennsylvanian (late Carboniferous) to the Capitanian of the Guadalupian (middle Permian) (Fig. 5). No age diagnostic fossils have been found yet from the upper part of the grey bedded chert, but this part presumably includes Lopingian strata, based on its position below the Permian–Triassic boundary. Another deep-sea section in the Otori Unit, the Okoshizawa section (Fig. 2), has been studied for the Carboniferous–Permian boundary (Muto *et al.*, 2023b). While the two sections are composed of a similar set of lithologies, there are noticeable differences in lithostratigraphy. Red siliceous claystone is present in the basal Permian in both sections, but it does not extend up into the Artinskian in Okoshizawa, while it continues up to the Kungurian in Otori (Fig. 8). This degree of variation in apparent silica content in coeval beds is not known from other intervals of pelagic deep-sea sedimentary rocks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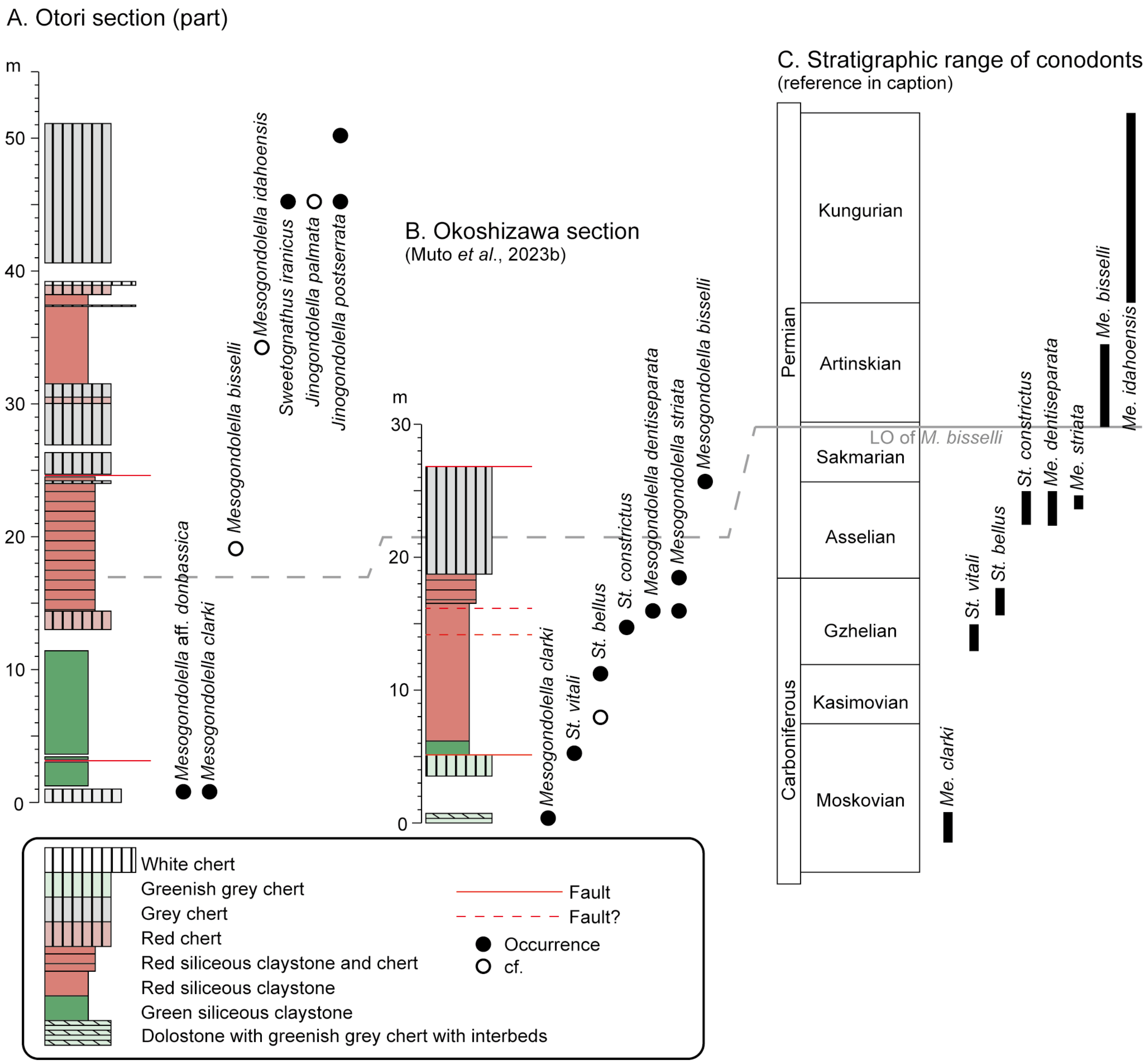

Fig. 8 Comparison of the lithostratigraphy and selected conodont occurrence of the Otori and Okoshizawa sections and correlation based on known stratigraphic range of conodonts. (A) Otori section (this study). (B) Okoshizawa section (Muto *et al.*, 2023b). (C) Range of conodonts (Henderson, 2018; Chernykh *et al.*, 2020; Ritter, 2020; Beauchamp *et al.*, 2022a, b). Only the Pennsylvanian to lower Guadalupian part of the Otori section is shown. The difference in lithofacies is easily noticed around the lowest occurrence (LO) of *M. bisselli*.

(←p. 8)

Fig. 7 Images of conodont specimens obtained by X-ray µCT. (A–E) *Jinogondolella altudaensis* (Kozur), 191213-05. (F, G) *Jinogondolella xuanhanensis* (Kozur), 191213-05. (H, I) *Jinogondolella*? sp., 191213-05. (J) *Jinogondolella postserrata* (Behnken), 191213-06. (K) *J.* cf. *postserrata* (Behnken), 191213-06. (L, M) *Jinogondolella*? sp., 191213-06. (N) *J. postserrata* (Behnken), 191213-07. (O) *Sweetognathus iranicus* Kozur *et al.*, 191213-07. (P) *Jinogondolella* cf. *palmata* Nestell and Wardlaw, 191213-07. (Q, R) *Mesogondolella* cf. *idahoensis* (Youngquist *et al.*), 191213-07.5. (S, T) *Mesogondolella* cf. *bisselli* Clark and Behnken, 191213-08. (U–W) *Mesogondolella clarki* (Koike), 191213-11. (X) *Mesogondolella* aff. *donbassica* (Kossenko). Scale bar is 200 µm.

in Japan. In addition, dolostone beds are present in the Moscovian of the Okoshizawa section, but not found in the Moscovian of the Otori section.

5. Notes on previously reported conodonts from the North Kitakami Belt

In the 1970s to 1980s, geologists investigated many localities of chert and limestone in the Jurassic accretionary complex of the North Kitakami Belt (the segment of the North Kitakami–Oshima Belt distributed in the Honshu Island). The occurrence of conodonts was highly significant, because the only age diagnostic fossils reported from the North Kitakami Belt till then were mostly fusulinids from limestone. Studies on conodonts eventually supported the introduction of plate tectonics to the region (Okami and Ehiro, 1988). Conodont fossils were of particular importance in the Kitakami Mountains, because metamorphism by Cretaceous plutons makes it mostly impossible to extract radiolarians from chert, leaving conodonts the only way of age assignment. Despite the significance, only a few works have presented illustrations of conodont fossils. In this section, we list previous reports of conodonts from the North Kitakami Belt (Table 1). Since conodont taxonomy has been significantly updated in the last few decades, some notes are made on the taxonomic aspect of the reports. Furthermore, we also aim to unravel the confusion caused by different works referring to the same locality without making it clear (shaded rows in Table 1).

5. 1. Carboniferous conodonts

Not many Carboniferous conodonts have been reported, and the majority comes from the Akka area of this study. Illustrations of specimens were scarce, but those from the Akka area are made available by Muto *et al.* (2023b) and this study. In addition to the Akka area, Murata *et al.* (1974) illustrated specimens that are undoubtedly of Carboniferous age including *Mesogondolella clarki* and *Idiognathodus* sp. (their *I. delicatus*). The oldest age confirmed by conodonts in the North Kitakami Belt is Moscovian: Toyohara *et al.* (1980) reported the occurrence of *Gondolella* sp. (their Loc. 36; Table 1), which would indicate the late Carboniferous, but no illustrations or descriptions were given.

5. 2. Permian conodonts

Permian conodonts have been reported from many localities in the North Kitakami Belt, but reliability is problematic in many of these reports. The term “Permian-type *Neogondolella*” was used in many localities with no clear definition and, in most cases, illustrations are not shown. The term apparently refers to Permian gondolellid genera currently placed under *Mesogondolella*, *Jinogondolella* and *Clarkina*, and it is true that they can be distinguished from Triassic gondolellids including the Middle Triassic *Neogondolella* (in the modern sense). However, without the statement of how “Permian-type *Neogondolella*” was distinguished, the age assignment cannot be accepted as decisive. Such cases are shown with brackets in our compilation list (Table 1). It should also be noted that classification of the aboral surface, which is probably the easiest way to differentiate between Carboniferous, Permian and Triassic gondolellids, is not applicable for early juveniles (Kozur, 1989). Since at least some of the figured specimens in previous works appear to be of early juvenile stages (Fig. 9A–D; Table 1), there is a significant degree of concern about the identification of these gondolellids. Of the previous reports of Permian conodonts, those including *Neostreptognathodus* can be regarded as reliable, since this genus only occurs in the Cisuralian, although the lack of illustrations of *Neostreptognathodus* is unhelpful. Also, those including *Anchignathodus* (*Hindeodus* in the present taxonomy) are generally reliable, since this taxon became extinct in the earliest Triassic. Ehiro *et al.* (2008) and Takahashi *et al.* (2016) illustrated “Permian-type *Neogondolella*” and stated that a wide platform characterizes this type. While the width of the platform is rather subjective as far as their illustrations show, terminal position of the loop (Fig. 10.1, 4 in Takahashi *et al.*, 2016), wide V-shaped attachment surface or low and discrete carina (Fig. 10.3 in Takahashi *et al.*, 2016), support placing at least some of their specimens in Permian taxa.

5. 3. Triassic conodonts

Triassic conodonts are the most abundantly reported conodonts in the North Kitakami Belt. Recognition of Triassic ages in the previous studies are based on identification of conodonts at the species level, unlike the case of the Permian. However, some of the species names reported therein need to be treated with caution, as detailed below.

Epigondolella abneptis (Huckriede) was recognized in many localities to indicate the Late Triassic. This species was chosen by Mosher (1968) as the type species of the genus *Epigondolella* that included Middle to Late Triassic conodonts with mostly denticulate platform margins, which are stratigraphically useful because of their distinct characters. However, *E. abneptis* was applied by many subsequent works to forms that would now be placed in different species or even different genera, partly due to the fact that Huckriede (1958) illustrated a wide range of forms from several ages when he erected this species (Moix *et al.*, 2007; Karádi, 2021). In the absence of clear illustrations in the works of the North Kitakami Belt, it is only possible to surmise that the occurrence of “*E. abneptis*” indicates the Middle or Upper Triassic. In fact, in the three cases where illustrations for “*E. abneptis*” were given, there are differences in morphological characters with the holotype of *E. abneptis* enough to conclude that they belong to a different species. The specimens in Pl. 3, fig. 1 of Murai *et al.* (1985) and Pl. 9 figs. 17–20 of Murata and Nagai (1972) have a rostro-caudally reduced

Table 1 List of reported conodont occurrences in the North Kitakami Belt with first citation in compilations (Suzuki *et al.* 2007a; Ehiro *et al.*, 2008; Uchino and Suzuki, 2020; this study), location in the division of 1: 50,000 Quadrangle Series, lithology of sample, presence or absence of figures, taxon name as in original reference, age indicated by the fossils and notes by the present authors. Numberings of bibliographic references follow Suzuki *et al.* (2007a), Ehiro *et al.* (2008) and Uchino and Suzuki (2020). Shadowed reports are citations of earlier reports that lacked referencing. Reports of conodonts with little biostratigraphic or taxonomic value, such as conodonts ranging across periods or elements belonging to many taxa of genus levels or higher are not listed here. In case of rarely used combination of genus and species names, currently used genus names are noted. When the age of the conodonts is mentioned in the original reference but is found to be questionable due to poor quality of the specimens, contradictory cooccurrence of taxa in modern biostratigraphic schemes or insufficient biostratigraphic constraints, the age is shown with a question mark.

	Reference	Locality	first citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
6	Murata and Sugimoto (1971)		Suzuki *et al.* (2007a)	Rikuchu-Seki	limestone	no		Late Triassic	Norian?	*Ep. bidentata* fauna. Same occurrence reported in Sugimoto (1974)?
				Rikuchu-Seki	limestone	no		Late Triassic	Norian?	*Ep. abneptis* fauna; Same occurrence reported in Sugimoto (1974)?
17	Yoshida (1980)	Loc. 3	Suzuki *et al.* (2007a) Deleted in Ehiro *et al.* (2008) and Uchino and Suzuki (2020)	Kawai	chert	no	*Neogondolella bulgarica*	Middle Triassic	Anisian	
						no	*Pollognathus kochi*			Current genus *Cratognathodus*.
		Loc. 4		Kawai	chert	no	Permian-type *Neogondolella* sp.	Permian?		
		Loc. 5		Kawai	chert	no	*Neogondolella excelsa*? or *Neogondolella polygnathiformis*?	Middle? or Late? Triassic	Anisian to Carnian?	
		Loc. 6		Kawai	chert	no	?*Misikella hernsteini*	Late Triassic?	Norian or Rhaetian?	
18	Toyohara *et al.* (1980)	Loc. 1	Suzuki *et al.* (2007a)	Iwaizumi	chert	no	*Epigondolella bidentata*	Late Triassic	Norian or Rhaetian	
						no	*Misikella hernsteini*			
		Loc. 3	Suzuki *et al.* (2007a)	Rikuchu-Seki	limestone	no	*Epigondolella primitia*	Late Triassic	Carnian or Norian	
		Loc. 4	Suzuki *et al.* (2007a)	Rikuchu-Seki	limestone	no	?*Neogondolella navicula steinbergensis*	Late Triassic?	Norian?	
		Loc. 5	Suzuki *et al.* (2007a)	Rikuchu-Seki	limestone	no	*Epigondolella primitia*	Late Triassic	Carnian or Norian	
		Loc. 6	Suzuki *et al.* (2007a)	Rikuchu-Seki	limestone	no	*Epigondolella primitia*	Late Triassic	Carnian or Norian	
		Loc. 7	Suzuki *et al.* (2007a)	Rikuchu-Seki	chert	no	*Neogondolella* sp.	(Triassic)		
		Loc. 8	Suzuki *et al.* (2007a)	Rikuchu-Seki	chert	no	*Neogondolella polygnathiformis*	Late Triassic	Carnian	
		Loc. 11	Suzuki *et al.* (2007a)	Rikuchu-Seki	chert	no	*Neohindeodella aequiramosa*	Middle Triassic	Anisian	
		Loc. 12	Suzuki *et al.* (2007a)	Rikuchu-Seki	chert	no	*Neogondolella bulgarica*	Middle Triassic	Anisian	
						no	*Neohindeodella aequiramosa*			
		Loc. 14	Suzuki *et al.* (2007a)	Rikuchu-Seki	siliceous mudstone	no	*Neospathodus homeri*	Early Triassic		
		Loc. 16	This study	Kado	chert	no	Permian-type *Neogondolella* sp.	(Permian)		
		Loc. 17	This study	Kado	siliceous mudstone	no	*Neospathodus homeri*	Early Triassic		
		Loc. 19	Suzuki *et al.* (2007a)	Kado	chert	no	?*Neogondolella polygnathiformis*	Late Triassic?	Carnian?	
	to next page	Loc. 21	Suzuki *et al.* (2007a)	Kado	chert	no	?*Neogondolella polygnathiformis*	Late Triassic?	Carnian?	

Table 1 Continued.

Reference	Locality	1st citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
18 Toyohara *et al.* (1980) (continued)	Loc. 22	This study	Kado	chert	no	Permian-type *Neogondolella* sp.	(Permian)		
	Loc. 23	This study	Kado	chert	no	Permian-type *Neogondolella* sp.	(Permian)		
	Loc. 24	This study	Kado	chert	no	*Neogondolella* sp. (*constricta*-type)	Middle Triassic		
	Loc. 26	This study	Iwaizumi	chert	no	Permian-type *Neogondolella* sp.	early Permian		
					no	*Neostreptognathodus* sp.			
	Loc. 28	This study	Iwaizumi	Siliceous mudstone	no	*Neospathodus homeri*	Early Triassic	Olenekian	
					no	*Neohindeodella dropla*			
					no	*Neohindeodella benderi*			
	Loc. 30	Suzuki *et al.* (2007a)	Kado	chert	no	*Epigondolella bidentata*	Late Triassic	Norian	
					no	*Neogondolella navicula steinbergensis*			
	Loc. 31	Suzuki *et al*. (2007a)	Kado	chert	no	?*Neogondolella bulgarica*	Triassic	Anisian?	
					no	*Neohindeodella multihamata*			
					no	?*Pollognathus kochi*			Current genus *Cratognathodus*.
	Loc. 32	Suzuki *et al*. (2007a)	Kado	chert	no	?*Neogondolella bulgarica*	Triassic	Anisian	
					no	*Neohindeodella aequiramosa*			
					no	*Neohindeodella triassica*			
	loc. 33	Suzuki *et al*. (2007a)	Kado	chert	no	*Epigondolella abneptis*	Late Triassic	Norian	
					no	*Neogondolella navicula hallstattensis*			
					no	*Neohindeodella dropla*			
	Loc. 34	This study	Okawa	chert	no	Permian-type *Neogondolella* sp.	early? Permian		
					no	neostreptognathid			
					no	*Neohindeodella triassica*			Contradictory occurrence.
	Loc. 36	This study	Okawa	chert	no	*Gondolella* sp.	Carboniferous?		
					no	*Xaniognathus* sp.			
	Loc. 37	This study	Okawa	chert	no	Permian-type *Neogondolella* sp.	(Permian)		
	Loc. 38	This study	Okawa	chert	no	Permian-type *Neogondolella* sp.	Permian		
					no	*Anchignathodus* sp.			
					no	*Neohindeodella triassica*			Contradictory occurrence.
	Loc. 40	This study	Okawa	chert	no	*Neogondolella* cf. *rozenkrantzi*	late Permian		
	Loc. 41	Suzuki *et al*. (2007a)	Kado	chert	no	?*Neohindeodella aequiramosa*	Triassic?		
	Hirosaki P	Suzuki *et al*. (2007a)	Hirosaki?	chert	no	Not mentioned	Permian		
	Hirosaki ml?	Suzuki *et al*. (2007a)	Hirosaki?	chert	no	?*Neohindeodella multihamata*	Triassic?		Constitutes multielement apparatus with *C. kochi* (Koike, 1999)
to next page	Natsudomari ab, Same as [47].	This study	Mutsukawauchi	limestone	no	*Epigondolella abneptis*	Late Triassic		

Table 1 Continued.

	Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
18	Toyohara *et al*. (1980) (continued)	Natsudomari bd, Same as [47].	This study	Mutsukawauchi	limestone	no	*Epigondolella bidentata*	Late Triassic		
		Shiriya E pr	Suzuki *et al*. (2007a)	Shiriyazaki	chert	no	*Epigondolella primitia*	Late Triassic	Carnian or Norian	
		Sw Yunokawa cn	This study	Mutsukawauchi	chert	no	*Neogondolella constricta*	Middle Triassic		
26	Ehiro *et al*. (2001)		Suzuki *et al*. (2007a)	Miyako	chert	no	*Cornudina breviramulis*	Triassic		Originally dated as the Anisian, Middle Triassic, but the species ranges up to the Norian.
31	Murai *et al*. (1985)	Loc. 7 Loc. 34 of [18]? (one mismatch)	Suzuki *et al*. (2007a)	Okawa	chert	no	*Neohindeodella triassica*	early Permian?		Contradictory cooccurrence.
						no	neostreptognathid			
		Loc. 8 Loc. 37 of [18]		Okawa	chert	no	Permian-type *Neogondolella* sp.	(Permian)		
		Loc. 9 Loc. 38 of [18]		Kado	chert	no	Permian-type *Neogondolella* sp.	Permian		
						no	*Anchignathodus* sp.			
						no	*Neohindeodella triassica*			Contradictory coocurrence.
		Loc. 10 Loc. 40 of [18]		Kado	chert	no	*Neogondolella* cf. *rosenkrantzi*	late Permian		
		Loc. 11		Kado	chert	no	*Neogondolella* cf. *carinata carinata*	late? Permian		Contradictory cooccurrence.
						yes	*Neogondolella* cf. *rosenkrantzi*			Figure not deciseve. (Aboral view only.)
						yes	*Anchignathodus minutus*			Figure not sharp.
		Loc. 12 Loc. 26 of [18]		Iwaizumi	chert	no	Permian-type *Neogondolella* sp.	early Permian		
						no	*Neostreptognathodus* sp.			
		Loc. 13 Loc. 28 of [18]		Iwaizumi	siliceous claystone	no	*Neospathodus homeri*	Early Triassic	Olenekian	
						no	*Neohindeodella benderi*			
						no	*Neohindeodella dropla*			
		Loc. 14 Loc. 6 of [18]		Kado	limestone	no	*Epigondolella primitius*	Late Triassic	Carnian or Norian	Misspelled.
						no	?*Epigondolella abneptis*			
		Loc. 15 Loc. 19 of [18]		Kado	chert	no	?*Neogondolella polygnathiformis*	Late Triassic?		
		Loc. 17 Loc. 21 of [18]		Kado	chert	no	?*Neogondolella polygnathiformis*	Late Triassic?		
		Loc. 18 Loc. 18 of [18]? Lithology mismatch.		Kado	chert	no	*Neogondolella* sp.	(Permian)		Age shown as "Permian" in text, but no indication as "Permian-type" for conodont occurrence.

to next page

Table 1 Continued.

	Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
31	Murai *et al.* (1985) (continued)	Loc. 19 Loc. 25 of [18].	Suzuki *et al*. (2007a)	Kado	chert	no	*Enantiognathus ziegleri*	Triassic?		Misspelled. Assigned to Middle Triassic but the species spans the entire Triassic.
						no	*Cypridodella muelleri*			Assigned to Middle Triassic but but the species spans the entire Triassic.
		Loc. 20		Kado	chert	yes	?*Epigondolella abneptis*	Triassic?		*E. abneptis*? is "*E.* cf. *abneptis*" in Plate caption, probably *Mockina*.
						yes	*Neogondolella* sp.			Figure not sharp.
		Loc. 21		Kado	chert	yes	*Neogondolella* cf. *rosenkrantzi*			Unidentifiable juvenile. Age revised accordingly from "Permian" in original work.
		Loc. 22 Loc. 16 in [18].		Kado	chert	no	Permian-type *Neogondolella* sp.	Permian?		
		Loc. 23 Loc. 24 in [18]		Kado	chert	no	*Neogondolella* sp. (*constricta*-type)	Triassic?		
		Loc. 24		Rikuchu-Seki	chert	part	*Neogondolella jubata*	Early Triassic?		Contradictory cooccurrence. Figures not sharp.
						part	*Neogondolella* cf. *planata*			
						part	*Neogondolella* cf. *milleri*			
		Loc. 25		Kado	chert	no	*Neogondolella* cf. *rosenkrantzi*	late Permian		
						no	*Anchignathodus minutus*			
						no	*Ellisonia granada*			
						no	*Neospathodus arcucristus*			Current genus *Merrillina*.
		Loc. 26		Kado	chert	yes	*Neogondolella polygnathiformis*	Late Triassic	Carnian	Figure not sharp but probably *Paragondolella* sp.
						no	*Gondolella carpathica*			
		Loc. 27 Loc. 17 in [18]		Kado	siliceous claystone	no	*Neospathodus homeri*	Early Triassic		
						no	*Neohindeodella triassica*			
		Loc. 28 Loc. 22 in [18]		Kado	chert	no	Permian-type *Neogondolella* sp.	(Permian)		
		Loc. 29 Loc. 23 in [18]		Kado	chert	no	Permian-type *Neogondolella* sp.	(Permian)		
32	Murai *et al.* (1986)	Loc. 30	Suzuki *et al*. (2007a)	Kado	chert	no	Permian-type *Neogondolella* sp.	Permian		
						no	*Anchignathodus typicalis*			
		Loc. 31		Kado	chert	no	*Neogondolella balkanica*	Middle Triassic		Misspelled.
						no	*Neospathodus sp.*			Contradictory cooccurrence. *Nicoraella* sp.?
		Loc. 32		Kado	chert	no	*Neogondolella haslachensis*	Triassic?	Ladinian or Carnian?	Contradictory cooccurrence.
						no	*Neospathodus* cf. *newpassensis*			
		Loc. 33 Loc. 41 in [18]		Kado	chert	no	?*Neohindeodella aequiramosa*	Triassic?		
		Loc. 34 Loc. 31 in [18]		Kado	chert	no	?*Neogondolella bulgarica*	Triassic?		
	to next page					no	?*Pollognathus kochi*			Misspelled.

Table 1 Continued.

	Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
32	Murai *et al*. (1986) (continued)	Loc. 35 Loc. 32 in [18]? One mismatch.	Suzuki *et al*. (2007a)	Kado	chert	no	*?Neogondolella bulgarica*	Triassic?		
						no	*Neohindeodella triassica*			
		Loc. 36		Kado	chert	no	*Epigondolella mungoensis*	Middle or Late Triassic	Ladinian or Carnian	
						no	*Neospathodus* sp.			*Mosherella*?
						no	*Gondolella mombergensis*			Contradictory cooccurrence. *N. mombergensis* is endemic to Europe.
		Loc. 37 Loc. 39 in [18]	Suzuki *et al*. (2007a)	Kado	chert	no	*Cypridodella muelleri*	Triassic?		
						no	*Neohindeodella suevica*			
		Loc. 38 Loc. 30 in [18]		Kado	chert	no	*Epigondolella bidentata*	Late Triassic	Norian	
						no	*Neogondolella navicula steinbergensis*			
		Loc. 39		Kado	chert	no	*?Neogondolella carinata carinata*	Middle or Late Triassic	Carnian?	Contradictory cooccurrence.
						no	*Neogondolella polygnathiformis*			
						no	*Neogondolella* cf. *reversa*			
						no	*Cratognathodus kochi*			
						no	*Gondolella haslachensis trammeri*			Contradictory cooccurrence. Misspelled.
		Loc. 40 Loc. 29 in [18]		Kado	chert	no	*Neohindeodella* sp.			
		Loc. 41		Kado	chert	no	*Neogondolella serrata postserrata*	middle Permian	Capitanian	
						no	*Anchignathodus minutus*			
		Loc. 42 Loc. 33 in [18]? One mismatch.		Okawa	chert	no	*Epigondolella abneptis*	Late Triassic	Norian	
						no	*Neogondolella navicula hallstattensis*			
		Loc. 43		Okawa	chert	no	*Neogondolella bulgarica*	Middle Triassic	Anisian	
		Loc. 44		Okawa	chert	no	*Neogondolella navicula navicula*	Late Triassic?		
34	Okami (1990)	OT-20	Suzuki *et al*. (2007a)	Otsuchi	chert	yes	*Neogondolella* cf. *navicula navicula*	(Triassic)		Unidentifiable juvenile.
		OT-4		Otsuchi	chert	yes	*Cornudina sp.*	(Triassic)		Unidentifiable ramiform.
						yes	*Neogondolella navicula navicula*			Unidentifiable juvenile.
		OT-5		Otsuchi	chert	yes	*Neogondolella* cf. *constricta*	(Late Triassic)		Unidentifiable juvenile.
						yes	*Neogondolella navicula hallstattensis*			Figure not sharp.
		OT-7		Otsuchi	chert	no	*Neogondolella* cf. *navicula navicula*	Late Triassic		
		OT-10-1		Otsuchi	chert	yes	*Neogondolella polygnathiformis*	Late Triassic		
						yes	*Neospathodus* sp.			Misidentified; basal cavity small and not upturned.
						no	*Neospathodus* cf. *newpassensis*			
		OT-10-2		Otsuchi	chert	yes	*Epigondolella* cf. *abneptis*	Late Triassic	Norian	*Mockina* sp. (Reduced platform in dorsal pat with upturned aboral margin).
	to next page					yes	*Epigondolella* sp.			Figure not sharp.

Table 1 Continued.

	Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
34	Okami (1990) (continued)	OT-17	Suzuki *et al*. (2007a)	Otsuchi	chert	no	*Neogondolella* cf. *polygnathiformis*	Late Triassic		
		OT-30		Otsuchi	chert	yes	*Neospathodus* cf. *spathi*	Early Triassic?		Misidentified; discrete denticles, low thick cusp. *Neospathodus cristagalli*?
		OT-32		Otsuchi	chert	yes	*Neogondolella* sp.	Middle or Late Triassic		Probably juvenile *Paragondolella* (high blade, dorsal platform development).
		O-2		Otsuchi	chert	no	*Cratognathodus kochi*	Late Triassic		
						no	*Neogondolella navicula*			
		O-8		Otsuchi	chert	yes	*Neogondolella* cf. *polygnathiformis*	Late Triassic		Image unclear. Broken?
		O-46		Otsuchi	chert	no	*Neogondolella jubata*	Middle Triassic?		
						no	*Neogondolella* cf. *regale*			
						no	*Neospathodus* cf. *spathi*			
						yes	*Neospathodus* sp.			Maybe *Chiosella* or *Paragondolella* (low blade and posterior brim of platform). Age revised accordingly.
		O-17		Otsuchi	chert	yes	*Neogondolella* sp.	Middle Triassic?		Figure not sharp.
						no	*Neospathodus triangularis*			Contradictory cooccurrence.
		O-19		Otsuchi	chert	no	*Cratognathodus kochi*	Middle Triassic		
						no	*Gondolella (Celsigondolella) watznaueri watznaueri*			
						no	*Neogondolella mombergensis*			*N*. *mombergensis* is endemic to the Germanic Basin.
		O-20		Otsuchi	chert	no	*Chirodella dindoides*	Triassic?		Contradictory cooccurrence.
						no	*Neospathodus dieneri*			
		O-21		Otsuchi	chert	no	*Neospathodus homeri*	Early or Middle Triassic		
						no	*Neospathodus timorensis*			
		O-48		Otsuchi	chert	no	*Neogondolella (Celsigondolella) watznaueri watznaueri*	Triassic		
						yes	*Neogondolella navicula navicula*			Figure not sharp.
35	Okami *et al.* (1993)	900914-1	Suzuki *et al.* (2007a)	Miyako	chert	no	*Neogondolella mombergensis*	(Triassic)		*N. mombergensis* is endemic to the Germanic Basin.
		900825-1		Miyako	chert	yes	*Anchignathodus typicalis*			Misspelled. *Hindeodus* sp.
		900825-7		Miyako	chert	yes	*Epigondolella abneptis*	Late Triassic	Norian?	*Epigondolella* sp.?
						yes	*Neogondolella polygnathiformis*			Long free blade: *Metapolygnathus*? Age interpreted based on revised identification.
						no	*Neogondoelalla* cf. *polygnathiformis*			
		900825-8		Miyako	chert	yes	*Neospathodus dieneri*	Early Triassic	Olenekian	*Neospathodus* ex gr. *waageni*, arcuate oral margin.
		900821-29		Miyako	chert	no	*Anchignathodus minutus*	Carboniferous or Permian?		Misspelled.
						no	*Diplognathodus* sp.			Misspelled.
		FRY-8		Miyako	chert	yes	*Neogondolella mombergensis*	Middle? Triassic		Misidentification (high middle carina); Triassic gondolellid. *N. mombergensis* is endemic to the Germanic Basin.
						no	*Neogondolella* cf. *mombergensis*			

to next page

Table 1 Continued.

Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
35 Okami *et al.* (1993) (continued)	FRY-10	Suzuki *et al*. (2007a)	Miyako	chert	yes	*Epigondolella mungoensis*	Middle or Late Triassic	Ladinian or Carnian	Questionable (no free blade).
					no	*Gladigondolella* cf. *tethydis*			
					no	*Neogondolella foliata*			
	FRY-11		Miyako	chert	yes	*Neogondolella foliata*	Middle Triassic	Ladinian or Carnian	*Paragondolella tadpole* or *P. polygnathiformis* ? (free blade present)
					no	*Epigondolella mungoensis*			
	FRY-12		Miyako	chert	no	*Cratognathodus kochi*	Late Triassic	Carnian	
					no	*Epigondolella abneptis*			
					yes	*Neogondolella polygnathiformis*			Figure not sharp.
					no	*Neogondoelalla* cf. *polygnathiformis*			
					no	*Neospathodus newpassensis*			
	FRY-15		Miyako	chert	yes	*Neogondolella subcarinata*	late Permian	Changhsingian	Figure not sharp.
	KG-12		Miyako	chert	yes	*Antignathodus minutus*			Misspelled. *Hindeodus* sp.
	KGR-9-D		Miyako	chert	yes	*Neogondolella mombergensis*	Middle Triassic	Anisian	Misidentification (high middle carina); Triassic gondolellid.
					yes	*Neogondolella* cf. *bulgarica*			
	KGW-2		Miyako	chert	yes	*Neospathodus homeri*	Early Triassic	Olenekian	
					no	*Neohindeodella* cf. *triassica*			
	KGW-4		Miyako	chert	yes	*Neogondolella subcarinata*	late Permian	Changhsingian	Juvenile. Figure not sharp.
	KGW-5		Miyako	chert	no	*Neogondolella subcarinata*	late Permian	Changhsingian	
	KGW-8		Miyako	chert	no	*Neogondolella subcarinata*	late Permian	Changhsingian	
	KGW-11		Miyako	chert	yes	*Neospathodus homeri*	Middle Triassic?		*Nicoraella* sp? (narrow basal cavity, carminate); Age revised accordingly.
					no	*Neohindeodella dropla*			
	KGW-12		Miyako	chert	yes	*Anchignathodus minutus*	late Permian	Changhsingian	Misspelled.
					no	*Neogondolella subcarinata*			
	KGW-13		Miyako	chert	yes	*Neogondolella* cf. *carinata*	late Permian?		Contradictory cooccurrence.
					no	*Neogondolella subcarinata*			
	KGW-20		Miyako	chert	no	*Neogondolella polygnathiformis*	Late Triassic	Carnian	
					no	*Epigondolella abneptis*			
	MNM-4		Miyako	chert	yes	*Neogondolella subcarinata*	late Permian?		Figure not sharp.
					no	*Neogondolella* cf. *carinata*			Contradictory cooccurrence.
	MNM-7		Miyako	chert	yes	*Anchignathodus minutus*	Permian?		Misspelled. *Hindeodus* sp.
					no	*Anchignathodus* cf. *typicalis*			
					no	*Neogondolella* sp.			Probably Permian or Triassic gondolellid judging from other specimens.
to next page	TMNM-10-1		Miyako	chert	no	*Neogondolella* cf. *carinata*	late? Permian		Judging from other cases of "*N. carinata*" occurrence, it is likely to refer to a Permian species.

Table 1 Continued.

	Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
35	Okami *et al*. (1993) (continued)	TMNM-10-2	Suzuki *et al*. (2007a)	Miyako	chert	yes	*Anchignathodus minutus*	early? Permian		Misspelled. *Hindeodus* sp.
						no	*Anchignathodus* cf. *minutus*			
						yes	*Neogondolella bisselli*			Juvenile, difficult to identify.
		TMNM-10-3		Miyako	chert	yes	*Diplognathodus* sp.	Carboniferous or Permian?		Figure not sharp. Very likely to be a misidentification.
		TMNM-14		Miyako	chert	no	*Neogondolella polygnathiformis*	Late Triassic		
		TYM-4		Miyako	chert	yes	*Neogondolella* cf. *navicula navicula*	Late Triassic		Juvenile, difficult to identify. TMNM-14 in figure caption.
						no	*Neospathodus newpassensis*			
38	Yoshida *et al.* (1987)	p. 14	Ehiro *et al.* (2008)	Rikuchu-Ono	chert	no	*Paragondolella polygnathiformis*	Late Triassic	Carnian	
		p. 17		Rikuchu-Seki	limestone	no	*Epigondolella abneptis*	Late Triassic	Norian	
		p. 18		Rikuchu-Seki	chert	no	*Epigondolella abneptis*	Late Triassic	Norian	
						no	*Epigondolella bidentata*			
		p. 19		Rikuchu-Seki	chert	no	*Epigondolella abneptis*	Late Triassic	Norian	
41	Takahashi *et al.* (2007) Illustrations published in Takahashi *et al.* (2009)	Pl. 1, fig. 1 (Takahashi *et al.*, 2009)	Ehiro *et al.* (2008)	Rikuchu-Seki	chert	yes	Permian-type *Neogondolella* sp.	Permian		Narrowed ventral platform: *Clarkina* ?; aboral view only.
		Pl. 1, fig. 2, 3 (Takahashi *et al.*, 2009)		Rikuchu-Seki	siliceous claystone	yes	*Hindeodus parvus*	Early Triassic	Induan	
		Pl. 1, fig. 4 (Takahashi *et al.*, 2009)		Rikuchu-Seki	siliceous claystone	yes	*Neospathodus cristagalli*	Early Triassic	Olenekian	
		Pl. 1, fig. 5 (Takahashi *et al.*, 2009)		Rikuchu-Seki	siliceous claystone	yes	*Neospathodus waageni*	Early Triassic	Olenekian	
43	Yamakita *et al.* (2008)		Ehiro *et al.* (2008)	Rikuchu-Seki	chert	no	*Gondolella clarki*	late Carboniferous	Moscovian	Not mentioned whether fossils were found from one horizon or several different horizons.
						no	*Gondolella gymna*			
						no	*Idiognathodus delicatus*			
						no	*Idiognathoides sinuatus*			
						no	*Diplognathodus atetsuensis*			
						no	*Diplognathodus coloradoensis*			
				Rikuchu-Seki	tuffaceous chert	no	*Gondolella bella*	late Carboniferous	Gzhelian	Not mentioned whether fossils were found from one horizon or several different horizons.
						no	*Streptognathodus elongatus*			
				Rikuchu-Seki	tuffaceous chert	no	*Neogondolella bisselli*	early Permian	Sakmarian or Artinskian	Not mentioned whether fossils were found from one horizon or several different horizons. Sakmarian to Artinskian forms of *S. whitei* are now separated from *S. whitei* and placed in *S.* cf. *asymmetricus* (see Petryshen *et al.*, 2020).
						no	*Sweetognathus* cf. *whitei*			

Table 1 Continued.

	Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
44	Yamakita *et al.* (2004)		Ehiro *et al.* (2008)	Miyako	chert	no	*Neogondolella bulgarica*	Middle Triassic	Anisian	
				Miyako	chert	no	*Neogondolella* cf. *excelsa*	Middle Triassic	Anisian or Ladinian	
				Miyako	chert	no	*Metapolygnathus polygnathiformis*	Late Triassic	Carnian	
				Miyako	chert	no	*Epigondolella* cf. *abneptis*	Late Triassic	Norian?	
				Miyako	chert	no	*Mockina* cf. *bidentata*	Late Triassic	Norian or Rhaetian	
45	Ehiro *et al.* (2008)	Fig.14.5, 14.6	Ehiro *et al.* (2008)	Kado	chert	yes	*Gondolella clarki*	late Carboniferous	Moscovian	Oral or aboral view only.
		Fig. 14.1, 14.2		Kado	chert (partly tuffaceous)	yes	*Mesogondolella* cf. *bisselli*	early Permian	Sakmarian–Artinskian?	Oral or aboral view only; Possibly other low-bladed *Mesogondolella* .
		Fig. 14.3, 14.4				yes	*Sweetognathus* cf. *whitei*			Rostro-caudal view only; *S.* cf. *asymmetricus* (see Petryshen *et al.* , 2020).
		Fig. 22.1–3		Rikuchu-Seki	chert	yes	*Neogondolella* sp.	Permian		Oral or aboral view only.
47	Murata and Nagai (1972)	Pl. 9 Fig. 21–24	Uchino and Suzuki (2020)	Asamushi	limestone	yes	*Epigondolella bidentata*	Late Triassic	Norian or Rhaetian	
		Pl. 9 Fig. 17–20			limestone	yes	*Epigondolella abneptis*	Late Triassic	Norian?	*Mockina* sp. (posterior carina).
49	Murata *et al.* (1974)		Uchino and Suzuki (2020)	Kodomari	chert, limestone	yes	*Gnathodus* cf. *roundyi*	Carboniferous	Moscovian	*Neognathodus roundyi* (current genus name) has narrower platform.
					chert, limestone	yes	*Gondolella clarki*	Carboniferous	Moscovian	Current genus *Mesogondolella* .
					chert, limestone	yes	*Idiognathodus delicatus*	Carboniferous	Moscovian	*I. delicatus* is often mistakenly used for other species.
					chert, limestone	yes	*Polygnathodella* cf. *convexa*	Carboniferous	Moscovian	Current genus *Idiognathoides* .
61	Takahashi *et al.* (2016)	F.L. 1	This study	Kado	chert	yes	*Epigondolella* sp.	Late Triassic	Norian	Probably *Epigondolella* or *Mockina.*
					chert	yes	*Metapolygnathus* cf. *polygnathiformis*	Late Triassic	Carnian	
		F.L. 2			chert	yes	Permian-type *Neogondolella* sp.	Permian		
					chert	yes	Permian-type *Neogondolella* sp.	Permian		
		F.L. 3			chert	yes	*Metapolygnathus* cf. *polygnathiformis*	Late Triassic	Carnian	Possibly *Metapolygnathus* sp.
		F.L. 5			chert	yes	*Metapolygnathus* cf. *polygnathiformis*	Late Triassic	Carnian	Possibly *Metapolygnathus* sp.
		F.L. 4			chert	yes	*Cratognathodus kochi*	Triassic		
		F.L. 8			chert	yes	Permian-type *Neogondolella* sp.	Permian		
62	Peyrotty *et al* . (2022)		This study	Shiriyazaki	limestone-chert alt.		*Epigondolella rigoi*	Late Triassic	Norian (lower)	
63	Muto *et al.* (2023a)		This study	Rikuchu-Seki	chert	yes	*Misikella longidentata*	Late Triassic	Carnian (lowermost)	
					chert	yes	*Paragondolella* cf. *inclinata*			
					chert	yes	*Paragondolella polygnathiformis*			
					chert	yes	*Sephardiella mungoensis*			
64	Muto *et al.* (2023b)		This study	Rikuchu-Seki	chert	yes	*Mesogondolella clarki*	late Carboniferous	Moscovian	
					chert	yes	*Idiognathodus sinuatus*			
					chert	yes	*Gondolella gymna*			

to next page

Table 1 Continued.

	Reference	Locality	First citation	Quadrangle	Lithology	Fig.	taxon (as in original)	Period / Epoch	Stage	notes
64	Muto *et al.* (2023b) continued.		This study	Rikuchu-Seki	chert	yes	*Streptognathodus vitali*	late Carboniferous	Gzhelian	
					chert	yes	*Streptognathodus* cf. *pauhuskaensis*			
					chert	yes	*Streptognathodus elongatus*			Also reported from same section in Muto *et al.* (2021b).
					chert	yes	*Streptognathodus ruzhencevi*			
					siliceous claystone	yes	*Streptognathodus* cf. *bellus*	late Carboniferous	Gzhelian	*S. bellus* reported from same section in Muto *et al.* (2021b).
					siliceous claystone	yes	*Gondolella postdenuda*			
					siliceous claystone	yes	*Streptognathodus constrictus*	early Permian	Asselian	
					siliceous claystone	yes	*Mesogondolella dentiseparata*			
					siliceous claystone	yes	*Mesogondolella belladontae*			
					siliceous claystone	yes	*Mesogondolella striata*			
					chert	yes	*Mesogondolella bisselli*	early Permian	Artinskian	
					chert	yes	*Mesogondolella* cf. *intermedia*			
					chert	yes	*Sweetognathus* cf. *asymmetricus*			
65	Muto *et al* . (2023c)		This study	Rikuchu-Seki	siliceous claystone	yes	*Ellisonia triassica*	Early Triassic	Olenekian	
					siliceous claystone	yes	*Distcretella* cf. *discreta*			
					siliceous claystone	yes	*Neospathodus dieneri*			
					siliceous claystone	yes	*Neospathodus cristagalli*			
					siliceous claystone	yes	*Neospathodus waageni eowaageni*			
					siliceous claystone	yes	*Neospathodus waageni*			
					siliceous claystone	yes	*Eurygnathodus costatus*			
					siliceous claystone	yes	*Guangxidella* cf. *bransoni*			
66	Ehiro (2008)	Fig. 4	This study	Kuzumaki	chert	yes	*Neogondolella foliata*	Middle Triassic	Ladinian	Age revised from original work.
67	Murai *et al.* (1983)	820827-85	This study	Miyako	chert	no		Late Triassic		
		K811007-44		Sotoyama	chert	no		Permian		
		81730-36		Sotoyama	chert	no		Permian		
		81730-39		Sotoyama	chert	no		Middle Triassic		
		81730-40		Sotoyama	chert	no		Middle Triassic		
		81802-05		Sotoyama	chert	no		Middle Triassic		

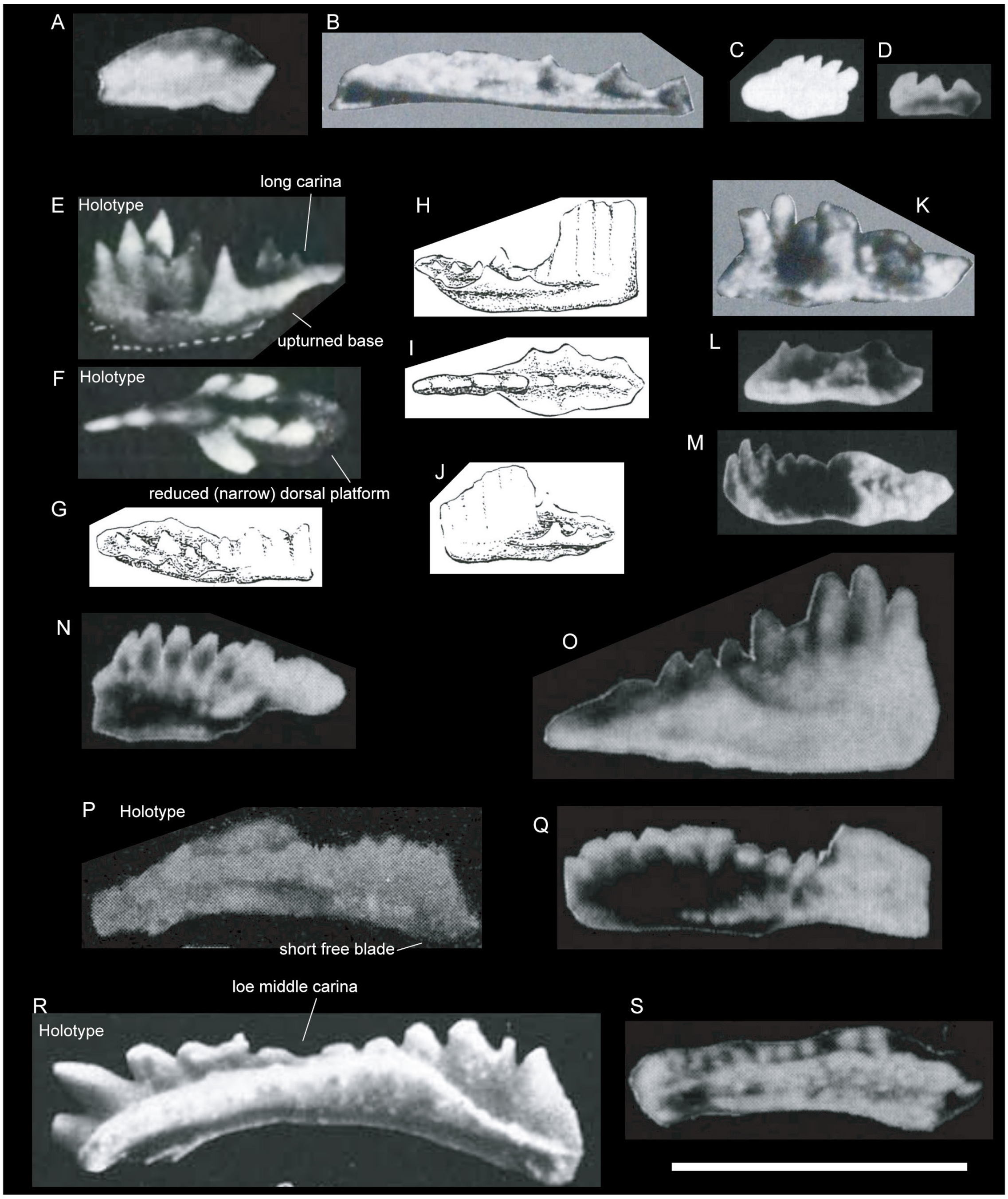

Fig. 9 Images of conodonts from previous studies compared to holotypes. Taxon names are maintained as in original paper. (A) *Neogondolella subcarinata*, Fig. 6.19 of Okami *et al.* (1993), KGW-4. (B) *Neogondolella* cf. *rosenkrantzi*, Pl. 3 Fig. 7 of Murai *et al.* (1985), Loc. 21. (C) *Neogondolella* cf. *constricta*, Fig. 8.6 of Okami (1990), OT-5. (D) *Neogondolella navicula navicula*, Fig. 8.20 of Okami (1990), OT-48. (E, F) Holotype of *Epigondolella postera*, the type species of *Mockina*, from Kozur and Mostler (1971). (E) Lateral view. (F) Oral view. (G–J) *Epigondolella abneptis* of Murata and Nagai (1972) Pl. 9. (G) Fig. 20. (H) Fig. 22. (I) Fig. 17. (J) Fig. 19. (K) *E.* cf. *abneptis* of Murai *et al.* (1985), Pl. 3 Fig. 1, Loc. 20. (L, M) *E.* cf. *abneptis* of Okami (1990), both from OT-10-2. (L) Fig. 8.11. (M) Fig. 8.12. (N, O) *E. abneptis* of Okami *et al.* (1993), both from 900825-7. (N) Fig. 6.9. (O) Fig. 6.10. (P) Holotype of *Gondolella polygnathiformis* from Budurov and Stefanov (1965). (Q) *Neogondolella polygnathiformis* of Okami *et al.* (1993) Fig. 6.18, 900825-7. (R) Holotype of *Gondolella mombergensis* from Tatge (1956). (S) *Neogondolella mombergensis* of Okami *et al.* (1993) Fig. 6.13, KGR-9-D. Scale bar is 500 µm.

and dorsally pointed platform with a carina extending to its end, which is seen in the late Norian genus *Mockina* (Fig. 9E–K). Specimens reported in Okami (1990) can also be placed in *Mockina* for the same reason (Fig. 9L, M). The two specimens in Figs. 6.9 and 6.10 in Okami *et al.* (1993) have respectively stepped and upturned aboral margins (Fig. 9N, O), while the holotype of *E. abneptis* has an arched one. Although this character in their Fig. 6.9 may be due to the immaturity of this specimen and not a taxonomic feature, the other figured specimen can certainly not be regarded as *E. abneptis*.

Epigondolella bidentata, now placed under the genus name *Mockina*, is another species that has been reported from many localities. This species is somewhat potentially problematic because early ontogenetic stages of Late Triassic conodonts with denticulate platforms can appear to be similar (e.g., Mazza and Martínez-Peréz, 2015), and many illustrated conodonts from the North Kitakami Belt are juveniles. On the other hand, at least some occurrences of true *M. bidentata* is confirmed from illustrated specimens (Murata and Nagai, 1972).

Epigondolella primitia, now placed under the genus *Metapolygnathus*, although debatably, have been used for forms now assigned to species of *Carnepigondolella* or *Metapolygnathus* (Mazza *et al.*, 2012; Karádi *et al.*, 2013). True *M. primitius* is considered to be endemic to North America (Mazza *et al.*, 2012). Due to the complete lack of illustrations, it is impossible to evaluate the specimens from the North Kitakami Belt, but it is probably safe to assume that they represent Carnian or Norian (Late Triassic) species.

There are other illustrated conodont specimens with identifications that need to be revised, apart from those mentioned above (refer to Table 1 for full list). In some cases, misidentification is evident, even in the rather poor image quality of the previous studies (Fig. 9P–S). Despite some problematic identifications, age assignment by Triassic conodonts in previous studies seem to be acceptable at the scales of epochs.

6. Conclusions

We investigated a pelagic deep-sea sequence composed of chert and siliceous claystone along the Akka River in Otori, Iwaizumi Town, Iwate Prefecture for conodont biostratigraphy. We identified *Mesogondolella clarki*, *Mesogondolella* aff. *donbasssica*, *Mesogondolella* cf. *bisselli*, *Mesogondolella* cf. *idahoensis*, *Jinogondolella* cf. *palmata*, *Jinogondolella postserrata*, *Sweetognathus iranicus*, *Jinogondolella altudaensis* and *Jinogondolella xuanhanensis* using microfocus X-ray computed tomography. These conodont species indicate the Moscovian of the Pennsylvanian to Capitanian of the Guadalupian for the sedimentary sequence. Comparing the Otori section with the Okoshizawa section, an earlier established pelagic deep-sea sequence in the same tectonostratigraphic unit, there are discrepancies in the stratigraphic distribution of red clayey lithologies. This type of lateral variation in pelagic deep-sea sedimentary rocks has rarely been reported.

We also compiled the reports of conodont occurrences from the North Kitakami Belt. Judging from the dates published, many of the previous reports are based on taxonomic concepts that are out-of-date, but the general lack of clear illustrations makes it impossible to evaluate most of the conodont occurrences. Permian ages of strata based on the occurrence of "Permian-type *Neogondolella*" are particularly problematic, and should be treated with great caution. Most of the species names of Triassic conodonts in the previous studies also do not comply with present taxonomic concepts, but age assignment based on these conodonts are generally acceptable at the epoch-level.

7. Taxonomic notes

(by Shun Muto)

This section is intended to provide objective reference for identification of conodonts and not a full systematic description.

Genus ***Jinogondolella*** Mei and Wardlaw, 1994

Type species ***Gondolella nankingensis*** Ching, 1960

Remarks: Generic distinction of Permian gondollelids is strictly defined by its multielement apparatus (Lambert *et al.*, 2007; Wardlaw and Nestell, 2010). In general, Cisuralian species and most Guadalupian and Lopingian cool-water species are placed in *Mesogondolella*, Guadalupian (mostly warm-water) species typically with serrated platform margins are placed in *Jinogondolella* and Lopingian warm-water species are placed in *Clarkina* (e.g., Henderson, 2018). *Jinogondolella* is the last erected of these three genera. Following this, part of the species included in *Mesogondolella* or *Clarkina* was assigned to *Jinogondolella* (e.g., Mei *et al.*, 1998; Wardlaw and Mei, 1998). While *Jinogondolella* P1 elements typically have serrations, although variably developed, on the ventral portion of the platform margins, our specimens are dominated by unserrated forms.

Jinogondolella altudaensis (Kozur)

(Fig. 7A–E)

1992 *Clarkina altudaensis* — Kozur, p. 103, 105–106, figs. 9–12, 14–17.

Remarks: This species is distinguished by a segminiplanate element with a platform that is biconvex in the dorsal part, rounded at the dorsal end and weakly biconcave in the ventral part due to increased narrowing around the ventral one fourth of the element. The carina is lowest at the middle and the cusp is small and indistinguishable.

Jinogondolella* cf. *palmata Nestell and Wardlaw

(Fig. 7P)

2010 *Jinogondolella palmata* — Nestell and Wardlaw, p. 188–192, pl. 1, figs. 1–26, pl. 2, figs. 1–10, pl. 3, figs. 1–9.

Remarks: This species is distinguished by a segminitpalante element with a broad platform and a carina that is fused in the middle and bears large denticles in the ventral part. Typical forms of this species are widest at the middle and has a cusp that is not distinct, but forms with a platform that is widest in the dorsal area and a distinguishably wide cusp, like the present specimen, are included in this species (e.g., Pl. 7 figs. 2, 6 in Wardlaw and Nestell, 2015).

Jinogondolella postserrata (Behnken)
(Fig. 7J, N)
Jinogondolella* cf. *postserrata (Behnken)
(Fig. 7K)

1975 *Neogondolella serrata postserrata* — Behnken, p. 307–308, pl. 2, figs. 28–36.

Remarks: This species is distinguished by a segminiplanate element with a narrow platform that has subparallel margins in the dorsal half, narrow but distinct furrows, erect cusp and denticles, and a carina that is lowest in the middle and forms a smooth arch in rostro-caudal view. Figure 7K is compared to this species because the cusp and ventral end of platform is partly not visible.

Jinogondolella xuanhanensis (Mei and Wardlaw)
(Fig. 7F, G)

1994a *Mesogonsolella xuanhanensis* — Mei and Wardlaw, p. 33, pl. 3, figs. 2–10, 14.

Remarks: This species is recognized by a segminiplanate element with a narrow platform tapering both ventrally and dorsally from near mid-point, a carina of partly fused denticles and a moderately large cusp.

Genus ***Mesogondolella*** Kozur 1989
Type species ***Gondolella bisselli*** Clark and Behnken, 1971

Remarks: Generally, *Mesogondolella* consists of all gondolellids in the Cisuralian and cold-water gondolellids in the Guadalupian to Lopingian. *Mesogondolella* species in the Pennsylvanian are somewhat problematic, since there is a gap in the stratigraphic record of this genus between the Moscovian and Asselian (Nemyrovska, 2017a; Chernykh, 2005; Muto *et al.*, 2023b). However, the Moscovian species are closer to the Permian *Mesogondolella* in their P1 element morphology compared with the coeval *Gondolella* and are placed in *Mesogondolella* for the time being.

Mesogondolella* cf. *bisselli (Clark and Behnken)
(Fig. 7S, T)

1971 *Gondolella bisselli* — Clark and Behnken, p. 429, pl. 1, figs. 12–14.

Remarks: This species is recognized by a long and narrow segminiplanate element with a low uniform carina and indistinct cusp at the rounded dorsal end.

Mesogondolella clarki (Koike)
(Fig. 7U–W)

1967 *Gondolella clarki* — Koike, p. 301–302, pl. 2, figs. 1–3, 6.

Remarks: This species is characterized by a low, discrete carina, biconvex platform and a cusp of moderate size, the base of which creates a posterior protrusion at the dorsal platform margin.

Mesogondolella* aff. *donbassica (Kossenko)
(Fig. 7X)

2016 *Mesogondolella donbassica* (Kossenko)— Qi *et al.*, fig. 7P.

Remarks: This species, distinguished by the wide, unornamented and round-ended platform and carina that ends short of the dorsal end, was first reported by Kossenko (1975) from the Donets Basin. The holotype has a fused ventral carina and a distinctive gap between the cusp and penultimate denticle. Our specimen has a platform and dorsal denticulation that is similar to *M. donbassica*, but it has more discrete denticles and no gap between the cusp and penultimate denticle, and is regarded as a separate species. Such a form has been reported from the Moscovian of South China (Qi *et al.*, 2016). The name of the author was spelled "Kosenko" in the English title of the original paper, but was spelled "Kossenko" in its systematic section and also in later works including an English paper summarizing the works of Ukranian conodont palaeontologists (Nemyrovska, 2017b).

Mesogondolella* cf. *idahoensis (Youngquist *et al.*)
(Fig. 7Q, R)

1951 *Gondolella idahoensis* — Youngquist, Hawley and Miller, p. 462, pl. 54, figs. 1–3, 14, 15.

Remarks: This species is distinguished by a segminiplanate element with a platform widest in the dorsal part, a squared dorsal margin in oral view, denticles lowering towards the cusp that is positioned at the dorsal end and dominantly higher and thicker than the other denticles. Specimens from near the type locality in Idaho including the holotype have a low ventral carina (Henderson and Mei, 2003, 2007), while forms with high and fused ventral carina are not uncommon elsewhere (Behnken, 1975; Lambert *et al.*, 2007; Zhang *et al.*, 2010). The present specimens from siliceous rocks deposited in pelagic deep Panthalassa belong to the latter type, as are previously recovered specimens from pelagic limestone deposited in Panthalassa (Igo, 1981; Muto *et al.*, 2021a).

Genus ***Sweetognathus*** Clark, 1972
Type species ***Spathognathodus whitei*** Rhodes, 1963

Sweetognathus iranicus Kozur *et al.*
(Fig. 7O)

1975 *Sweetognathus iranicus* — Kozur *et al.*, p. 9–10, pl. 4, figs. 1–10, pl. 5, fig. 1.

Remarks: This species is characterized by a carminiscaphate element with a dorsal platform bearing a continuous carina of node-like denticles with pustular tops and a free blade about half the length of the platform. In our specimen, the free blade appears longer because the aboral part of the platform is broken off.

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岩手県岩泉町大鳥の層状チャートから産出した石炭紀・ペルム紀コノドント化石 ならびに北部北上帯の既報コノドントのレビュー

武藤　俊・高橋　聡・村山　雅史

要　旨

ジュラ紀付加体中の遠洋域深海堆積岩層において，コノドント生層序は世界規模で対比可能な時間軸を与える．北部北上山地は，特にコノドント生層序区分が不完全な古生代の時代に関して研究を進展させうる層序記録を保持している．本報告では，岩手県岩泉町に位置する大鳥セクションと名付けた深海堆積岩セクションにおいて産出したコノドント化石を報告する．コノドント化石はマイクロフォーカスX線CTを用いた手法によって画像を取得した．同定された種は，*Mesogondolella clarki*, *Mesogondolella* aff. *donbassica*, *Mesogondolella* cf. *bisselli*，*Mesogondolella* cf. *idahoensis*，*Jinogondolella* cf. *palmata*，*Jinogondolella postserrata*，*Sweetognathus iranicus*，*Jinogondolella altudaensis*，*Jinogondolella xuanhanensis* である．これらのコノドントはモスコビアン期（ペンシルバニアン亜紀中期，石炭紀）からキャピタニアン期（グアダルピアン世後期，ペルム紀）の年代を示す．本研究ではさらに，先行研究による北部北上山地におけるコノドント産出報告をレビューした．先行研究でも石炭紀後期から三畳紀の時代がコノドント化石をもとに指示されているが，これらのうちペルム紀の年代の大部分は分類記載と画像が示されていないために検証できない．

難読･重要地名

Akka：安家，Okoshizawa：大越沢，Otori：大鳥