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Report

Conodont fossils from the Kiryu and Ashikaga District (Quadrangle series 1:50,000), central Japan with emphasis on the reexamination of "Carboniferous" conodonts from the Ashio Belt

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Abstract: Many conodonts have been reported from the Ashio Mountains, but there have been little attempts to update the information of the specimens based on the present knowledge of conodont taxonomy and biostratigraphy. This study revisits conodont specimens reported from the Kiryu and Ashikaga District in addition to presenting a few newly obtained Early Triassic conodonts. Previously published illustrations allowed reidentification of some conodonts. The geological age of some specimens was revised based on the reidentification. Notably, many of the conodonts previously considered as "Carboniferous" species were revealed to be Permian or Triassic species, and no Carboniferous species were confirmed.

Keywords: conodont, Ashio Mountains, Jurassic accretionary complex, Ashio Belt, reexamination

1. Introduction

The basement rocks of the Ashio Mountains are composed of Palaeozoic and Mesozoic rocks that form the Jurassic accretionary complex of the Ashio Belt (e.g., Kamata, 1996). During the earliest stages of research, the rocks of the Ashio Belt were dated based mainly on fusulinids that occur primarily from limestones (e.g., Fujimoto, 1961). As stratigraphic studies of the Palaeozoic and Mesozoic in Japan commenced, the first conodonts in Japan were found from siliceous, argillaceous and tuffaceous sedimentary rocks the Ashio Belt (Hayashi, 1963). Subsequently, conodonts became acknowledged as useful index fossils due to their occurrence in siliceous and argillaceous rocks in addition to limestones (Igo, 1972). Palaeozoic and Mesozoic conodonts of the Ashio Belt have since been reported by a large number of works, many of which were published before plate tectonics and the concept of accretionary complexes were widely accepted in Japan (Hayashi, 1963, 1964, 1968a, b, 1971; Koike *et al.*, 1971a, b, 1991; Conodont Research Group, 1972, 1974; Hayashi and Hasegawa, 1981; Aono, 1985; Hayashi *et al.*, 1990; Kamata and Kajiwara, 1996; Motoki and Sashida, 2004; Muto *et al.*, 2018, 2021; Ito, 2019, 2020a; Ito *et al.*, 2021a, b).

The conodonts obtained from the Ashio Belt have been valued as a means of age determination, which is vital information for interpretation of sedimentary and tectonic history. For instance, early studies used the geochronological information of conodonts in an attempt to interpret the history of sedimentation in the Ashio Mountains in the context of geosynclines (Conodont Research Group, 1972). On the other hand, conodonts provided evidence of the thrusting of Palaeozoic strata onto Mesozoic strata, ultimately leading to the recognition of accretionary complexes (Koike *et al.*, 1971a, b, 1974; Yanagimoto, 1973; Kamata, 1996, 1997). Following the wide acceptance of subduction-accretion as the origin of the Ashio Belt, conodonts were mainly used as a means to reconstruct the oceanic plate stratigraphy (see Isozaki *et al.*, 1990 for terminology). Due to its widespread occurrence and high evolutionary rates, conodonts allowed researchers to determine the age of Palaeozoic to Triassic rocks in the Ashio Belt that have undergone extensive tectonic deformation and thus are otherwise difficult to understand in a stratigraphic context (Koike *et al.*, 1971a, b, 1991; Igo, 1981; Aono, 1985; Kamata and Kajiwara, 1996; Motoki and Sashida, 2004; Muto *et al.*, 2018, 2021). One of the notable results by previous studies is the occurrence of early Carboniferous or even Devonian conodonts from chert and limestone (Hayashi *et al.*, 1990; Editorial team of Omama Town's history, 1996), which is far older than the oldest radiolarians reported from the Ashio Belt (early Permian; Kamata, 1996; Ito, 2019, 2020a).

Most studies on conodonts in the Ashio Belt were

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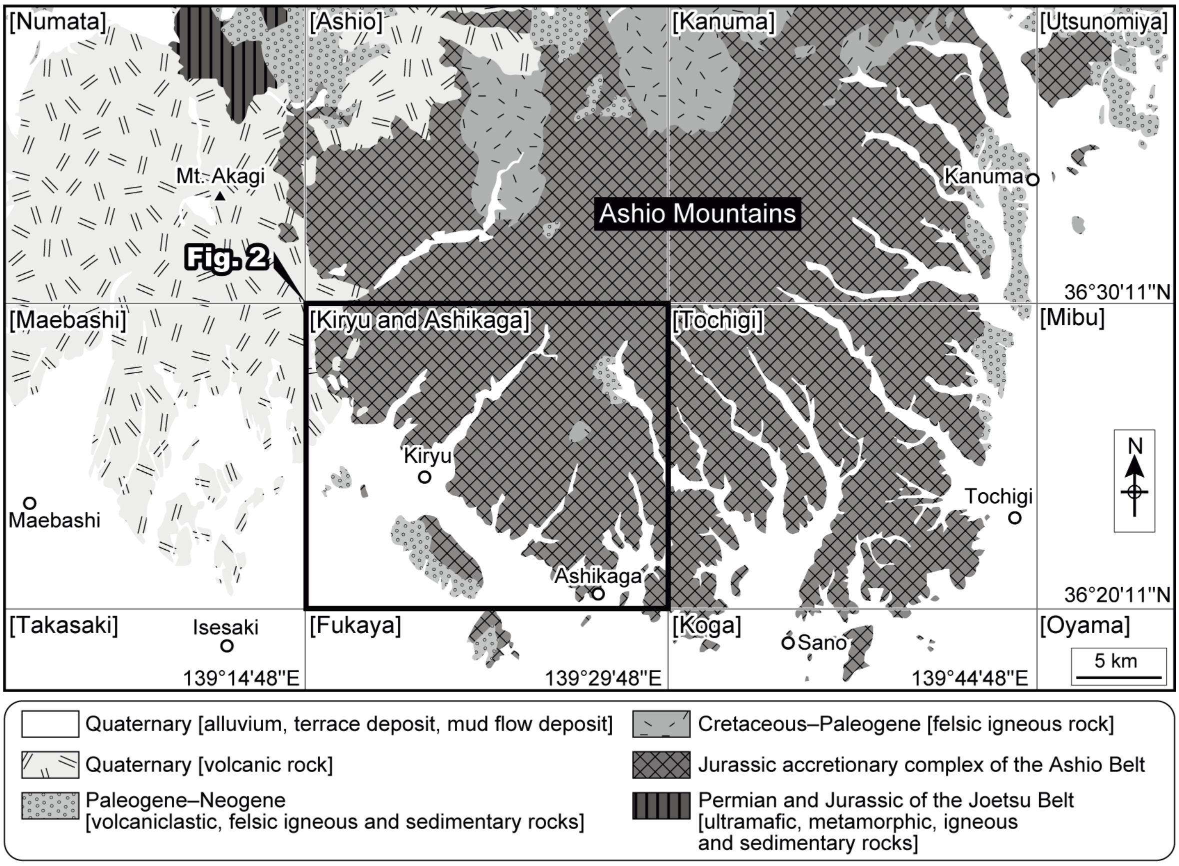


Fig. 1 Index and simplified geologic maps of the Ashio Mountains (modified after from Sudo *et al.*, 1991; Geological Survey of Japan, AIST, 2018). Geographical names in brackets indicate 1:50,000 topographic maps published by Geospatial Information Authority of Japan.

conducted until the beginning of the 1990s. While such studies are still informative, interpreting their results based on the current knowledge of conodonts is somewhat problematic. This is because major refinements in the taxonomy of conodonts have taken place in the last three decades, which have modified the chronological significance of some taxa. For example, Permian platform conodonts previously assigned to the genus *Gondolella* (as in Clark and Mosher, 1966) were split into *Mesogondolella*, *Jinogondolella* and *Clarkina* (Kozur, 1989; Mei and Wardlaw, 1994). Triassic platform conodonts also underwent major taxonomic revisions, and genera such as *Paragondolella* and *Carnepigondolella* are now widely accepted (e.g., Chen *et al.*, 2016). Late Triassic conodonts have recently attracted particular attention, with some debates still continuing today. For instance, Orchard (2013, 2014, 2019) revised the taxonomy of species belonging to *Paragondolella*, *Metapolygnathus*, *Carnepigondolella* and *Epigondolella*, and erected five new genera *Quadralella*, *Parapetella*, *Kraussodontus*, *Acuminatella* and *Primatella*, while Mazza *et al.* (2018) questioned the validity of genera such as *Quadralella*.

The refinements in the taxonomy of conodonts inevitably modify the age assignment of some conodonts previously reported from the Ashio Belt. In this study, we reinvestigate the chronological significance of previously reported conodonts from the Kiryu and Ashikaga District (Quadrangle series 1:50,000). We also report new occurrences of Early Triassic conodonts from the area. The up-to-date chronological information of conodonts provided in this study is valuable when considering the oceanic plate stratigraphy of the Ashio Belt.

2. Geological Setting

The Jurassic accretionary complex of the Ashio Belt (eastern part of the Tamba–Mino–Ashio Belt) is widely distributed in the Ashio Mountains (Fig. 1; Yamakita and Otoh, 2000; Isozaki *et al.*, 2010; Kojima *et al.*, 2016). Kamata (1996) classified the Jurassic accretionary complex of the Ashio Belt into the Kurohone–Kiryu, Omama and Kuzu complexes. Ito (2021a, this volume) newly recognised the Gyodosan Complex.

Detailed description of the lithofacies of each complex is provided in Ito (2021a), but below is a brief summary. The Kurohone–Kiryu Complex is composed of broken to coherent facies of chert and mudstone with minor amounts of siliceous claystone. The mudstone of this complex is characterised by slaty cleavage. The Omama Complex is composed of broken to mixed facies of mafic rocks, chert and pelitic mixed rocks. The Kuzu Complex is composed of coherent to broken facies of chert, siliceous claystone, siliceous mudstone, mudstone and sandstone. The Gyodosan Complex is composed mainly of pelitic mixed rocks and chert accompanied by minor amounts of siliceous mudstone, mudstone and sandstone. The age of the formation of these complexes inferred from age-diagnostic radiolarians is late Middle Jurassic for the Kurohone–Kiryu, Omama and Gyodosan complexes and Late Jurassic for the Kuzu Complex (Ito, 2021b, this volume).

3. Methods

The taxonomy of the conodonts reported in previous studies were reinvestigated based on published text and illustrations. When images were not available, the taxon names are simply modified to the presently used scientific name. For Late Triassic conodonts, the taxonomy of which is still much debated, we will follow Mazza *et al.* (2012, 2018).

The newly obtained conodonts were found from siliceous claystone in the study area. The conodonts were obtained by the chip method (Muto *et al.*, 2018, 2019), in which conodonts are found by examining the surface of rocks cleaved parallel to the bedding.

Individual conodont elements are dismembered parts of a skeletal feeding apparatus, and pectiniform elements of the P1 position are generally used to distinguish a taxon. However, elements from other positions that are described as form taxa are also useful in biostratigraphy. Such form taxa are referred to in brackets (e.g., "*Neohindeodella benderi*").

4. Newly obtained conodonts and their geological age

We obtained Early Triassic conodonts from siliceous claystone exposed in Ban-yama and Kaizawa near the border of Tochigi and Gunma prefectures (Fig. 2).

From the Ban-yama locality, we obtained the form species "*Neohindeodella benderi* (Kozur and Mostler)" (Fig. 3.1). "*Neohindeodella benderi*" has been reported from the same locality by Sahida *et al.* (1992). This species is known from the latest Olenekian (late Spathian) to middle Anisian (early Bithynian) in carbonates and deep-sea siliceous rocks of pelagic Panthalassa found in Japan (Koike, 1981; Muto *et al.*, 2018, 2019). Identical ramiform elements have also been reported from Spathian Tethyan limestone in Oman (Agematsu *et al.*, 2008).

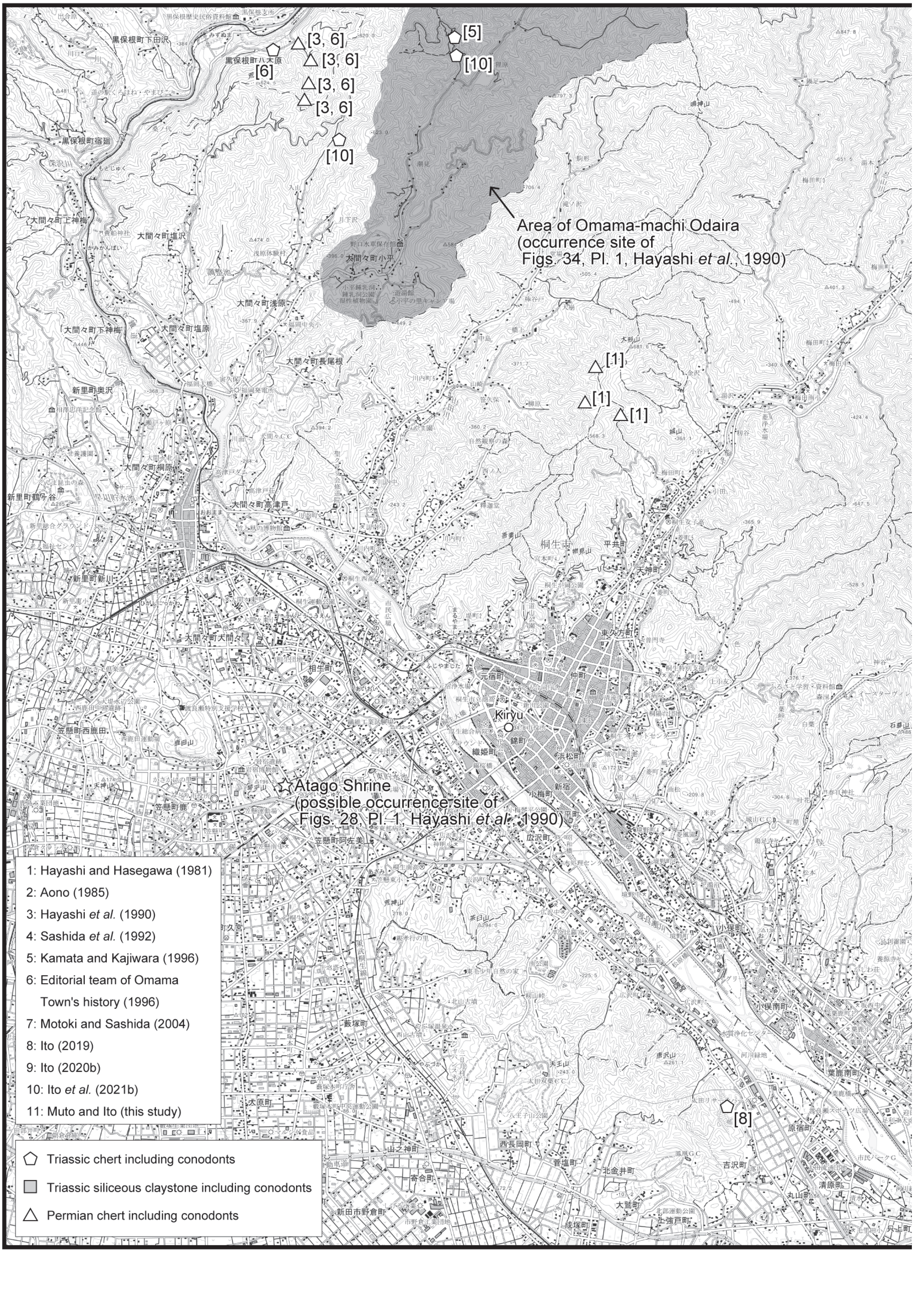
From the Kaizawa locality, we obtained *Triassospathodus abruptus* (Orchard), *Triassospathodus homeri* (Bender) and *Triassospathodus unialatus* (Mosher) (= *Neospathodus symmetricus* Orchard; see Taxonomic Notes) (Fig. 3.2–7). These species are known from the Spathian in pelagic carbonates and deep-sea siliceous rocks in Japan (Koike, 1981; Maekawa *et al.*, 2018; Muto *et al.*, 2018, 2019). They also occur from Spathian strata in South China (e.g., Zhao *et al.*, 2007; Lehrmann *et al.*, 2015), Vietnam (Maekawa and Igo, 2014), North America (Orchard, 1995), north India (Matsuda, 1983) and elsewhere (Orchard, 1995). Hence, these species are considered as globally useful indicators of the Spathian (Orchard, 2007), although *T. homeri* and *T. unialatus* occur partly from the lowermost Anisian (Orchard, 1995; Goudemand *et al.*, 2012; Lehrmann *et al.*, 2015; Ovtcharova *et al.*, 2015). The same Spathian age is indicated by conodonts for Section 2 of Motoki and Sashida (2004), which is situated ~1.3 km to the southwest of the Kaizawa locality. In addition to the age, the attitude of the bedding plane and lithofacies of our Kaizawa locality are also similar with that of Section 2 of Motoki and Sashida (2004). Therefore, the former is considered as a lateral extension of the latter.

5. Revision of the taxonomy of previously reported conodonts

In this chapter, we mention the identification of specimens with illustrations, with emphasis on chronologically significant specimens. Unfortunately, only a few studies present photographs and, even when they are available, the poor image quality and limited picture angle hinder detailed identification in most cases. For full results, the reader is referred to Table 1. Which complex a sample belongs to is considered on the basis of Ito (2021a).

Hayashi *et al.* (1990) illustrated several conodonts which they assigned to the early Carboniferous, but they include specimens that are misidentified Late Triassic conodonts. For example, Figures 44, 46 and 49 in the plate of Hayashi *et al.* (1990) are segminiplanate elements with a well-developed keel on the lower surface and a forward-shifted pit. Such traits are characteristic to Triassic gondolellids and are clearly different from Palaeozoic segminiplanate elements that have poorly developed keels and terminal pits; Figure 44 in the plate can be compared with the Carnian conodont *Paragondolella noah* (Hayashi) and Figure 49 is comparable with juvenile forms of Carnian *Paragondolella*. Figures 45, 50, 51 and 52 in the plate of Hayashi *et al.* (1990) have platform ornamentations that are characteristic to Triassic conodonts, although the keel and pit are not clearly observable due to the picture angle.

Some segminiplanate elements in the Plate of Hayashi *et al.* (1990) were identified as the late Carboniferous *Mesogondolella clarki* (Koike), but none of them are identical to this species. Figures 28, 32 and 34 have more closely spaced posterior denticles and higher and more fused anterior denticles compared to *M. clarki*. Of these, Figures 28 and 34 are comparable to *Mesogondolella gujioensis* (Igo), while Figure 32 cannot be identified. The locality of the specimen in Figure 28 was noted as "Omama Town, Atago-jinjiya". This is possibly Atago Shrine in Kasagake-cho Azami, Midori City (Fig. 2),


[3, 6]
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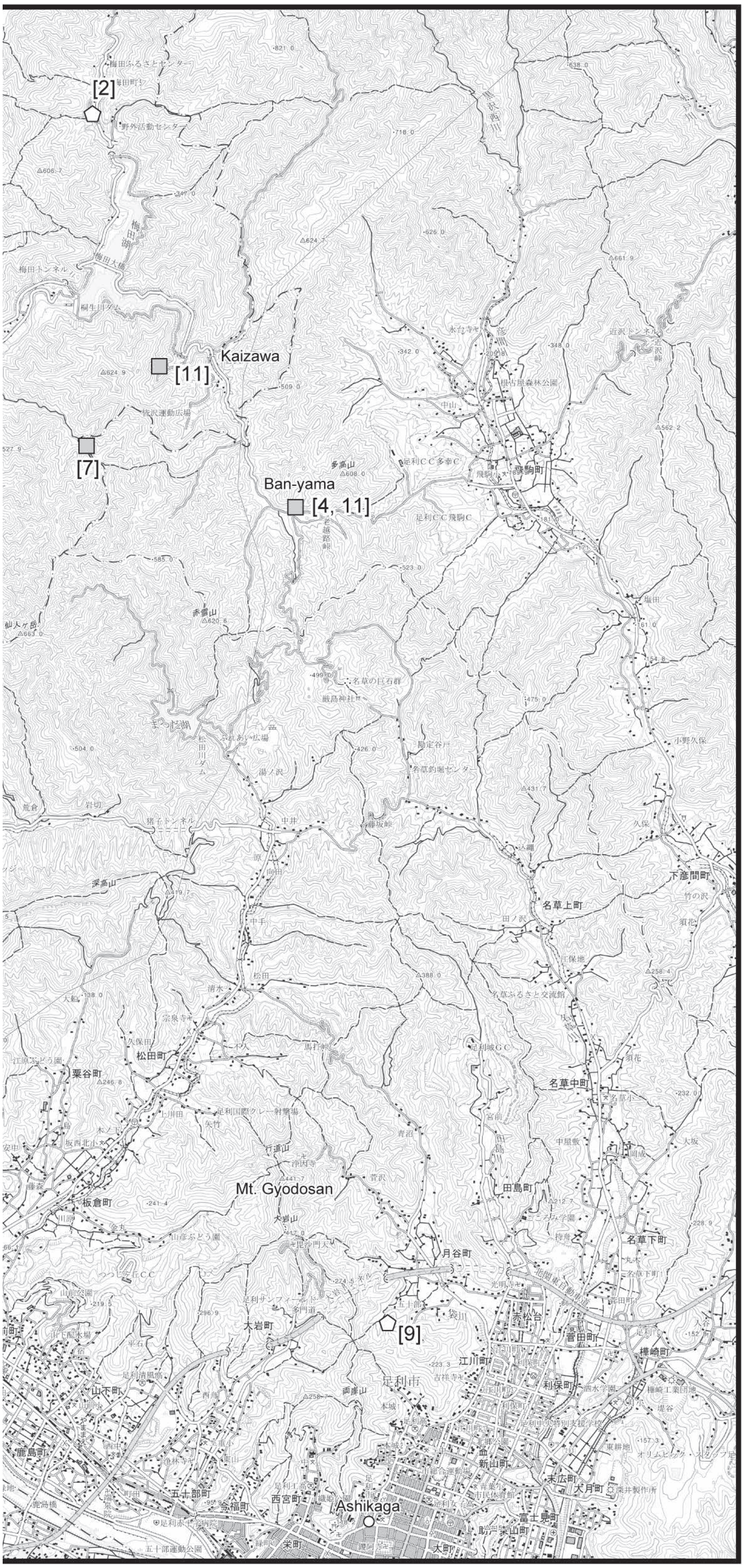
[10]
[10]
Area of Omama-machi Odaira
(occurrence site of
Figs. 34, Pl. 1, Hayashi *et al.*, 1990)
[1]
[1]
[1]
Kiryu
Atago Shrine
(possible occurrence site of
Figs. 28, Pl. 1, Hayashi *et al.*, 1990)
[8]
1: Hayashi and Hasegawa (1981)
2: Aono (1985)
3: Hayashi *et al.* (1990)
4: Sashida *et al.* (1992)
5: Kamata and Kajiwara (1996)
6: Editorial team of Omama Town's history (1996)
7: Motoki and Sashida (2004)
8: Ito (2019)
9: Ito (2020b)
10: Ito *et al.* (2021b)
11: Muto and Ito (this study)
Triassic chert including conodonts
Triassic siliceous claystone including conodonts
Permian chert including conodonts



(p. 328, 329)

Fig. 2 Conodont occurrence sites of the present and previous studies in the Kiryu and Ashikaga District (Quadrangle series 1:50,000).
Base from the Geospatial Information Authority of Japan with its approval (Approval number: R2JHs 66-GISMAP 44702). This map uses GISMAP 50000R+ "Kiryu and Ashikaga" by Hokkaido-Chizu Co. Ltd.

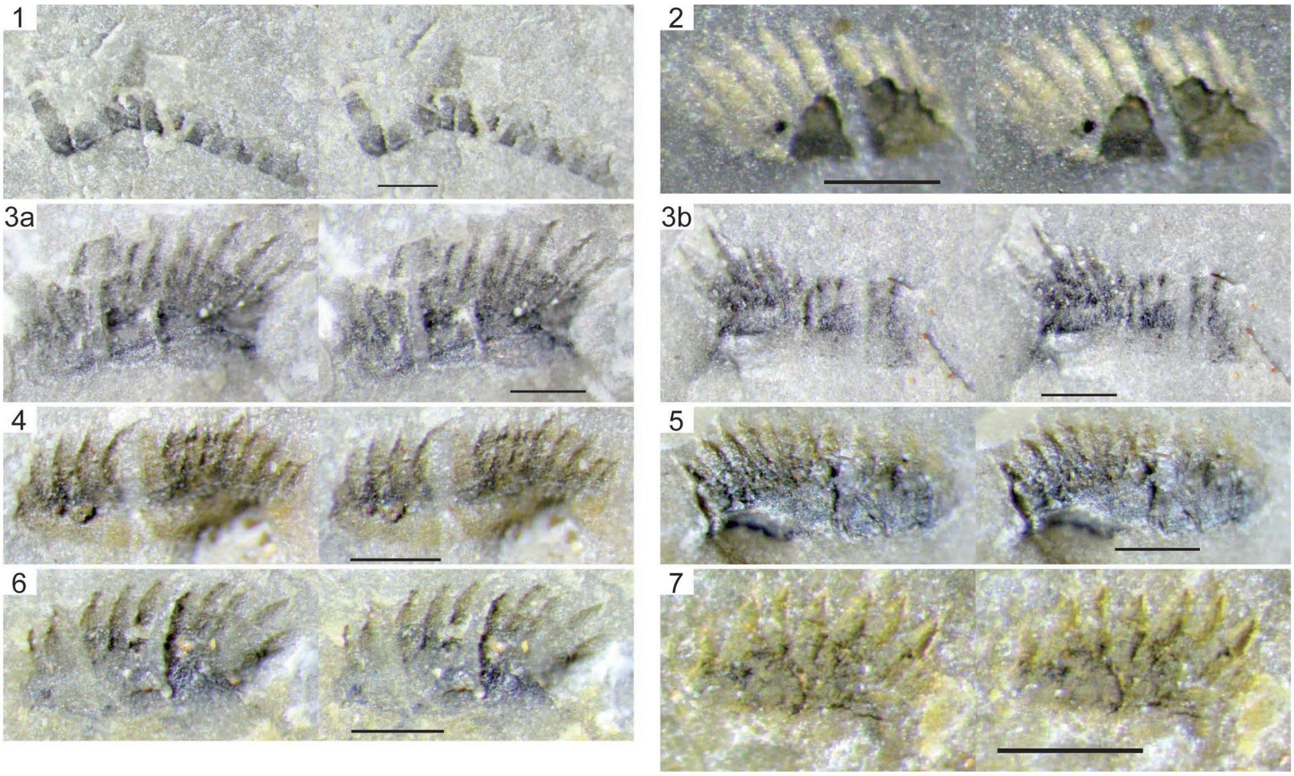


Fig. 3 Stereo-photographs (parallel view) of conodonts obtained in this study. Figure 2 is normally arranged. 3a and 3b are counterparts. All other figures are reversely arranged so that the moulds appears as casts. Scale bars are 200 µm.
1: “*Neohindeodella benderi* (Kozur & Mostler)” (form species). Ban-yama Mine.
2, 3: *Triassospathodus abruptus* (Orchard). 2. K96-2-B. 3. K96-2-A.
4: *Triassospathodus homeri* (Bender). K96-2-A.
5, 6: *Triassospathodus unialatus* (Mosher). K96-2-A.
7: *Triassospathodus* sp. K96-2-A.

where chert outcrops are exposed. This locality is within the area of distribution of the Kurohone–Kiryu Complex (Ito, 2021a). The locality of the specimen in Figure 34 was noted as “Omama Town, Odaira”. The current area of Omama-cho Odaira is around the upper reaches of the Odaira River (Fig. 2), which is within the area where the Omama Complex is distributed (Ito, 2021a). Figures 29 and 30 were also identified as *M. clarki*, but they are both significantly different from this species: the former in lacking a posterior protrusion of the platform and having a smaller basal cavity and the latter in having parallel sides of the posterior platform. In addition, some other specimens that Hayashi *et al.* (1990) considered as Carboniferous species appear similar to species of *Neostreptognathodus* (Figures 38, 39 and 40) and *Pseudosweetognathus* (Figure 42), which both indicate the Permian (Kungurian to Roadian).

To summarise the above, there are no illustrated specimens that indicate the Carboniferous Period and many that were considered to be so are in fact Permian or Triassic conodonts. To be meticulous, it may be inaccurate to conclude that all the conodonts assigned to the Carboniferous are erroneously identified, since some of the illustrated conodonts have not been confidently reidentified. In addition, the age of the “Carboniferous” limestone in Hayashi *et al.* (1990) was also supported by the occurrence of corals (Fujimoto, 1960). However, the conclusion is that none of the illustrations in the previous studies can be undoubtedly identified as Carboniferous conodonts. The oldest conodonts according to our reinvestigation is the late Artinskian to early Kungurian (middle Cisuralian) *M.* cf. *gujioensis* from the Kurohone–Kiryu and Omama complexes.

Hayashi *et al.* (1990) also illustrated some Triassic conodonts. While the age assignment need not be modified, some elements can be reidentified. Figures 4 and 6 in the plate of Hayashi *et al.* (1990) have the triangular shaped, anteriorly denticulate but posteriorly inornate platform diagnostic to the Late Triassic *Epigondolella rigoi* Noyan and Kozur. Figure 5 in the plate has a round and denticulate platform diagnostic to the Late Triassic *Epigondolella spatulata* (Hayashi).

Sashida *et al.* (1992) and Motoki and Sashida (2004) illustrated conodonts obtained from siliceous claystone, which were identified as Spathian species. While we agree with the age assignment, as supported by conodonts

Table 1 List of conodonts from the Kiryu and Ashikaga District (Quadrangle series 1:50,000) reported in previous studies (re-identified in this study) and this study. For specimens with no available images, modification of scientific names was made simply by replacing old taxon names with modern ones when possible (shown in grey). For assignments of samples to tectonostratigraphic divisions, see Ito *et al.* (2021a) in this volume. Question marks (?) following a species name or the abbreviation sp. shows that the identification of the specimen is questionable. Taxon names in quotation marks (e.g., "Subbyranthodus sp.") are form species defined by discrete elements rather than multielement apparatuses.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
Hayashi (1964)								
1	siliceous claystone		*Lonchodus* sp.	yes				
2	siliceous claystone		*Neoprioniodus* sp.	yes	ramiform dygirate			
3	siliceous claystone		*Lonchodina* sp.	yes	"*Subbyranthodus* sp."			"*Lonchodina*" is a ramiform element, while the specimen is an angulate element.
Hayashi and Hasegawa (1981)								
1	limestone	Omama (Lower part)	*Idiognathodus* sp. cf. *I. attenuata* Harris and Hollingsworth	no	*Idiognathoides* cf. *attenuatus* (Harris and Hollingsworth)	early Carboniferous	middle Carboniferous?	
			Idiognathodus sp. cf. *I. convexa* (Ellison and Craves)	no	*Idiognathoides* cf. *convexus* (Ellison and Craves)		middle Carboniferous?	
			Cavusgnathus sp. cf. *C. noduliferus* Ellison and Craves	no	*Declinognathodus* cf. *noduliferus* (Ellison and Graves)		middle Carboniferous?	
			Gnathodus sp. cf. *G. bilineatus* (Roundy)	no			middle Carboniferous?	*Gnathodus bilinieatus* is a latest Mississippian to earliest Pennsylvanian species.
			Gnathodus sp. cf. *G. ouachitensis* (Harlton)	no	*Idiognathoides* cf. *ouachitensis* (Harlton)		middle Carboniferous?	
			Polygnathus sp. cf. *P. flabellus* Branson and Mehl	no				
			Anchignathodus sp.	no				
2	limestone	Omama (Lower part)	*Gnathodus* sp. cf. *G. nodosus* Bischoff	no	*Lochriea* cf. *nodosa* (Bischoff)		middle Carboniferous?	*Lochriea nodosa* is a latest Mississippian to earliest Pennsylvanian species.
			Polygnathus sp. cf. *P. symmetrica* Branson	no	*Polygnathus* cf. *symmetricus* (Branson)			
3	limestone	Omama (Lower part)	*Gnathodus* spp.	no		late Carboniferous–early Permian		
4	limestone	Omama (Lower part)	*Gondolella* sp. cf. *G. clarki* Koike	no	*Mesogondolella clarki* (Koike)			
			Gondolella spp.	no				
5	limestone	Omama (Lower part)	flagments only	no				
6	limestone	Omama (Lower part)	*Gondolella* sp. cf. *G. clarki* Koike	no	*Mesogondolella clarki* (Koike)			
7	limestone	Omama (Lower part)	*Gondolella* spp.	no				
8	limestone	Omama (Lower part)	flagments only	no				

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
9	chert	Omama (Lower part)	*Gondolella* sp. cf. *G. clarki* Koike	no	*Mesogondolella* cf. *clarki* (Koike)	late Carboniferous–early Permian		
			Gondolella bisselli ~ *G. idahoensis* (intermediate)	no	*Mesogondolella intermedia* (Igo)			
			Gnathodus spp.	no				
			Anchignathodus sp.	no				
10	chert	Omama (Lower part)	*Gondolella bisselli* ~ *G. idahoensis* (intermediate)	no	*Mesogondolella intermedia* (Igo)	late Carboniferous–early Permian		
			Gondolella spp.	no				
11	chert	Omama (Lower part)	*Gnathodus* spp.	no				
Aono (1985)								
U3	chert	Kurohone–Kiryu (Lower part in the Kiryu area)	*Epigondlella primitia* Mosher	no	*Metapolygnathus primitius* (Mosher)	Middle Triassic	Late Triassic (late Carnian–early Norian)	
Hayashi *et al.* (1990) Tables								
80	chert	Omama (Lower part)	*Neogondolella* sp. cf. *N. regale*	no		Middle Triassic		
			Neospathodus spp.	no				
			Gladigondolella tethydis	no				
			Metapolygnathus sp. cf. *M. truempyi*	no	*Sephardiella* cf. *truempyi*		Middle–Late Triassic (Ladinian–earliest Carnian)	*Sephardiella* is the senior synonym of *Budurovignathus* .
			Metapolygnathus sp. cf. *M. permica*	no	*Carnepigondolella* ? cf. *permica*		Late Triassic?	
			Metapolygnathus abneptis	no	*Carnepigondolella* sp., *Epigondolella* sp. or *Metapolygnathus* sp.		Late Triassic?	
			Metapolygnathus sp. cf. *M. nodosus*	no	*Carnepigondolella* cf. *nodosa*		Late Triassic?	
			Cypridodella spp.	no				
			Lonchodina spp.	no				
			Parachirognathus sp.	no			Early Triassic?	*Parachirognathus* is an Early Triassic genus.
			Prioniodina spp.	no				
81	chert	Omama (Lower part)	*Neogondolella* sp. cf. *N. bisselli*	no	*Mesogondolella* cf. *bisseli*	middle Permian	early Permian?	*M. bisseli* is an early Permian (late Sakamarian–Artinskian) species.
			Neogondolella sp. cf. *N. rosenkrantzi*	no	*Mesogondolella* ? cf. *rosenkrantzi*		late Permian?	*M. rosenkrantzi* is a late Permian (Wuchapingian–early Changhsingian) species.
			Anchignathodus sp.	no				
			Enantiognathus sp.	no				
			Lonchodina sp.	no				

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
82	chert	Omama (Lower part)	*Neogondolella* sp. cf. *N. bisselli*	no	*Mesogondolella* cf. *bisseli*	early–middle Permian		
			Neogondolella sp. cf. *N. excelsa*	no			?	*Paragondolella excelsa* is a Middle Triassic (late Anisian–early Ladinian) species.
			gondolellids	no				
			Cypridodella sp.	no				
			Ozarkodina sp.	no				
			Parachirognathus sp.	no			?	*Parachirognathus* is an Early Triassic genus.
83	chert	Omama (Lower part)	*Gladigondolella tethydis*	no		Permian	Middle–Late Triassic	Slender but vertically thick platform, position of cusp and pit with respect to platform and keel make *G. tethydis* correctly identified even in early studies (e.g. Hayashi, 1968).
			Priniodina sp.	no				
84	chert	Omama (Lower part)	*Prioniodella* sp.	no		-		
Hayashi *et al.* (1990) Plate								
2	chert	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neogondolella navicula*	yes	*Norigondolella navicula* (Huckriede)?	Triassic	Late Triassic?	Upper view only, but it is similar to *N. navicula.*
3	chert	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neogondolella navicula*	yes	*Norigondolella* sp.?	Triassic	Late Triassic?	Lower view only, but is similar to *Norigondolella.*
4	limestone	Kurohone–Kiryu (Kurohone area)	*Metapolygnathus* sp.	yes	*Epigondolella* cf. *rigoi* (Budurov)	Triassic	Late Triassic (latest Carnian–Norian)	Posterior platform is not completely flat as in typical *E. rigoi*. Possibly transitional to *E. triangularis*.
5	chert	Possibly Kurohone–Kiryu (Kurohone area)	*Metapolygnathus* sp.	yes	*Epigondolella spatulata* (Hayashi)	Triassic	Late Triassic (Norian)	
6	chert	Possibly Kurohone–Kiryu (Kurohone area)	*Metapolygnathus* sp. nov.	yes	*Epigondolella* cf. *rigoi* Noyan & Kozur	Triassic	Late Triassic (latest Carnian–Norian)	
7	chert	Gyodosan	*Misikella* sp.	yes	not changed	Triassic	Late Triassic (latest Norian–Rhaetian)	
8	chert	Gyodosan	*Misikella* sp.	yes	*Misikella hernsteini* (Mostler)	Triassic	Late Triassic (latest Norian–Rhaetian)	Termianl cusp; denticles decline in height towards cusp (apart form anteriormost); four denticles.
9	chert	Omama (Lower part)	*Neogondolella* sp. A	yes	*Mesogondolella* sp.?	Permian	Permian?	
10	chert	Omama (Lower part)	*Neogondolella* sp. B	yes	*Mesogondolella* sp.	Permian	late Carboniferous–early Permian	Low keel, terminal pit.
11	chert	Omama (Lower part)	*Neogondolella* sp. C	yes	*Mesogondolella* sp.?	Permian	Permian?	

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
12	chert	Omama (Lower part)	*Neogondolella* cf. *idahoensis*	yes	*Mesogondolella* cf. *idahoensis* (Youngquist et al.)	Permian	Cisuralian (Kungurian)	Low carina, terminal large and high cusp.
13	chert	Omama (Lower part)	*Gnathodus* sp.	yes	*Sweetognathus* sp.	Permian	Cisuralian–Guadalupian	upper and basal margins meet at the posterior end.
14	chert	Possibly Kurohone–Kiryu (Kurohone area)	*Gnathodus* sp.	yes	carminiscaphate element	Permian	Permian?	*Sweetognathus* sp.? Basal margin broken. Could also be *Gullodus* sp.
15	chert	not mentioned	not mentioned	yes	*Hindeodus permicus*	Permian	Cisuralian (late Kungurian)	Erect anterior and posterior margins. Small denticles at the posterior end.
16	chert	Possibly Kurohone–Kiryu (Kurohone area)	*Neogondolella* cf. *serrata*	yes	*Jinogondolella nankingensis* ?	Permian	Guadalupian?	Platform serreation is not clearly observable, and misidentification cannot be ruled out.
17	chert	Possibly Kurohone–Kiryu (Kurohone area)	*Neogondolella* cf. *serrata*	yes	*Jinogondolella nankingensis* ?	Permian	Guadalupian?	Platform serreation is not clearly observable, and misidentification cannot be ruled out.
18	chert	Kurohone–Kiryu (Kurohone area)	*Neogondolella* sp.	yes	*Mesogondolella* sp. or *Neogondolella* sp.	Permian	Permian or Triassic	Lower surface not visible.
19	chert	Kurohone–Kiryu (Kurohone area)	*Neogondolella* cf. *serrata*	yes	*Mesogondolella* sp. or *Neogondolella* sp.?	Permian	Permian or Triassic?	Platform serreation is not visible.
20	chert	Kurohone–Kiryu (Kurohone area)	*Neogondolella* sp. nov.	yes	segminiplanate element	Permian	?	Lower surface not visible.
21	chert	Kurohone–Kiryu (Kurohone area)	*Neogondolella* sp.	yes	*Mesogondolella* sp.?	Permian	Permian?	Partly covered.
22	chert	Possibly Kurohone–Kiryu (Kurohone area)	*Gnathodus* sp.	yes	carminiscaphate element	Permian	Permian?	
23	chert	Possibly Kurohone–Kiryu (Kurohone area)	*Neogondolella* sp.	yes	*Mesogondolella* sp.?	Permian	Permian?	
24	chert	Kurohone–Kiryu (Kurohone area)	*Neogondolella* sp.	yes	*Jinogondolella* sp.?	Permian	Permian?	Weak serretion on anterior platform. Lower Surface not visible.
25	chert	Kurohone–Kiryu (Kurohone area)	*Neogondolella* sp.	yes	*Jinogondolella* sp.?	Permian	Permian?	
26	chert	Kurohone–Kiryu (Kurohone area)	*Neogondolella* sp.	yes	Segminiplanate element	Permian	?	
27	chert	Kurohone–Kiryu (Kurohone area)	*Gnathodus* sp. & *Neogondolella* sp.	yes	Carminiscaphate element & segminiplanate element	Permian	Permian?	Possibly *Gullodus* sp. & *Mesogondolella* sp.
28	chert	Kurohone–Kiryu (possibly Upper part in the Kiryu area)	*Neogondolella* cf. *clarki*	yes	*Mesogondolella* cf. *gujioensis* (Igo)	Carboniferous	Cisuralian (late Artinskian–early Kungurian)	Posterior denticles more closely spaced than *M. clarki* . Anterior denticles more fused and higher than *M. clarki* .

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
29	chert	Kurohone–Kiryu (possibly Upper part in the Kiryu area)	*Neogondolella* cf. *clarki*	yes	*Mesogondolella* sp. not *M. clarki* .	Carboniferous	Permian?	*M. clarki* has the basal part of cusp forming a conspicuous posterior protrusion at posterior end of platform and a larger basal cavity.
30	limestone	Omama (Lower part)	*Neogondolella* cf. *clarki*	yes	Not *M. clarki* .	Carboniferous	Permian?	Parallel-sided platform.
31	limestone	Omama (Lower part)	*Neogondolella* cf. *clarki*	yes	*Mesogondolella* sp.?	Carboniferous	Permian?	
32	limestone	Omama (possibly Upper part)	*Neogondolella* cf. *clarki*	yes	Not *M. clarki* .	Carboniferous	?	Posterior denticles more closely spaced than *M. clarki* . Anterior denticles more fused and higher than *M. clarki* .
33	limestone	Omama (possibly Upper part)	*Neogondolella* cf. *clarki*	yes	*Mesogondolella* sp.?	Carboniferous	Permian?	
34	chert	Omama (Lower part)	*Neogondolella* cf. *clarki*	yes	*Mesogondolella* cf. *gujioensis* (Igo)	Carboniferous	Cisuralian (late Artinskian~early Kungurian)	Posterior denticles more closely spaced than *M. clarki* . Anterior denticles more fused and higher than *M. clarki* .
35	limestone	Omama (Lower part)	*Gnathodus* sp.	yes	*Sweetognathus* sp. or *Gullodus* sp. or *Hindeodus* sp.	Carboniferous	Permian?	
36	limestone	Omama (Lower part)	*Gnathodus* sp.	yes	*Hindeodus* sp.?	Carboniferous	?	Image too small.
37	limestone	Omama (Lower part)	*Gnathodus* sp.	yes	?	Carboniferous	?	
38	limestone	Omama (Lower part)	*Gnathodus* sp.	yes	*Neostreptognathodus* sp.?	Carboniferous	Permian? (Kungurian –Roadian?)	
39	limestone	Omama (Lower part)	*Streptognathodus* sp.	yes	*Neostreptognathodus* sp.?	Carboniferous	Permian? (Kungurian –Roadian?)	
40	limestone	Omama (Lower part)	*Cavusgnathodus* sp.	yes	*Neostreptognathodus* sp.?	Carboniferous	Permian? (Kungurian –Roadian?)	Connection of blade and carina needs to be visible for confirmation of *Cavusgnathus* .
41	limestone	Omama (Lower part)	*Neospathodus* sp.	yes	Carminiscaphate element?	Carboniferous	Permian?	
42	limestone	Omama (Lower part)	*Neospathodus* sp.	yes	*Pseudosweetognathus* sp.?	Carboniferous	Permian? (Kungurian –Roadian?)	Not segminate *Neospathodus* . Carinal blade should be present if it is *Idiognathodus* .
43	limestone	Omama (Lower part)	*Siphonodella* sp.	yes	?	Carboniferous		

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
44	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	*Paragondolella* cf. *noah* (Hayashi)	early Carboniferous	Late Triassic (Carnian)	Well developed keel, anteriorly shifted (not terminal) basal pit is different from Palaeozoic species. Posesses posterior node unlike *P. polygnathiformis* . Lacks nodes on geniculation points unlike *M. praecommunisti* . *Quadralella* according to Orchard (2013, 2014).
45	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	*Carnepigondolella* sp.?	early Carboniferous	Late Triassic?	
46	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	*Mockina* sp.?	early Carboniferous	Late Triassic	Developed keel. Carina extends to posterior.
47	chert	Omama (Lower part)	Conodonta gen. & sp. Indet & *Gondolella* sp.	yes	*Paragondolella* sp.? & segminiplanate element	early Carboniferous	Middle–Late Triassic?	Broken segminiplanate element.
48	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	?	early Carboniferous	?	
49	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	evolved *Paragondolella*	early Carboniferous	Late Triassic (Carnian)	Juvenile specimen. *Quadralella* sp. According to Orchard (2013, 2014). Upturned platform distinguishes it from primitive *Paragondolella* .
50	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	*Sephardiella* sp.?	early Carboniferous	Triassic	Developed keel is different from Carboniferous and Permian species.
51	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	*Sephardiella mostleri* ?	early Carboniferous	Triassic	Carina extends to posterior. Posteriormost denticle not thick.
52	chert	Omama (Lower part)	Conodonta gen. & sp. indet	yes	*Sephardiella* sp.?	early Carboniferous	Triassic	Carina extends to posterior. Posteriormost denticle not thick.
53	chert	Omama (Lower part)	*Anchignathodus* sp.	yes	Carminiscaphate element	early Carboniferous	?	
54	chert	Omama (Lower part)	*Anchignathodus* sp.	yes	Carminiscaphate element	early Carboniferous	?	
55	chert	Omama (Lower part)	*Gondolella* sp.	yes	Segminiplanate element?	early Carboniferous	?	
56	chert	Omama (Lower part)	*Icriodus* ? sp.	yes	?	early Carboniferous	?	
57	chert	Omama (Lower part)	*Icriodus* ? sp.	yes	?	early Carboniferous	?	
58	chert	Omama (Lower part)	*Icriodus* ? sp.	yes	?	early Carboniferous	?	
Sashida *et al.* (1992)								
KIS-16	siliceous claystone	Kurohone–Kiryu (Lower partt in the Kiryu area)	*Neospathodus homeri* (Bender)	yes	*Triassospathodus* ex. gr. *homeri*	Early Triassic	Early Triassic (late Olenekian)	Fig. 5.6. Since the form of the basal cavity is unclear, they could be *Triassospathodus unialatus* (= *Neospathodus symmetricus* Orchard; see Taxonomic Notes).

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
BAN-4	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neohindeodella aequiramosa* Kozur and Mostler	yes	"*Neohindeodella gebzeensis* (Gedik)" (part)	Early Triassic	Early–Middle Triassic (late Olenekian–Anisian)	Fig. 5.9, 5.12. Anteriormost denticle connects smoothly with basal margin in "*N. aequiramosa* ". Fig. 5.11 is "*Neohindeodella* sp.".
			Neohindeodella benderi (Kozur and Mostler)	yes	maintained		Early(–Middle) Triassic (late Olenekian–early Anisian)	
BAN-5	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus homeri* (Bender)	yes	*Triassospathodus* ex. gr. *homeri*	Early Triassic	Early Triassic (late Olenekian)	Fig. 5.5, 5.7. Since the form of the basal cavity is unclear, they could be *T. unialatus* (= *Neospathodus symmetricus* Orchard).
			Cypridodella muelleri (Tatge)	yes	?			In "*C. muelleri* ", the base is flared laterally below the cusp and denticles on the long process are strongly inclined.
			Neohindeodella aequiramosa Kozur and Mostler	yes				Fig. 5. 20. Broken.
			Neohindeodella triassica (Müller)	yes	"*Neohindeodella* cf. *gebzeensis* (Gedik)" (part), "*Cypridodella* sp." (part)		Early–Middle Triassic (late Olenekian–Anisian)	5.10. "*Neohindeodella* sp.". 5.14. "*Grodella* sp.?" Denticles recline towards opposite directions in the anterior and posterior processes of "*N. triassica* ", but denticles are all inclined to the left in specimen. 5.15., 5.18. "*N.* cf. *gebzeensis* ". 5.21, 5.22. "*Cypridodella* sp.".
			Neohindeodella benderi (Kozur and Mostler)	yes	maintained		Early(–Middle) Triassic (late	
			Diplododella sp.	yes				
Motoki and Sashida (2004)								
B-2	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus abruptus* Orchard, Pa element	no		Early Triassic		
B-3	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus* sp. Sc element	no		Early Triassic		

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
A-24	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus brevissimus* Orchard, Pa element	no		Early Triassic		
A-25	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus abruptus* Orchard, Pa element	no		Early Triassic		
			Neospathodus symmetricus Orchard, Pa element	yes	*Triassospathodus unialatus* (Mosher)?		Early Triassic (late Olenekian)	Fig. 6.10. Posterior denticles are lower than typical *T. unialatus* .
			Neospathodus brevissimus Orchard, Pa element	yes	*Triassospathodus abruptus* (Orchard)?		Early Triassic (late Olenekian)	Fig. 6.7. In lateral view, arcuate with heighest point in the posterior, different from the subquadrate profile of *T. brevissimus* .
			Neospathodus sp., Pb element	no				
			Neospathodus sp., Sb2 element	yes	"*Cypridodella* sp."			
			Neospathodus sp., Sc element	no				
			Neospathodus sp., M element	no				
A-26	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus abruptus* Orchard, Pa element	no		Early Triassic		
A-28	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus* sp. Sc element	yas	"*Neohindeodella* sp."	Early Triassic		Fig. 6.14.
A-29	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus* sp. Sc element	no		Early Triassic		
A-30	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus abruptus* Orchard, Pa element	yes		Early Triassic	Early Triassic (late Olenekian)	Figs. 6.2, 6.6 only. In Fig. 6.4, 6.5, the abrupt decrease in height of the posterior denticles is not conspicuous.
			Neospathodus symmetricus Orchard, Pa element	yes	*Triassospathodus unialatus* (Mosher)		Early Triassic (late Olenekian)	Fig. 6.9. *T. unialatus* is the senior synonym of*Neospathodus symmetricus* Orchard (see Taxonomic Notes).
			Neospathodus brevissimus Orchard, Pa element	no				
			Neospathodus sp., Pb element	no				
			Neospathodus sp., Sb1 element	no				
			Neospathodus sp., Sb2 element	no				
			Neospathodus sp., Sc element	no				
			Neospathodus sp., M element	yes	"*Cypridodella* sp."			Fig. 6.17. Dygirate ramiform element.

Table 1 Continued.

No.	Rock facies	Complex	Original identification	Image	Reidentification	Age	Revised age	Notes
A-31	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Neospathodus abruptus* Orchard, Pa	yes	*Triassospathodus unialatus*	Early Triassic	Early Triassic (late	Fig. 6.3. Denticle height is subequal.
			Neospathodus sp., Pb element	no				
			Neospathodus sp., Sb2 element	no				
			Neospathodus sp., Sc element	no				
			Neospathodus sp., M element	no				
Ito (2019)								
IT16071201	chert	Gyodosan	condont fragment	yes		-		
Ito (2020b)								
IT18101408	chert	Kuzu (Unit 3)	condont fragment	yes		-		
IT18101409	chert	Kuzu (Unit 3)	condont fragment	yes		-		
Ito *et al.* (2021b)								
164	chert	Omama (Lower part)	condont fragment	yes		-		
234	chert	Omama (Lower part)	condont fragment	yes		-		
257	chert	Omama (Lower part)	condont fragment	yes		-		
This study								
Ban-yama	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	"*Neohindeodella benderi* (Kozur & Mostler)"	yes		Early(–Middle) Triassic (late olenekian–early Anisian)		
K96-2-A	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Triassospathodus abruptus* (Orchard)	yes		Early Triassic (late Olenekian)		*Novispathodus* is regarded as a junior synonym of*Triassospathodus* see Taxonomic notes.
			Triassospathodus homeri (Bender)	yes		Early Triassic (late Olenekian)		
			Triassospathodus unialatus (Mosher)	yes		Early Triassic (late Olenekian)		*T. unialatus* is the senior synonym of *Neospathodus symmetricus* Orchard (see Taxonomic Notes).
			Triassospathodus sp.	yes		Early Triassic (late Olenekian)		Anterobasal margin and posteriormost denticle is not clearly visible.
K96-2-B	siliceous claystone	Kurohone–Kiryu (Lower part in the Kiryu area)	*Triassospathodus abruptus* (Orchard)	yes		Early Triassic (late Olenekian)		

obtained in the present study, the identification of some specimens needs to be reconsidered, as mentioned below.

Sashida *et al.* (1992) showed conodonts from Ban-yama (see also 4 Newly obtained conodonts and their geological age). The form species "*Neohindeodella aequiramosa* Kozur and Mostler" possesses anteriorly reclined and projecting denticles at the anterior end, the anterior margin of which connects smoothly with the antero-basal margin. However, the specimens identified as this species in Sashida *et al.* (1992) have either an anteriormost denticle that connects at a right angle with the antero-basal margin (their Figures 5.9, 5.11, 5.12) or is considerably broken (their Figure 5.20). In fact, the morphology of the anterior process and numerous erect denticles on the posterior process in the specimens in Figures 5.9 and 5.12 match the characters of a different form species "*Neohindeodella gebzeensis* (Gedik)". In addition, two specimens identified as "*Neohindeodella triassica* (Müller)" (Figures 5.15 and 5.18), which is a species with a basal margin protruding downwards below the cusp, are comparable to "*N. gebzeensis*". The other specimens identified as "*N. triassica*" are also misidentified: Figure 5.10 is much more bent in lateral view, while Figures 5.14, 5.21 and 5.22 are digyrate elements of the form genus "*Grodella*" and "*Cypridodella*".

Motoki and Sashida (2004) reported *T. abruptus*, which is characterised by abrupt shortening of the denticles in the posterior. While the character can be seen in Figures 6.2 and 6.6, it is not seen in Figures 6.3, 6.4 and 6.5. The sub-equal denticles of the latter three are closer to that of *T. unialatus*. On the other hand, the specimen identified as *Neospathodus symmetricus* (= *T. unialatus*) in their Figure 6.10 has a small denticle at the posterior end, which is not a feature of this species according to the original description (Orchard, 1995). *Triassospathodus brevissimus* was illustrated in Figure 6.7 of Motoki and Sashida (2004), but this specimen does not possess the sub-quadrate lateral outline formed by small erect denticles of mostly equal height that distinguishes this species (Orchard, 1995; Maekawa *et al.*, 2018; Muto *et al.*, 2019).

6. Conclusions

1) Conodonts were newly found from siliceous claystone near the border of the Tochigi and Gunma prefectures. We obtained the form species "*Neohindeodella benderi* (Kozur & Mostler)" from Ban-yama and *Triassospathodus abruptus* (Orchard), *Triassospathodus homeri* (Bender) and *Triassospathodus unialatus* (Mosher) (= *Neospathodus symmetricus* Orchard) from Kaizawa. These conodonts indicate the Spathian (late Olenekian Age).
2) We reinvestigated the illustrations of conodonts provided by previous studies. Many of the conodonts previously identified as Carboniferous conodonts are Permian and Triassic species. In particular, two out of six specimens identified as *Mesogondolella clarki* (Koike) were reidentified as *Mesogondolella* cf. *gujioensis* (Igo) and some specimens identified as early Carboniferous species of unknown genera should be identified as Late Triassic species such as *Paragondolella* cf. *noah* (Hayashi).
3) As far as the conodonts are concerned, there is no compelling evidence indicating the presence of Carboniferous limestone and chert, which was reported by previous studies. The oldest age that can be confirmed by conodonts is the late Artinskian to early Kungurian age of the Cisuralian (early Permian) indicated by *M.* cf. *gujioensis* from the Kurohone–Kiryu and Omama complexes.

7. Taxonomic notes

Remarks for the conodonts obtained in this study are mentioned here. For detailed synonym lists, the reader is referred to Muto *et al.* (2019, 2020).

"***Neohindeodella benderi*** (Kozur and Mostler)" (form species)
(Figure 3.1)
Remarks: This form species is easily recognised by its anterior process that is conspicuously bent down and bears a long denticle at the anterior end, but otherwise is poorly denticulate.

Triassospathodus abruptus (Orchard)
(Figures 3.2, 3.3)
Remarks: A species characterised by segminate elements with denticles that decrease height rapidly at the posterior. This species was defined as the type species of the genus *Novispathodus abruptus* by Orchard (2005), but the distinguishing features of *Novispathodus* are seen as intraspecific variations in related neospathodids (Koike, 2004; Muto *et al.*, 2020). Therefore, *Novispathodus* is regarded as a junior synonym of *Triassospathodus*.

Triassospathodus homeri (Bender)
(Figure 3.4)
Remarks: This species has a short posterior process of up to five denticles above the elongated posterior part of the basal cavity.

Triassospathodus unialatus (Mosher)
(Figures 3.5, 3.6)
Remarks: The P1 element of this species is a segminate element with denticles of subequal height and a posteriorly rounded basal cavity. The P1 element was described as *Neospathodus symmetricus* by Orchard (1995) and was shown to be accompanied by the form species "*Cypridodella unialata* (Mosher)" as its S2 element (Koike, 2004), which has the priority (Muto *et al.*, 2020).

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References

Agematsu, S., Orchard, M. J. and Sashida, K. (2008) Reconstruction of an apparatus of *Neostrachanognathus tahoensis* from Oritate, Japan and species of *Neostrachanognathus* from Oman. *Palaeontology*, **51**, 1201–1211.

Aono, H. (1985) Geologic structure of the Ashio and Yamizo Mountains with special reference to its tectonic evolution. *Science reports of the Institute of Geoscience, University of Tsukuba. Section B, Geological Sciences*, **6**, 21–57.

Chen, Y., Krystyn, L., Orchard, M. J., Lai, X. L. and Richoz, S. (2016) A review of the evolution, biostratigraphy, provincialism and diversity of Middle and early Late Triassic conodonts. *Papers in Palaeontology*, **2**, 235–263.

Clark, D. L. and Mosher, L. C. (1966) Stratigraphic, geographic, and evolutionary development of the conodont genus *Gondolella*. *Journal of Paleontology*, **40**, 376–394.

Conodont Research Group (1972) Conodonts at the Permian-Triassic boundary in Japan—Conodonts from the basal part of the Adoyama Formation—. *Journal of the Geological Society of Japan*, **78**, 355–368 (in Japanese with English abstract).

Conodont Research Group (1974) Conodonts at the Permian-Triassic boundary in Japan—Stratigraphy and faunas of the Nabeyama and Adoyama formations in Karasawa area, southeast Ashio Mountains—. *Earth Science (Chikyu Kagaku)*, **28**, 86–98 (in Japanese with English abstract).

Editorial team of Omama Town's history* (1996) *Omama Town's History, Basic Data VIII: Geography and Geology of Omama Town**. Publication committee of Omama Town's history*, Omama Town (current administrative division: Kiryu City), Gunma.

Fujimoto, H. (1960) Carboniferous System of Japan. *Geological Survey of Japan, Report Special Number* (D). 65p.

Fujimoto, H. (1961) *Explanatory text of the Geological Map of Japan, scale 1:50,000, "Tochigi"*. Geological Survey of Japan, 62p. (in Japanese with English abstract).

Geological Survey of Japan, AIST (2018) Seamless digital geological map of Japan 1: 200,000. January 26, 2018 version. Geological Survey of Japan, AIST. https://gbank.gsj.jp/seamless/v2full/ (Accessed:2018-1-26)

Goudemand, N., Orchard, M. J., Bucher, H. and Jenks, J. (2012) The elusive origin of Chiosella timorensis (Conodont Triassic). *Geobios*, **45**, 199–207.

Hayashi, S. (1963) On the conodonts newly discovered from the Ashio Mountains, central Japan. *Earth Science (Chikyu Kagaku),* **68**, 9–12 (in Japanese with English abstract).

Hayashi, S. (1964) Discovery of conodonts from "Narutakite". *The Journal of the Geological Society of Japan*, **70**, 596 (in Japanese with English abstract).

Hayashi, S. (1968a) The Permian conodonts in chert of the Adoyama Formation, Ashio Mountains, central Japan. *Earth Science (Chikyu Kagaku)*, **22**, 9–12 (in Japanese with English abstract and descriptions).

Hayashi, S. (1968b) Redescription of the new forms proposed in "The Permian conodonts in chert of the Adoyama Formation, Ashio Mountains, central Japan," 1968. *Earth Science (Chikyu Kagaku)*, **22**, 305 (in Japanese with English abstract and descriptions).

Hayashi, S. (1971) Conodonts from the Nabeyama Formation, Kuzuu District, Tochigi Prefecture, Japan. *Earth Science (Chikyu Kagaku)*, **25**, 251–257 (in Japanese with English abstract).

Hayashi, S. and Hasegawa, Y. (1981) Chichibu System in the Ashio Belt: Macrofossil- and conodont-based age (Part 2)*. *Studies on Late Mesozoic Tectonism in Japan*, no. 3, 233–249. (in Japanese with English abstract).

Hayashi, S., Iijima, S., Nakajima, T., Sawaguchi, T., Tanaka, H., Yoshida, H. (1990) Late Paleozoic to Mesozoic formations in the southwestern Ashio Mountains. *Bulletin of the Gunma Prefectural Museum of History*, **11**, 1–34 (in Japanese with English abstract).

Igo, Hh. (1981) Permian conodont biostratigraphy of Japan. *Palaeontological Society of Japan, Special Papers*, **24**, 1–51.

Igo, Hy. (1972) Conodonts, as a new index fossil in Japan. *Journal of Geography (Chigaku-Zasshi)*, **81**, 142–151 (in Japanese with English abstract).

Isozaki, Y., Maruyama, S. and Furuoka, F. (1990) Accreted oceanic materials in Japan. *Tectonophysics*, **181**, 179–205.

Isozaki, Y., Maruyama, S., Aoki, K., Nakama, T., Miyashita, A. and Otoh, S. (2010) Geotectonic Subdivision of the Japanese Islands Revisited: Categorization and definition of elements and boundaries of Pacific-type (Miyashiro-type) orogen. *Journal of Geography (Chigaku-Zasshi)*, **119**, 999–1053 (in Japanese with English abstract).

Ito, T. (2019) A report of Permian, Triassic, and Jurassic radiolarian occurrences from the Ashio terrane in the Hachioji Hills, eastern Gunma Prefecture, central Japan. *Bulletin of the Geological Survey of Japan*, **70**, 225–247.

Ito, T. (2020a) A Cisuralian (early Permian) radiolarian assemblage and a new species of *Latentibifistula* Nazarov and Ormiston from central Japan. *Revue de Micropaléontologie*, **66**, 100407.

Ito, T. (2020b) Radiolarian age of Triassic striped chert within the Jurassic accretionary complex of the Ashio terrane in the Ashikaga area, Tochigi Prefecture, central Japan. *Bulletin of the Geological Survey of Japan*, **71**, 297–312.

Ito, T. (2021a) Geology and correlation of Jurassic accretionary complex in the Ashio Mountains, central Japan: Investigation on the Kiryu and Ashikaga District (Quadrangle series 1:50,000). *Bulletin of the Geological Survey of Japan*, **72**, 201–285.

Ito, T. (2021b) Radiolarians from Jurassic accretionary complexes of the Ashio belt in the Kiryu and Ashikaga District (Quadrangle series 1:50,000), Gunma and Tochigi prefectures, central Japan. *Bulletin of the Geological Survey of Japan*, **72**, 287–324.

Ito, T., Nakamura, K., Hinohara, T. and Kurihara, T. (2021a) Occurrence report of Triassic and Jurassic radiolarians from the Jurassic accretionary complexes of the Ashio belt in eastern Mt. Narukami, Ashio Mountains, central Japan. *Bulletin of the Geological Survey of Japan*, **72**, 345–358.

Ito, T., Suzuki, N. and Sashida, K. (2021b) Radiolarians and foraminifers from the Omama Complex of Jurassic accretionary complex in the Ashio Mountains, central Japan. *Bulletin of the Geological Survey of Japan*, **72**, 359–370.

Kamata, Y. (1996) Tectonostratigraphy of sedimentary complex in the southern part of the Ashio terrane, central Japan. *Science reports of the Institute of Geoscience, University of Tsukuba, Section B, Geological Sciences*, **17**, 71–107.

Kamata, Y. (1997) Reconstruction of the chert-clastic sequence of the Ashio terrane in the Kuzuu area, central Japan. *The Journal of the Geological Society of Japan*, **103**, 343–356 (in Japanese with English abstract).

Kamata, Y. and Kajiwara, Y. (1996) Sulfur isotopic data from the Permian/Triassic boundary in a chert sequence at Motegi, Gunma Prefecture, in the Ashio terrane, central Japan. *In*, Noda, H. and Sashida, K. eds., *Professor Hisayoshi Igo Commemorative Volume on geology and paleontology of Japan and Southeast Asia*, Gakujyutsu Tosho Insatsu Co. Ltd., Tokyo, 19–27.

Kojima, S., Hayasaka, Y., Hiroi, Y., Matsuoka, A., Sano, H., Sugamori, Y., Suzuki, N., Takemura, S. Tsujimori, T. and Uchino, T. (2016) Pre-Cretaceous accretionary complexes. *In* Moreno, T.,Wallis, S. R., Kojima, T. and Gibbons, W. eds., *The Geology of Japan*. The Geological Society of London, London, England, 61–100.

Koike, T. (1981) Biostratigraphy of Triassic conodonts in Japan. *Science reports of the Yokohama National University. Section 2, Biology and geology*, **28**, 25–46.

Koike, T. (2004) Early Triassic *Neospathodus* (Conodonta) apparatuses from the Taho Formation, southwest Japan. *Paleontological Research*, **8**, 129–140.

Koike, T., Igo, Hh., Takizawa, S. and Kinoshita, T. (1971a) Contribution to the geological history of the Japanese Islands by the conodont biostratigraphy part II. *The Journal of the Geological Society of Japan*, **77**, 165–168.

Koike, T., Kinoshita, T., Igo, Hh., Takizawa, S. (1971b) Conodonts from the Tochigi Group and the discovery of a thrust fault in the vicinity of Kuzuu, Tochigi Prefecture. *The Journal of the Geological Society of Japan*, **77**, 221–222 (in Japanese with English abstract).

Koike, T., Igo, Hy., Igo, Hh. and Kinoshita, T. (1974) Geological significance of the unconformity between the Permian Nabeyama and Triassic Adoyama formations in the vicinity of Kuzuu, Tochigi Prefecture. *The Journal of the Geological Society of Japan*, **80**, 293–306 (in Japanese with English abstract).

Koike, T., Kodachi, Y., Matsuno, T. and Baba, H. (1991) Triassic conodonts from exotic blocks of limestone in northern Kuzuu, the Ashio Mountains. *Science Reports of Yokohama National University Section II*, no. 38, 53–69.

Kozur, H. (1989) The taxonomy of the gondolellid conodonts in the Permian and Triassic. *Courier Forschungs Institut Senckenberg*, **117**, 385–406.

Lehrmann, D. J., Stepchinski, L., Altiner, D., Orchard, M. J., Montgomery, P., Enos, P., Ellwood, B. B., Bowring, S. A., Ramezani, J., Wang, H., Wei, J., Yu, M., Griffiths, J. D., Minzoni, M., Schaal, E. K., Li, X., Meyer, K. M. and Payne, J. L. (2015) An integrated biostratigraphy (conodonts and foraminifers) and chronostratigraphy (paleomagnetic reversals, magnetic susceptibility, elemental chemistry, carbon isotopes and geochronology) for the Permian-Upper Triassic strata of Guandao section, Nanpanjiang Basin, south China. *Journal of Asian Earth Sciences*, **108**, 117–135.

Maekawa, T. and Igo, H. (2014) Conodonts. *In* Shigeta, Y., Komatsu, T., Maekawa, T. and Dang, H. T. eds., *Olenekian (Early Triassic) Stratigraphy and Fossils Assemblages in Northeastern Vietnam*, 190–271, National Museum of Nature and Science Monographs, **45**, National Museum of Nature and Science, Tokyo.

Maekawa, T., Komatsu, T. and Koike, T. (2018) Early Triassic conodonts from the Tahogawa Member of the Taho Formation, Ehime Prefecture, Southwest Japan. *Paleontological Research*, **22**, 1–62.

Matsuda, T. (1983) Early Triassic conodonts from Kashmir, India, part 3: *Neospathodus* 2. *Journal of Geosciences, Osaka City University*, **27**, 87–102.

Mazza M., Rigo M. and Gullo M. (2012). Taxonomy and stratigraphic record of the Upper Triassic conodonts of the Pizzo Mondello section (Western Sicily, Italy), GSSP candidate for the base of the Norian. *Rivista Italiana di Paleontologia e Stratigrafia*, **118**, 85–130.

Mazza, M., Nicora, A. and Rigo, M. (2018) *Metapolygnathus parvus* Kozur, 1972 (Conodonta): a potential primary marker for the Norian GSSP (Upper Triassic). *Bollettino della Società Paleontologica*

Italiana, **57**, 81–101.

Mei, S. and Wardlaw, B. R. (1994) *Jinogondolella*: A new genus of Permian gondolellids. *International Symposium on Permian Stratigraphy, Environments and Resources, Abstracts, Guiyang, China*, 20–21.

Motoki, H. and Sashida, K. (2004) Preliminary report on the chronological and lithostratigraphical studies of the Toishi-type shale (siliceous claystone) distributed in the Ashio Mountains. *News of Osaka Micropalaeontologists (NOM), Special Volume*, no. 13, 47–57 (in Japanese with English abstract).

Muto, S., Takahashi, S., Yamakita, S., Suzuki, N., Suzuki, N. and Aita, Y. (2018) High sediment input and possible oceanic anoxia in the pelagic Panthalassa during the latest Olenekian and early Anisian: Insights from a new deep-sea section in Ogama, Tochigi, Japan. *Palaeogeography. Palaeoclimatology, Palaeoecology*, **490**, 687–707.

Muto, S., Takahashi, S., Yamakita, S., Soda, K. and Onoue, T. (2019) Conodont-based age calibration of the Middle Triassic Anisian radiolarian biozones in pelagic deep-sea bedded chert. *Bulletin of the Geological Survey of Japan*, **70**, 43–89.

Muto, S., Takahashi, S., Yamakita, S., Onoue, T. (2020) Scarcity of chert in upper Lower Triassic Panthalassic deep-sea successions of Japan records elevated clastic inputs rather than depressed biogenic silica burial flux following the end-Permian extinction. *Global and Planetary Change*, **195**, 103330.

Muto, S., Okumura, Y. and Mizuhara, T. (2021) Late Kungurian conodonts of the pelagic Panthalassa from seamount-capping limestone in Ogama, Kuzuu, Tochigi Prefecture, Japan. *Paleontological Research*, **25**, 105–119.

Orchard, M. J. (1995) Taxonomy and correlation of Lower Triassic (Spathian) segminate conodonts from Oman and revision of some species of *Neospathodus*. *Journal of Paleontology*, **69**, 110–122.

Orchard, M. J., (2005) Multielement conodont apparatuses of Triassic gondolelloidea. *Special Papers in Palaeontology*, **73**, 73–101.

Orchard, M. J. (2007) Conodont diversity and evolution through the latest Permian and Early Triassic upheavals. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **252**, 93–117.

Orchard, M. J. (2013) Five new genera of conodonts from the Carnian-Norian boundary beds of Black Bear Ridge, northeast British Columbia, Canada. *The Triassic system: New Mexico Museum of Natural History and Science Bulletin*, **61**, 445–457.

Orchard, M. J. (2014) *Conodonts from the Carnian-Norian Boundary (Upper Triassic) of Black Bear Rideg, Northeastern British Columsia, Canada*. New Mexico Museum of Natural History and Science Bulletin, 64. New Mexico Museum of Natural History and Science, Albuquerque.

Orchard, M. J. (2019) The Carnian-Norian boundary GSSP candidate at Black Bear Ridge, British Columbia, Canada: update, correlation, and conodont taxonomy. *Albertiana*, **45**, 50–68.

Ovtcharova, M., Goudemand, N., Hammer, Ø., Guodun, K., Cordey, F., Galfetti, T., Schaltteger, U. and Bucher, H. (2015) Developing a strategy for accurate definition of a geological boundary through radio-isotopic and biochronological dating: The Early–Middle Triassic boundary (South China). *Earth-Science Reviews*, **146**, 65–76.

Sashida, K., Kamata, Y. and Igo, Hy. (1992) Toishi-type shale in the Ashio Mountains, central Japan. *Annual report of the Institute of Geoscience, the University of Tsukuba*, **18**, 59–66

Sudo, S., Makimoto, H., Hata, M., Unozawa, A., Takizawa, F. and Sakamoto, T. (1990) *Geological map of the Utsunomiya district*. Quadrangle Series, 1:200,000, Geological Survey of Japan.

Yamakita, S. and Otoh, S. (2000) Tectonostratigraphic division of accretionary-sedimentary complex of the Tamba–Mino–Ashio Belt and comparison with the Northern and Southern Chichibu Belts. *Structural Geology*, **4**, 5–32. (in Japanese with English abstract)

Yanagimoto, Y. (1973) Stratigraphy and geological structure of the Paleozoic and Mesozoic formations in the vicinity of Kuzuu, Tochigi Prefecture. *The Journal of the Geological Society of Japan,* **79**, 441–451 (in Japanese with English abstract).

Zhao, L., Orchard, M. J., Jinnan, T., Zhiming, S., Jinxun, Z., Suxin, Z. and Ailing, Y. (2007) Lower Triassic conodont sequence in Chaohu, Anhui Province, China and its global correlation. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **252**, 24–38.

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5 万分の 1 地質図幅「桐生及足利」地域から産出したコノドント化石：足尾テレーンの“石炭紀”コノドントを中心とした再検討

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要　旨

これまで足尾山地からは多くのコノドント化石の産出が報告されているが，多くの研究は古い分類や生層序の知見に基づいている．本研究では，5 万分の 1 地質図幅「桐生及足利」地域内から報告されているコノドント化石を現在の分類と生層序に基づき再検討した．図示されている標本については必要に応じて同定の修正を試み，図示されていないものについては現在の分類体系に基づいて分類群名を読み替えた．また，本研究で独自に得た前期三畳紀のコノドントも併せて報告する．特筆すべきは，石炭紀のコノドントとして報告されていた標本の多くがペルム紀または三畳紀のものであり，石炭紀のものだと断定できる標本が無いことである．その結果，同地域で確認できる最も古い岩石の年代はシスウラリアン世（前期ペルム紀）となり，同地域から報告されている最も古い放散虫の年代とほぼ一致した．