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Cyclotella kitabayashii sp. nov., a new fossil diatom species from Pliocene sediment in southwestern Japan

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Abstract

A new fossil diatom species *Cyclotella kitabayashii* H.Tanaka sp. nov. is described from Pliocene sediment of the Tsubusagawa Formation in Kyushu, southwestern Japan. The new species is characterized by larger circular valves and smaller elliptical valves, valve faces that are tangentially undulate with fultoportulae arranged in a circular pattern in the central area with many areolae. Internally, there are alveolae in the marginal area. Every costa or every second (rarely third) costa is recessed and bears a fultoportula. Valve face and mantle fultoportulae have uniquely shaped satellite pore covers. The authors were unable to find any taxon that has the combination of these characteristics and accordingly propose *C. kitabayashii* as a new species. The new species is compared to similar taxa.

Key index words : *Cyclotella kitabayashii*, freshwater, Kyushu, Japan, Pliocene

Introduction

While studying freshwater centric diatoms in Japan, the authors found a unique fossil freshwater diatom having morphological characteristics of either *Puncticulata* or *Cyclotella* from Pliocene sediment of the Tsubusagawa Formation in Kyushu, southwestern Japan. Genus *Cyclotella* was established by Brébisson (1838) raising the subgenus *Cyclotella* Kütz. to genus *Cyclotella* (Kütz.) Bréb. Since then *Cyclotella* has been divided into four genera. One of these genera is *Puncticulata* which was recently separated from *Cyclotella* having the characteristics of concentrically undulate valve face, areolae and valve face fultoportulae on central area, complex patterns of alveolate striae of different thickness and length on marginal area and rimoportula(e) on valve face by Håkansson (2002). However Houk *et al.* (2010) reported genus *Puncticulata* was illegitimate by the International Code of Botanical Nomenclature, Art. 52 as to *Puncticulata austriaca* (Perag.) Håk. Because the genus *Puncticulata* has been deemed illegitimate, we decided to describe it as a new species which belongs to the genus *Cyclotella*. In the present paper we describe the morphology of the new species with light (LM) and scanning electron microscopy (SEM) and compare its characteristics to similar taxa.

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Material and methods

The material investigated was collected from an outcrop of bluish siltstone interbedded with thin tuff. The outcrop is situated on the left bank of the Amari River, tributary of Ena River, in Amari, Usa City (former Innai Town), northern part of Oita Prefecture, southwestern Japan (Fig. 1). The sediment of the outcrop is reported to belong to the Tsubusagawa Formation (Matsumoto *et al.* 1984) which is of Pliocene age based on its stratigraphic relations (Matsumoto *et al.* 1984) and fission track method classification (Hase *et al.* 2001). The siltstone of this

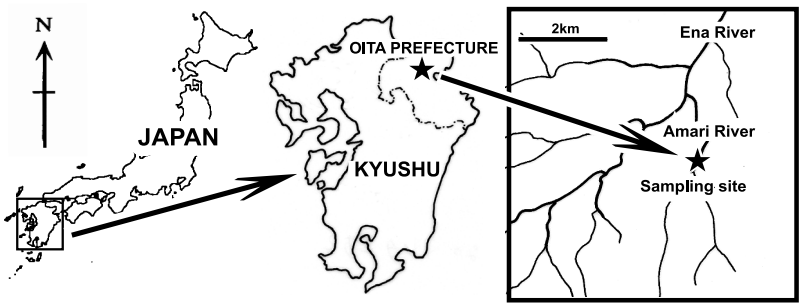


Fig. 1. Location of sampling site, Amari River, Usa City, Oita Prefecture, Japan.

outcrop was about 30 m thick with its upper part consisting of slump structure. In the middle part of the outcrop below the slump structure, the new diatom described here was found.

The samples were boiled in a 30% H_2O_2 solution to separate the sediment particles from the diatom valves and to eliminate organic material, and then washed several times with distilled water. The cleaned material was mounted in Pleurax or Styrax. Holotype slide is made as single specimen slide using a method by Tanaka (2007). LM observations were made using a Nikon Apophot microscope with a Nikon planapochromat 100× oil immersion objective (NA = 1.4) and SEM observations were made using a Hitachi S-4000 field emission microscope. Terminology was based on Håkansson (2002), Tanaka & Nagumo (2004) and Houk *et al.* (2010).

Description of new species

Cyclotella kitabayashii H.Tanaka sp. nov. (Figs 2-22)

Small valves elliptical, large valves circular, diameter 8-49 μm. Central area of valve face strongly tangential undulate and having many areolae. Marginal area of valve face consists of striae and interstriae. Interstriae end at valve face/mantle junction or mantle fultoportulae, 7-10 in 10 μm at valve face/mantle junction. Valve face fultoportulae in small numbers located mostly on raised part of valve face, arranged in a circular pattern. Mantle fultoportula openings on every, or every second, (rarely third) interstria and a single rimoportula opening on edge of raised part of valve face near margin. Rimoportula opening and mantle fultoportulae openings lack tubes.

Internally, valve face fultoportulae, each with three satellite pores arranged in a circular pattern on valve face. Mantle fultoportulae, also with three satellite pores each, located on every, or every second, (rarely third) costa which is always recessed. An alveolus with both centrifugal and centripetal roofing over is formed between two costae. Rimoportula with stalked labium located on edge of valve face.

Holotype: MPC-04890, Micropaleontology Collection, The National Museum of Nature and Science, Tokyo, Japan. Single specimen slide (Figs 2, 3).

Type locality: Amari, Usa City, Oita Prefecture, Kyushu Island, southwestern Japan, (33°22′43″ N, 131°18′55″E).

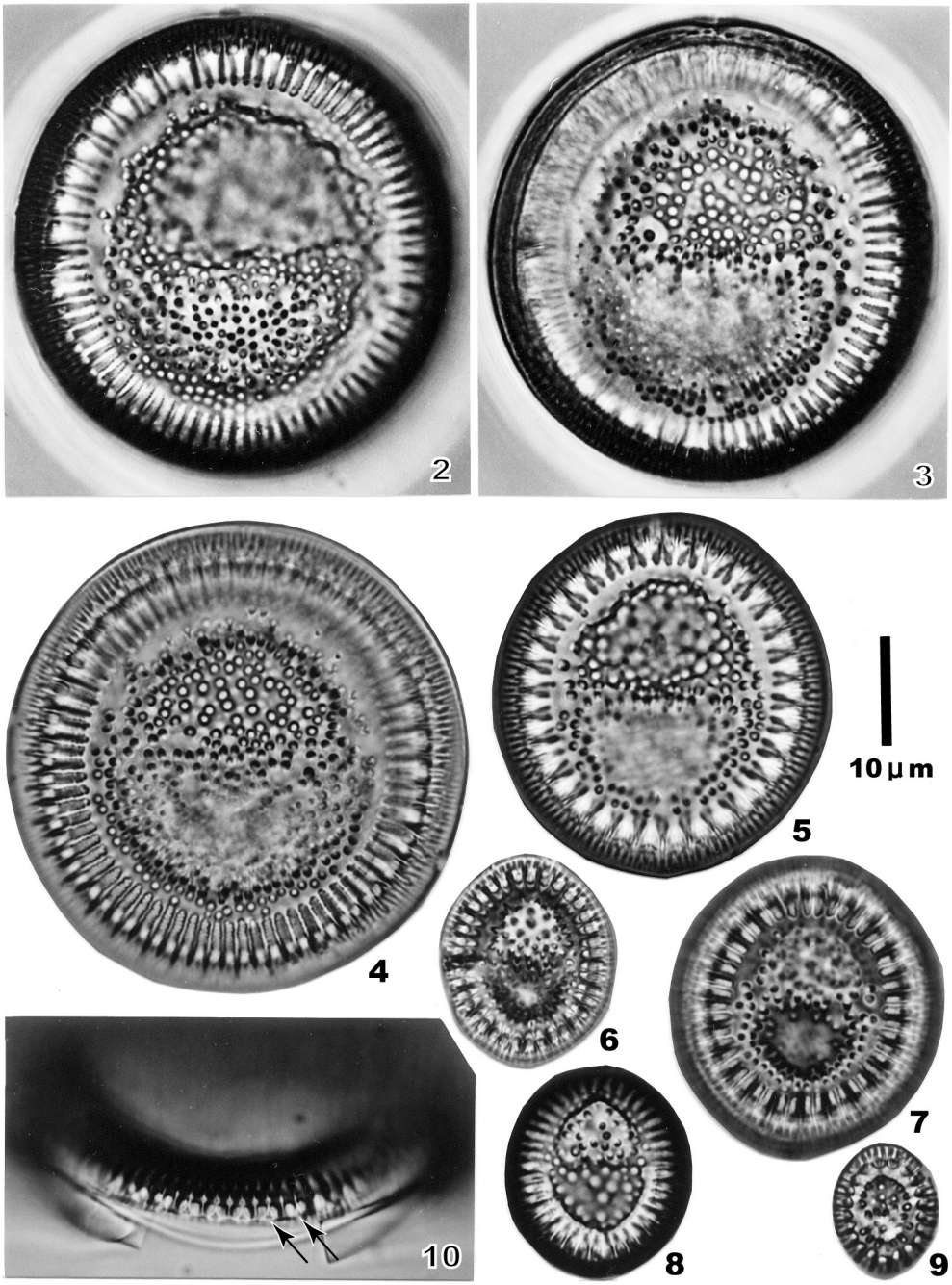
Type material: OIT-207, bluish siltstone of Tsubusagawa Formation, Pliocene, collected by H. Tanaka and K. Kashima on 29 April 2001.

Etymology: The species name refers to Mr. Eiichi Kitabayashi who helped with our diatomite investigation in Kyushu.

Observations

In LM, the valves of *Cyclotella kitabayashii* are circular in larger valves and elliptical in smaller valves: the largest valve was 49 μm in diameter, while the smallest valve was 10 μm in length and 8 μm long and the central area was tangential undulate. The marginal area consists of striae and interstriae. Interstriae are 7-10 in 10 μm (Figs 2-10).

External SEM observation of the valve face shows a verrucose central area with strong tangential undulation (Figs 12, 14). Interstriae are raised and extend to valve face/mantle junction. Every, or every second, (rarely third) interstria, however, continues to the mantle and ends at a mantle fultoportula opening (Figs 13, 16). The

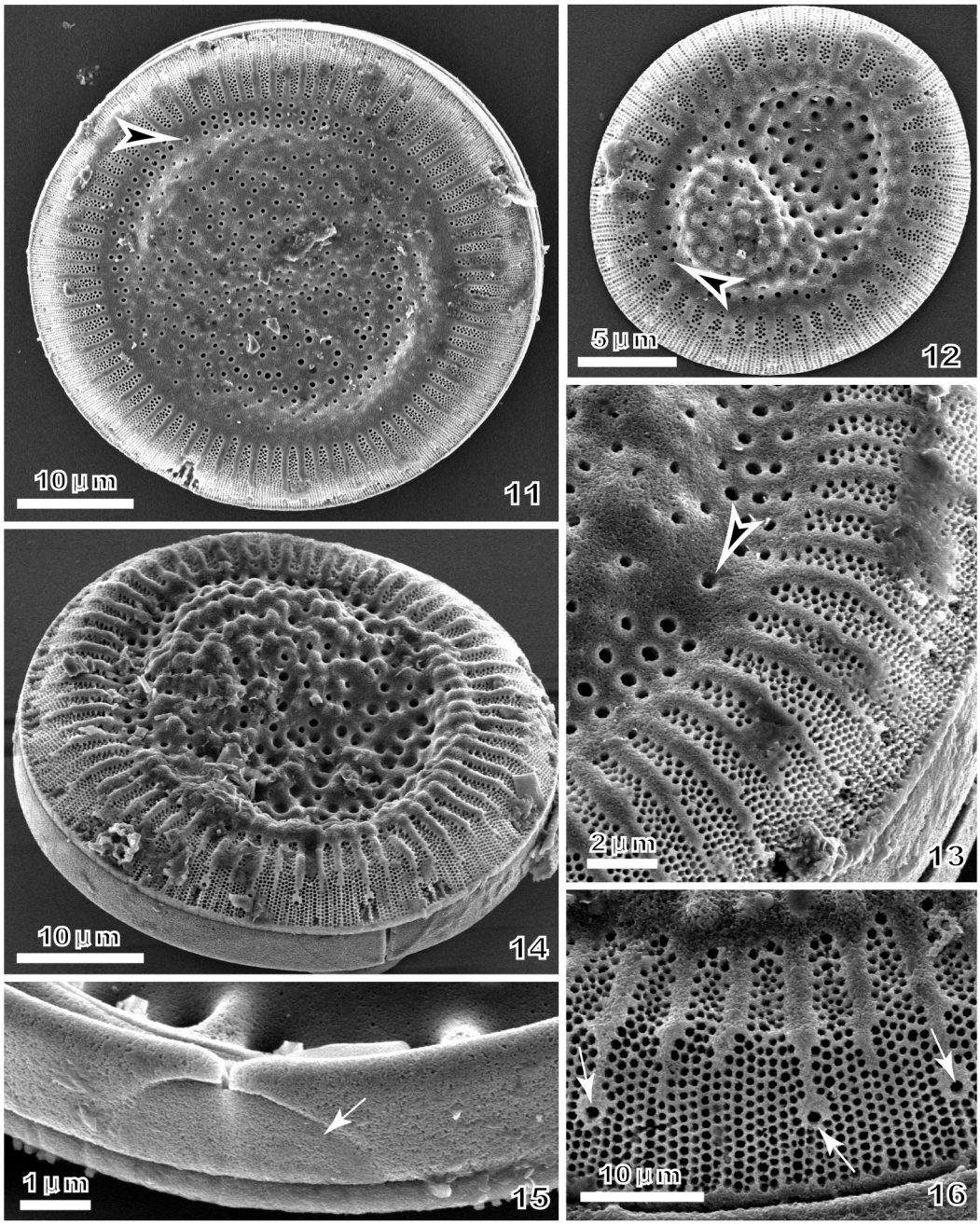


Figs 2-10. *Cyclotella kitabayashii* sp. nov. LM. **Figs 2, 3.** Holotype, MPC-04890, The National Museum of Nature and Science, Tokyo, Japan. Same valve shown at different focal planes. **Fig. 10.** Oblique view of mantle showing mantle fultoportulae on recessed costae (arrows).

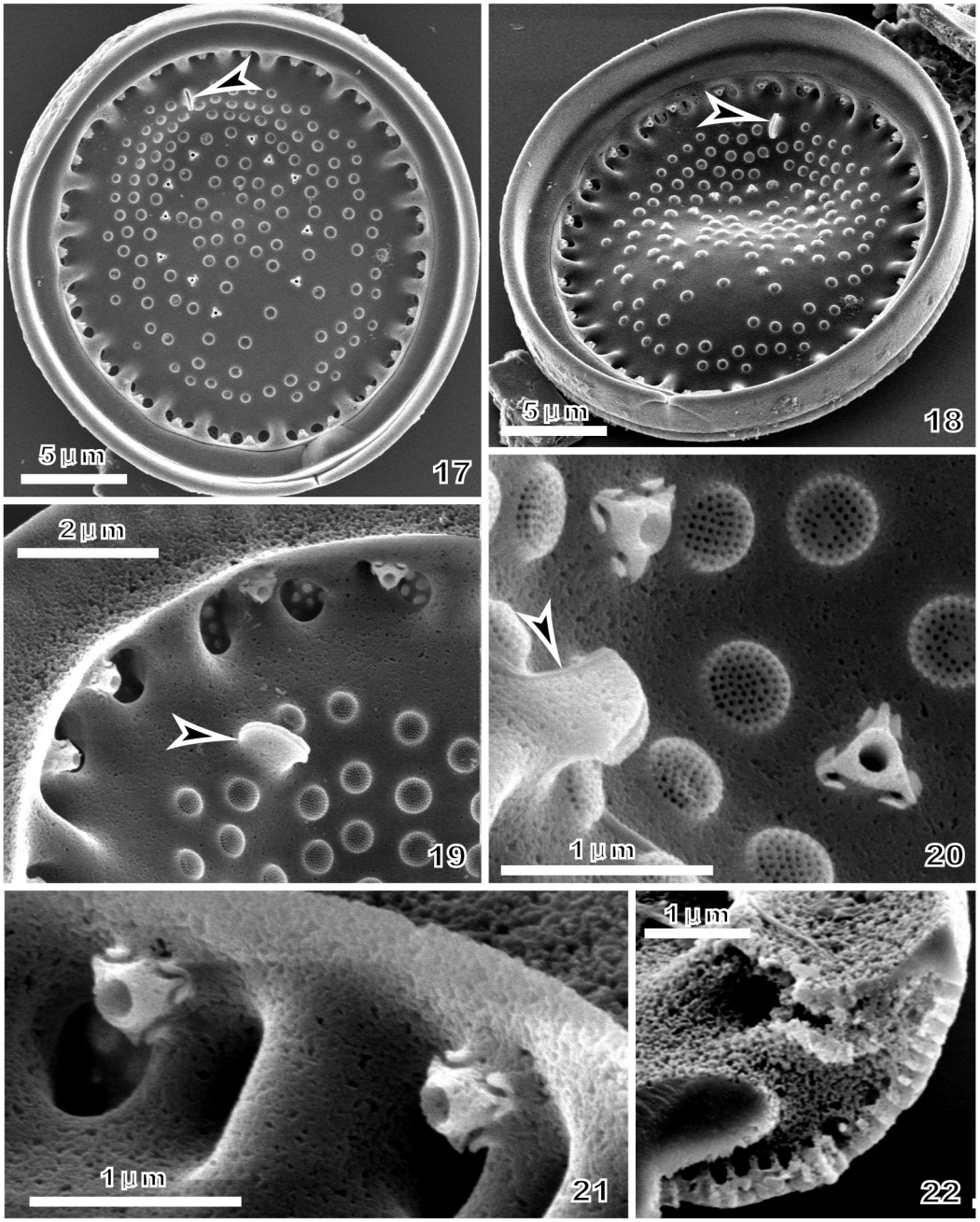
openings of mantle fultoportulae lack tubes and are arranged on the middle part of mantle (Figs 13, 16). One rimoportula opening is located on the edge of raised part of valve face near the margin (Figs 11-13).

Internal SEM view shows areolae occluded by domed cribra. Valve face fultoportulae are arranged in a circular pattern around raised part

of valve (the depressed part of internal view; Figs 17, 18). Each fultoportula has three satellite pores (Fig. 20). A single stalked labium rimoportula is located on the marginal side of the raised



Figs 11-16. *Cyclotella kitabayashii* sp. nov. SEM, external views. **Fig. 11.** Larger whole valve, arrowhead indicates external opening of rimoportula. **Fig. 12.** Smaller whole valve, arrowhead indicates external opening of rimoportula. **Fig. 13.** Detailed view of Fig. 11 showing marginal area of valve face and mantle, arrowhead indicates external opening of rimoportula. **Fig. 14.** Oblique view showing tangential undulate central area of valve face. **Fig. 15.** Detailed view of cingulum showing ligula-like segment (arrow). **Fig. 16.** Detailed view of valve margin showing striae, interstriae and external openings of mantle fultoportulae (arrows).



Figs 17-22. *Cyclotella kitabayashii* sp. nov., SEM, internal views. **Fig. 17.** Whole valve showing areolae, valve face fultoportulae arranged in a circular pattern and rimopotula (arrowhead). **Fig. 18.** Oblique view of valve showing rimoportula (arrowhead) and recessed costae with mantle fultoportulae. **Fig. 19.** Enlargement of valve margin showing rimoportula (arrowhead) and recessed costae with mantle fultoportulae. **Fig. 20.** Detailed view of the stalked rimoportula (arrowhead), two valve face fultoportulae each with three satellite pores and a central tube having satellite pore covers and domed cribra. **Fig. 21.** Detailed view of two mantle fultoportulae on recessed costae showing satellite pore covers curving downward forming valleys in the cowling. **Fig. 22.** Cross section of marginal valve showing alveolus having both centrifugal and centripetal roofing over.

Table 1. Comparison of *Cyclotella kitabayashii* with *C. rhomboideo-elliptica* var. *rounda* and *C. comta.*

Characteristics	C. *kitabayashii*	C. *rhombiodeo-elliptica* var. *rounda*	C. *comta*
Diameter (μm)	8-49	15-37	5-32
Valve face			
shape	circular, elliptical	circular	circular
undulation	tangential	tangential	flat to concentric
external thickness of interstriae	all the same	thick & thin	all the same
Roofing over of alveolae	centrifugal & centripetal	centrifugal & centripetal	centrifugal & centripetal
Location of mantle fultoportulae	every recessed costa	every thicker costa	every thicker costa
References	this paper	Houk *et al.* (2010)	Houk *et al.* (2010)

part of the valve face (Figs 17-19). Costae are on the marginal valve face with every, or every second, (rarely third) costa recessed (Fig. 18) and has a mantle fultoportula bearing three satellite pores (Fig. 21). All fultoportula tubes have three satellite pore covers which curve downward forming valleys in the cowling (Figs 20, 21). Alveolae have both centrifugal and centripetal roofing over (Fig. 22).

Cingulum is composed of four bands, a broad valvocopula (open band), two open bands and a ligula-like segment (Tanaka & Nagumo 2004 ; Fig. 15).

Discussion

Genus *Pliocaenicus* was erected by Round & Håkansson (1992) with two new species both from the same Pliocene lake sediment. The authors regard an important distinction separating the genus *Cyclotella* and *Pliocaenicus* being the former alveolae with both centrifugal and centripetal roofing over while the latter has only centrifugal roofing over. *Cyclotella kitabayashii*, also found from Pliocene sediment, looks similar to *Pliocaenicus costatus* (Lupik.) Flower *et al.* (Round & Håkansson 1992, Flower *et al.* 1998) as they both exhibit either circular or elliptical valve faces, but *C. kitabayashii* has alveolae with both centrifugal and centripetal roofing over while all *Pliocaenicus* species lack centripetal roofing over (Round & Håkansson 1992).

Cyclotella kitabayashii is similar to *Cyclotella rhomboideo-elliptica* var. *rounda* Qi et Yang in its central area which is tangential undulate with scattered areolae and circularly arranged valve face fultoportulae. The external interstriae of *C. kitabayashii*, however, are all the same in thickness whereas those of *C. rhomboideo-elliptica* var. *rounda* are alternately thick and thin. Also, internally, the mantle fultoportulae of the former are located on every recessed costa while those of the latter are located on every thicker costa (Houk *et al.* 2010).

Cyclotella kitabayashii has many areolae scattered around the central area of its valve face. Some specimens of *Cyclotella comta* Kütz. also have this feature. In this aspect, the two species look similar. *C. kitabayashii*, however, has a tangential undulate valve face and mantle fultoportulae on recessed costae while *C. comta* has a flat to slightly concentric undulate valve face and mantle fultoportulae on thicker costae (Houk *et al.* 2010).

Both *Cyclotella ornata* (Skvortsov) Flower and *Cyclotella minuta* (Skvortsov) Antipova have verrucose and tangential undulate central areas and appear similar to *C. kitabayashii* in valve view under LM. SEM observations, however, reveals that *C. ornata* and *C. minuta* have no areolae on the central area of their valve faces (Houk *et al.* 2010) while, *C. kitabayashii* has many.

The authors compared this taxon to other similar taxa in the genera *Cyclotella* and still more *Pliocaenicus* (e.g. Simonsen 1987, Loginova 1990, Krammer & Lange-Bertalot 1991, Round & Håkansson 1992, Håkansson 2002, Tanaka 2007), but were unable to find any taxon that had the following combination of characteristics observed in our specimens : tangential undulate central area, many areolae scattered around central area of valve face, valve face fultoportulae arranged in a circular pattern, alveolae having both centrifugal and centripetal roofing over, one stalked rimoportula on marginal area of valve face and mantle fultoportulae located on recessed costae. We therefore propose *Cyclotella kitabayashii* as a

new species.

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