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Azpeitia komurae n. sp., a Biostratigraphically Useful Diatom from the Neogene of Japan

By

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Abstract A new Neogene diatom species, *Azpeitia komurae* is described on the basis of both light and scanning electron microscope observations. The species is similar to *A. nodulifer* (A. SCHMIDT) FRYXELL & SIMS, but is distinguished by having a subcentral hyaline area. Its occurrence is restricted to the uppermost part of the Upper Miocene *Rouxia californica* Zone (NPD7A) of AKIBA (1983, 1986) in the North Pacific, and hence it is a good marker species to recognize the horizon.

Introduction

In a recently revised Neogene diatom zonation for the middle-to-high latitudes of the North Pacific (AKIBA, 1983, 1986), several new diatom zones including the Upper Miocene *Rouxia californica* Zone have been established, in order to make those previously published zonations (KOIZUMI, 1973 a, b, 1977, 1979; BARRON, 1980, 1985) more useful. Taxonomic backgrounds for most of the revised zones are presented in detail by AKIBA and YANAGISAWA (1986) and partly by AKIBA (1986). A biostratigraphically useful taxon, "*Coscinodiscus* sp. A" (AKIBA, 1982, 1986), which occurs in a restricted interval at the top of the *Rouxia californica* Zone, however, has been left for discussion in the present paper, partly because the generic position of the taxon was not certain at that time. Very recently, FRYXELL *et al.* (1986) separated a group of species from the genus *Coscinodiscus* and included them in a revived diatom genus *Azpeitia* M. PERAGALLO. "*Coscinodiscus* sp. A" of AKIBA evidently belongs to the latter genus, and it is described here as *Azpeitia komurae* n. sp. with the discussion of its biostratigraphic significance in the Northwest Pacific.

Material and Methods

Stratigraphic occurrences of *Azpeitia komurae* n. sp. and other zonal marker species in the following five Neogene sequences of Japan (Fig. 1) are presented in order to clarify the biostratigraphic usefulness of the new species. Among them, an off-shore well, Yufutsu-oki B-4, from which the type material of the new species was selected, is examined in detail. Diatom data from other sections are based upon

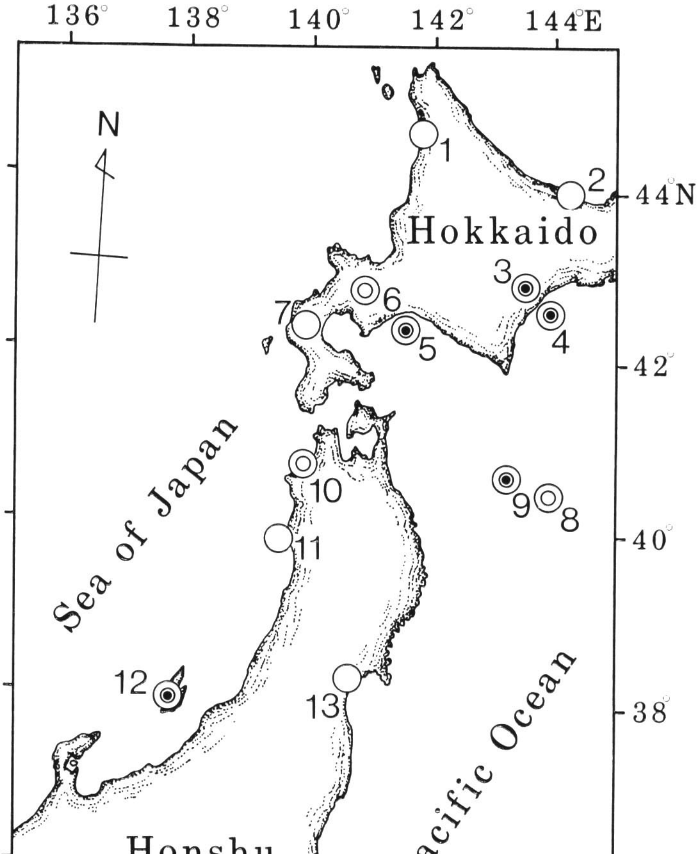

Fig. 1. Index map showing localities of selected Neogene sequences in Japan, where the Upper Miocene *Rouxia californica* Zone has been recognized. 1; Enbetsu, 2; Abashiri, 3; Ikuchise, 4; MITI Tokachi-oki Well, 5; Yufutsu-oki B-4 Well, 6; Sapporo, 7; Imagane, 8; DSDP, Leg 87, Hole 584, 9; DSDP, Leg 57, Hole 438A, 10; Ajigasawa, 11; Oga, 12; Sado, 13; Matsushima. Double and triple circles indicate localities of *Azpeitia komurae* Akiba n. sp.; triple circle denotes five stratigraphic sections where ranges of selected diatom species are determined as shown in Fig. 2.

several publications as cited below, with some re-examination of the original material.

1) Nakayama-Toge section, Sado Island (AKIBA, 1986; AKIBA, in press).
2) Yufutsu-oki B-4 Well, off central Hokkaido (this study).
3) Ikuchise section, eastern Hokkaido (MAIYA *et al.*, 1981 a; AKIBA *et al.*, 1982a).

4) MITI Tokachi-oki Well, off eastern Hokkaido (SASAKI *et al.*, 1985).

5) DSDP, Leg 57, Hole 438A, off Northeast Honshu (AKIBA, 1986).

The preparation and counting methods of diatoms follow those of AKIBA (1982, 1986). Scanning electron microscope (SEM) observations are made using a JSM-T200 model SEM in the National Science Museum, Tokyo.

Taxonomy

Family Nitzschiacae GRUNOW (1860).

Genus *Azpeitia* M. PERAGALLO in TEMPÈRE & PERAGALLO (1912).

For description of the genus, see FRYXELL *et al.*, 1986, p. 6.

Azpeitia komurae AKIBA, sp. nov.

(Plate 1, figs. 1–5c, Plate 2, figs. 1–13)

Synonym: *Coscinodiscus curvatulus* GRUNOW. KOIZUMI, 1966, pl. 2, fig. 2; *Coscinodiscus nodulifer* A. SCHMIDT. WHITING and SCHRADER, 1985, pl. 4, fig. 9; *Coscinodiscus* sp. A. AKIBA, 1986, p. 442, pl. 3, figs. 1–5, not AKIBA *et al.*, 1982b, pl. 1, fig. 9.

Description: Valve heavily silicified, circular and almost flat, sometimes slightly depressed near center, 15–62 μm in diameter with defined margin, 1–1.5 μm wide. Valve face covered with dense hexagonal to quadrangular areolae except for sub-central hyaline area, where several more or less isolated smaller areolae present. Also a "nodule"-like structure observable at sub-center, and arranged diagonally to the hyaline area; however, this structure not always clearly differentiated from smaller areolae. Areolae arranged in fascicules, being clearer in larger specimens than in smaller ones. In some smaller specimens, such fascicular arrangements hardly discernible. Areolae larger around sub-central hyaline area, 4–5 areolae in 10 μm, and gradually decreasing in size towards valve margin, where 6–7 areolae in 10 μm are observed. Margin with two rows of small areolae, the inner one being less clearly discernible and the outer one looking like marginal striae, about 10 striae in 10 μm.

Holotype: Plate 1, figs. 5 a–c, Slide no. Zu 3/46, deposited in the Hustedt Collection, Bremerhaven. Location of the type specimen is marked by diamond pencil.

Isotype: Plate 2, fig. 2, Slide no. MPC04033, deposited in Micropaleontology Collection, National Science Museum, Tokyo.

Type locality: An off-shore well, Yufutsu-oki B-4, 42°27′55.25″N, 141°46′9.04″E, 860–880 m subbottom depth, Sample no. JDS-9817.

Geologic age: Latest Miocene (the *Rouxia californica* Zone).

SEM observation: SEM observations reveal the following morphologic characters. Areolae on valve face hexagonal with external cribrum (Pl. 1, fig. 2) and internal circular foramina (Pl. 1, fig. 4). A "nodule" in sub-center of the valve is a labiate process, of which the tube slightly protrudes outward, and is similar in size to the

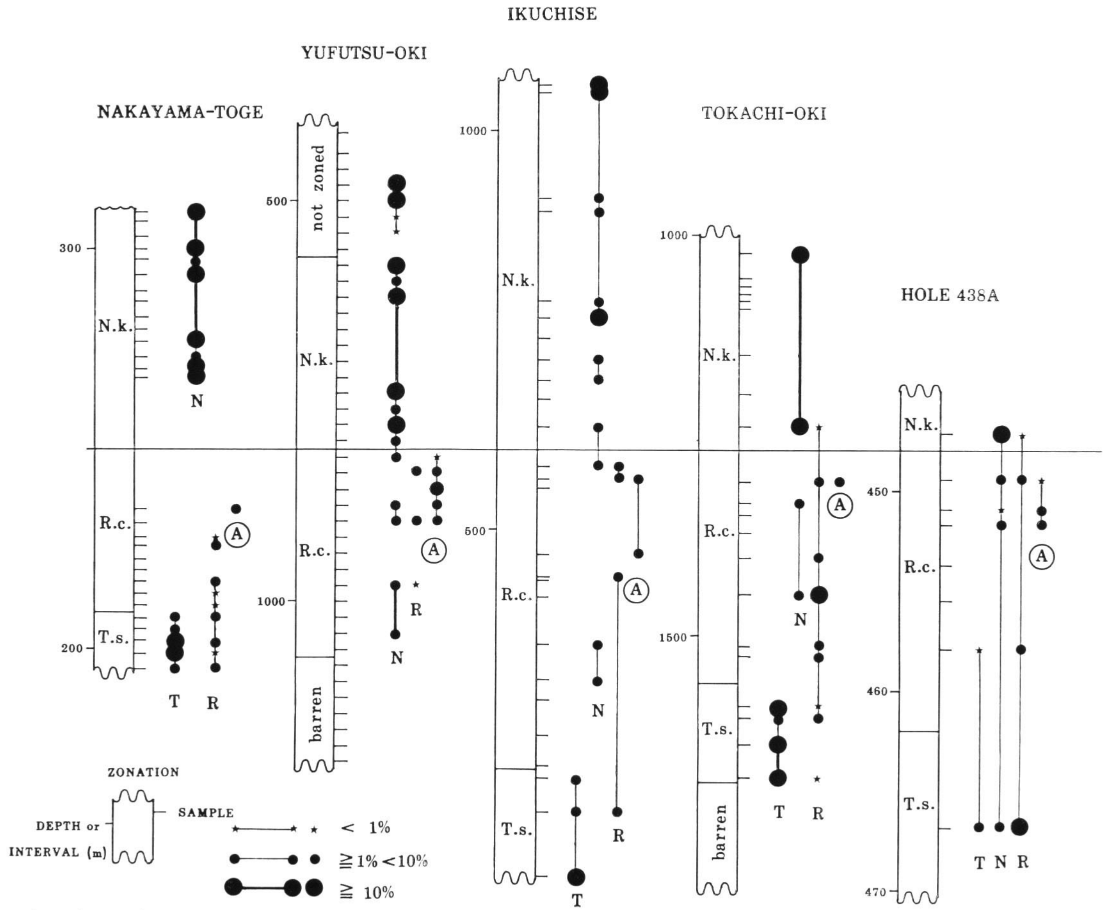

Fig. 2. Stratigraphic occurrences of *Azpeitia komurae* in five Neogene sequences of Japan. Diatom zonal subdivisions are after AKIBA (1983, 1986). Circled A—*Azpeitia komurae* n. sp.; N (N, k.)—*Neodenticula kamtschatica* (Zone); R (R. c.)—*Rouxia californica* (Zone); and T (T. s.)—*Thalassionema schraderi* (Zone). See Fig. 1 for location of each sequence.

surrounding areolae (Pl. 1, fig. 2). Silica ridge is present along the edge between valve face and mantle, and is interrupted regularly at the outer end of the longest row of areolae in each fasciculus (Pl. 1, fig. 3), where a labiate process is present internally (Pl. 1, fig. 4). These marginal labiate processes have no discernible outer projections, but rather have a simple, slightly radially elongated opening. Valve mantle is furnished with two rows of alternating areolae, and the inner one is almost perpendicular to the valve face and the outer row slanting toward the periphery (Pl. 1, fig. 3).

Remarks: The presence of a sub-central and a row of marginal labiate processes clearly indicates this species to be a member of the genus *Azpeitia*.

This new *Azpeitia* species closely resembles *A. nodulifer* (SCHMIDT) FRYXELL & SIMS, but differs from it in having the sub-central hyaline area and the clear fasciculation. The general morphology of this new species also agrees well with the description of *Azpeitia vetustissima* (PANTOCSEK) SIMS of KANAYA (1971; given as *Coscinodiscus vetustissimus* PANTOCSEK) except that it lacks the sub-central hyaline area and the size of areolae decreases towards margin. From another related form, *A. praenodulifer* (BARRON) SIMS & FRYXELL (BARRON, 1983, p. 511, pl. 3, figs. 9–10, pl. 6, fig. 8 described as *Coscinodiscus praenodulifer*), *A. komurae* is distinguished by its larger areolae and the decrease in size of areolae.

The species is sincerely dedicated to Dr. Seiichi KOMURA, a senior diatom colleague at JAPEX who has helped me for many years in various ways.

Distribution

KOMURA (1966MS) and KOIZUMI (1966) first recognized and illustrated *Azpeitia komurae* as *Coscinodiscus nodulifer* A. SCHMIDT from central Hokkaido and as *Coscinodiscus curvatulus* GRUNOW from Aomori Prefecture, Northeast Japan, respectively. The species of KOMURA comes from subsurface samples at Teine Mein, north of Sapporo, Hokkaido, from a horizon assigned to his *Rouxia peragalli-Thalassiosira decipiens-Nitzschia* cfr. *frigida* Zonule.

This taxon has since been ignored until AKIBA (1982) referred to it as *Coscinodiscus* sp. A from Hokkaido and noted its high biostratigraphic usefulness. The species has been recognized in subsequent observations from several other localities of Northeast Honshu and Hokkaido (Fig. 1). No information on its occurrence in the Northeast Pacific was available until WHITING and SCHRADER (1985) recently illustrated it as *C. nodulifer* A. SCHMIDT from off-shore samples of Oregon. *Azpeitia komurae*, therefore, has a wide geographic distribution in the North Pacific.

Stratigraphic Occurrence

AKIBA (1982) noted a short stratigraphic occurrence of *Azpeitia komurae* (recorded as *Coscinodiscus* sp. A) in Upper Miocene sequences of central and eastern Hokkaido, at a stratigraphic horizon approximately correlative with the top of his lower A Subzone of the *Denticulopsis kamtschatica* Zone. This subzone was later redefined as the *Rouxia californica* Zone (AKIBA, 1983, 1986). AKIBA first became aware of a high stratigraphic utility of *Azpeitia komurae* when he examined eight exploration wells drilled in an area off the coast of Hidaka area, central Hokkaido, by the Hokkaido Petroleum Exploration Co. Ltd. (JPH) during 1976 through 1978. Abundant diatoms have been recognized from nearby on-land Neogene sediments of this area, generally in the Biratori Formation and the overlying Nina Formation (AKIBA, 1975, 1986; MAIYA *et al.*, 1981 b), and the diatom zonation recognized in those strata includes five zones from the lower Upper Miocene *Thalassiosira yabei* Zone upward to the Pliocene *Neodenticula kamtschatica* Zone, with a missing horizon corresponding to the *Denticulopsis katayamae* Zone. Due to deep burial of these Neogene sediments, occurrences of diatoms in those well are, however, restricted generally to younger horizons, represented only by two diatom zones, the *Rouxia californica* Zone and the overlying *Neodenticula kamtschatica* Zone.

The result of diatom biostratigraphy for one of the wells, Yufutsu-oki B-4, is presented here (Table 1). This off-shore well is located about 23 km southeast of Tomakomai, central Hokkaido (Fig. 1). Of the total 38 examined cutting samples taken from 415 m to 1180 m subbottom depths, those between 580 m and 1060 m yielded common to abundant diatoms. Above and below the interval, diatom remains are rarely recognized, and they are interpreted here as being reworked and resulted from down core contamination, respectively.

The interval from 580 m through 1060 m depths can easily be subdivided into upper and lower intervals based primarily on occurrence of *Neodenticula kamtschatica* (Zabelina) AKIBA & YANAGISAWA, whose common-to- abundant occurrence (5–40%) distinguishes the upper interval (580–800 m). The lower interval (820–1060 m) also yields *N. kamtschatica*, but its occurrence is very sporadic. The occurrence of such species as *Azpeitia komurae* n. sp., *Rouxia californica* M. PERAGALLO, *Synedra jouseana* SHESHUKOVA, *Thalassiosira singularis* SHESHUKOVA and *T. temperei* (Brun) AKIBA & YANAGISAWA is characteristic of the lower interval. Although the occurrence of the latter four species is rare and is generally rather sporadic, these species are nontheless restricted to the lower interval. Especially important and consistent is the occurrence of *Azpeitia komurae*, which is limited to the upper part of the lower interval. The last occurrence of this species coincides with the boundary between the upper and lower intervals.

According to the diatom zonal scheme of AKIBA (1983, 1986), the pattern of diatom occurrences in the upper and lower intervals of the well enable the assignement of these two intervals to the *Neodenticula kamtschatica* Zone (NPD7B) and *Rouxia californica* Zone (NPD7A), respectively. The zonal boundary between the two is originally defined by the last common occurrence of *R. californica* on the basis of data from DSDP, Legs 57 and 87 holes, west of Japan Trench, off Northeast Japan (AKIBA, 1986).

This event is, however, not clearly discernible in some sequences, for example Yufutsu-oki B-4. One reason is that the abundance of *R. californica* is not high enough

Table 1. Stratigraphic occurrences of selected diatom species in Yufutsu-oki B-4 Well, Hokkaido. Bi.; Biratori Formation, Kr.; Karumai Formation, +; fragments or presence of diatoms.

FORMATION	Moebetsu								Nina																									Br. + Kr.				
DIATOM ZONE	PD								N. kamtschatica												R. californica													P D				
SAMPLE / DIATOM	415	440	460	480	500	520	540	560	580	600	620	640	660	680	700	720	740	760	780	800	820	840	860	880	900	920	940	960	980	1000	1020	1040	1060	1080	1100	1120	1140	1160
ABUNDANCE(valves/slide,X10)	2	2	2	12	40	2	2	6	120	60	60	52	90	52	90	52	90	51	90	60	52	51	120	120	120	60	90	60	60	51	51	40	22	3	2	3	1	1
MARINE DIATOMS																																						
Actinocyclus ingens	+	+	+	2	4		+	+	2	1				1	2	1	2		1	5	2	1	1	2	1	2	1	3	1	+	3	2	1					
A. ochotensis																									1	1						1						
A. octonaris					1													2		2		3						2	1				1					
Actinoptychus senarius					1			+		1		1	5	3	1	6	3		3	1	2	3		1	1		1	2	1	3	+	1					+	
Azpeitia komurae n. sp.																					+	2	18	3	1													
Cocconeis costata								+	2	4	2		2	1		4		1		1	1					1								+			+	
Coscinodiscus marginatus			+	2	1	+	+	+		3	7	5	3	8	10	6	12	25	16	11	9	9	14	6	7	3	11	11	3	+	9	19	7	+	+	+	+	+
C. spp.		+	+	4			+	+				1	1	1		1		1	1		1	6	5		3	3		2				2		+		+	+	+
Cosmiodiscus insignis									1											2	+						1					1						
Cymatosira debyi				2						2	2	1		1				1										1										
Denticulopsis dimorpha																												2	2									
D. hustedtii s. l.	+	+	+	11	3	+			1		+			1		2	6			1	1	2		1		1	1	2				1		+			+	
D. hyalina		+	+		1					1	2	•1			1	3	2		1		1		2	2			3			1	1							
D. lauta & aff. lauta	+	+		4	1					6										1							1						1					
D. praedimorpha			+													2																						
Grammatophora spp.	+									3	1	1	2			1		2	1							1					3							
Hyalodiscus obsoletus				1	1			+	1	1	2		1	2		1						1		1	2				1	1								
Ikebea tenuis		+							3		1	31	1	1	1	2	+		6	3	12	2	3		1	3	5	6	9	1	3			+				
Kisseleviella carina																					1	1																
Neodenticula kamtschatica				23	63	+	+		30	4	25	17	41	28	21	28	26	8	10	5	1			1	1				1	1	1	2		+	+	+		
N. seminae					1																																	
Nitzschia fossilis													1															1										
N. rolandii				1					3	8	8	5	1	1	6	3	4	3	2	1	1	1		1	1				1	2		1						+
N. reinholdii s. l.															+					1	+								1		1		4					
N. suikoensis											1	1																										
N. sp. 1									1			1		+			4	1			1					1	1						1					
Odontella aurita													1		1				5	2	3	4					3				1							
Paralia sulcata				1	2		+	+	3	1	2	4	1	3	2				1	4	1	2	1	3	1				2			1	1					
Rhizosolenia barboi				2											1		1					2		1	3	1	2	3		1	2		1					
R. aff. styliformis				2		+			1	1			1															2		2			1					
R. cf. hebetata	+			1					2	1			1	1		1						1						2	2	2					+			
Rouxia californica																						1			1				+						+			
Stephanopyxis spp.		+	+	3	1	+		+	1			2		1		3	1	5	12	4	17	13	4	5	6	6	17	12	4	4	6	9	10	+	+		+	+
Synedra jouseana																									2	1			+	1	+							
Thalassionema nitzschioides		+		22	5	+	+	+	26	34	25	14	20	33	31	21	23	30	23	32	30	24	35	61	44	56	34	36	50	50	45	37	38	+	+	+	+	+
T. schraderi													1															1										
Thalassiosira antiqua									2							1									1		1		1	3	2	1	1					
T. delicata					1				2																													
T. gravida & f. fossilis				2			+			1	2		1	+		1		2										1				1	2		+			
T. manifesta																	1				+						1				1							
T. nidulus s. l.							+		3	1	2	2	1	1		1	1		1	1	1	2			1		2	2	1	4	2							
T. jacksonii											1	1	1		1								1				1		1									
T. punctata										1							+			2					1		1											
T. singularis																						1		1														
T. temperei																						1	2	1			1		+									
T. zabelinae				10	+		+	+		4	5		3	3	5	2	3	6	1	11	1	2	1				3					4	3	+	+			
T. spp.			+	5	9	+		+	13	18	9	6	8	7	15	6	7	12	12	10	9	16	6	10	20	19	7	9	16	23	20	15	27	+		+	+	+
Trochosira concava					1			+	1	2	1	3	2	2	1	1	3	1	2		3	1	3		1											+		
MISCELLANEOUS				4	8				4	3	2	2	1	2	3	4	3		3	5	4		5	2	2	3	2	3	1	1	3	4	2					
NONMARINE DIATOM																																						
Aulacosira granulata s. l.								+				1														1	1		2			1						
Total number of valves counted	+	+	+	100	100	+	+	+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	+	+	+	+	+
Resting spores of Chaetoceros	+	+	+	30	12	+	+	+	44	30	44	76	53	37	53	37	34	58	45	67	58	37	20	8	45	87	83	109	85	51	84	75	34	+	+	+	+	+

relative to other zonal marker species and the other is that preservational (and/or possibly biogeographical) conditions as well as differing methods of sample preparation and specimen counting might truncate the last common occurrence. I, therefore, suggest two additional alternative criteria for recognizing the NPD7A-NPD7B boundary, namely a sudden upward increase to common-to-abundant occurrence of *N. kamtschatica* and the top of short-ranging *A. komurae*. These criteria can be used widely in many sections of Japan as shown below.

The *Rouxia californica* Zone has widely been recognized in many localities of Japan (Fig. 1). Figure 2 shows the stratigraphic occurrence of *A. komurae* n. sp. and three selected diatom zonal marker species, *Neodenticula kamtschatica*, *Rouxia californica* and *Thalassionema schraderi* AKIBA in five Neogene sequences of Japan including Yufutsu-oki B-4. In the Nakayama-Toge section, Sado Island (AKIBA, in press), the top of the *R. californica* Zone can be recognized by a single occurrence of *A. komurae*, and the last occurrence of *R. californica* is slightly below it. *N. kamtschatica* does not occur in the *R. californica* Zone in this section, and its sudden abundant occurrence is recognized in the overlying *N. kamtschatica* Zone. The absence of *N. kamtschatica* in the *R. californica* Zone is also recognizable in an exposed section of the Oga Peninsula (AKIBA, unpublished data). In the Ikuchise section, eastern Hokkaido (MAIYA *et al.*, 1981 a; AKIBA *et al.*, 1982a), the base of continuous occurrence of *N. kamtschatica* and the top of *R. californica* with *A. komurae* are separated by a stratigraphic distance of 20 meters, and the last occurrence of *R. californica* is taken to mark the top of the zone. Finally, a beautiful coincidence of these three criteria to delineate the top of the *R. californica* Zone can be recognized in both MITI Tokachi-oki well section, off the southern coast of eastern Hokkaido (SASAKI *et al.*, 1985; AKIBA, unpublished data) and DSDP, Hole 438A (AKIBA, 1986).

Such a coincidence of diatom biostratigraphic events as the last common occurrence of *Rouxia californica*, last occurrence of *Azpeitia komurae* and a sudden upward increase in abundance of *Neodenticula kamtschatica* at the top of the *R. californica* Zone, is likely to reflect a significant paleoceanographic change during the latest Miocene. AKIBA (in press) has suggested that this horizon is probably correlates with the initiation of a global cooling in the Messinian Stage in the area studied.

Concluding Remarks

Azpeitia komurae n. sp. is characterized by a robust valve and has very short stratigraphic occurrence in the upper part of the Upper Miocene *Rouxia californica* Zone of the Northwest Pacific. Therefore, the species is biostratigraphically highly useful. The robust valve character may make this species easily recognizable even in poorly preserved samples. Such an example is found in HIRAYAMA and UEMURA (1985), who recognized this species in calcareous nodule samples solely containing dissolution-resistant diatoms. Stratigraphic usefulness of this species can also be expected in the Northeast Pacific, because the illustration of this species by WHITING and SCHRADER (1985) ascertains its distribution in that region.

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Explanations to the Plates

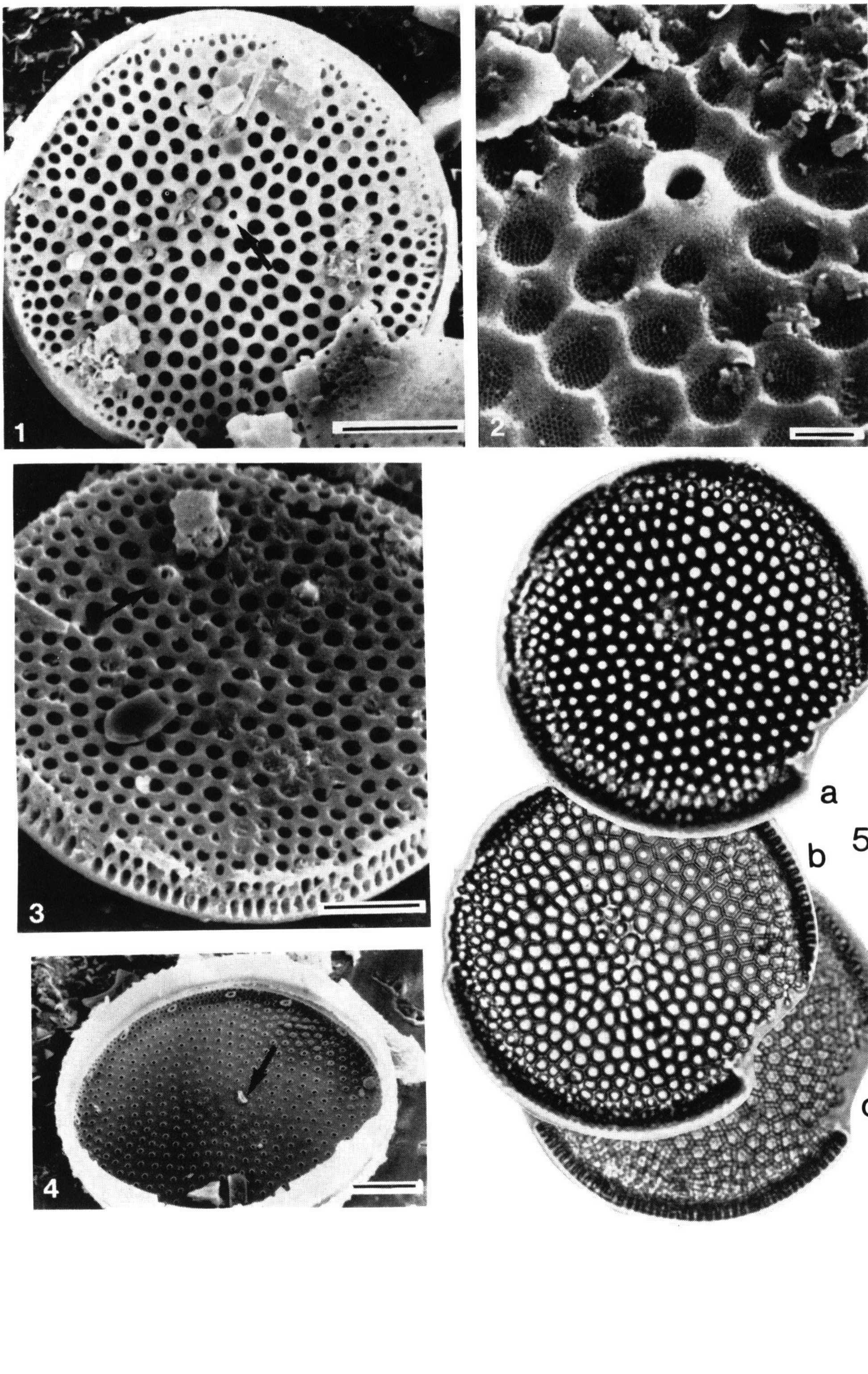
Plate 1

Plate 1. *Azpeitia komurae* AKIBA n. sp. All specimens from holotype material, JDS-9817. Scale bar in SEM figures equals 10 μm except for fig. 2 which is 1 μm. Fig. 1, Valve view from biological outside, note sub-central hyaline area and outer opening of sub-central labiate process (indicated by an arrow). Fig. 2, Close-up view of valve face. Fig. 3, Oblique valve view, double rows of areolae on the mantle and a discontinuous ridge at the edge of valve face are visible. Outer opening of sub-central labiate process is indicated by an arrow. Fig. 4, Valve view from biological inside, a row of labiate processes along valve edge and a sub-central labiate process (indicated by an arrow).

Figs. 5a–c. Holotype specimen, Sample JDS-9817, Yufutsu-oki B-4 Well, 860–880 m, Slide no. Zu 3/46, deposited in the Hustedt Collection, Bremerhaven, Magnification ×1400.

Plate 2

Plate 2. *Azpeitia komurae* AKIBA n. sp., (Magnification ×930, except for fig. 2, which is ×1400). Holotype material, JDS-9817, showing morphological variations of the species. Fig. 2, Isotype specimen, Figs. 12–13, Smaller specimens which have no conspicuous fasciculations.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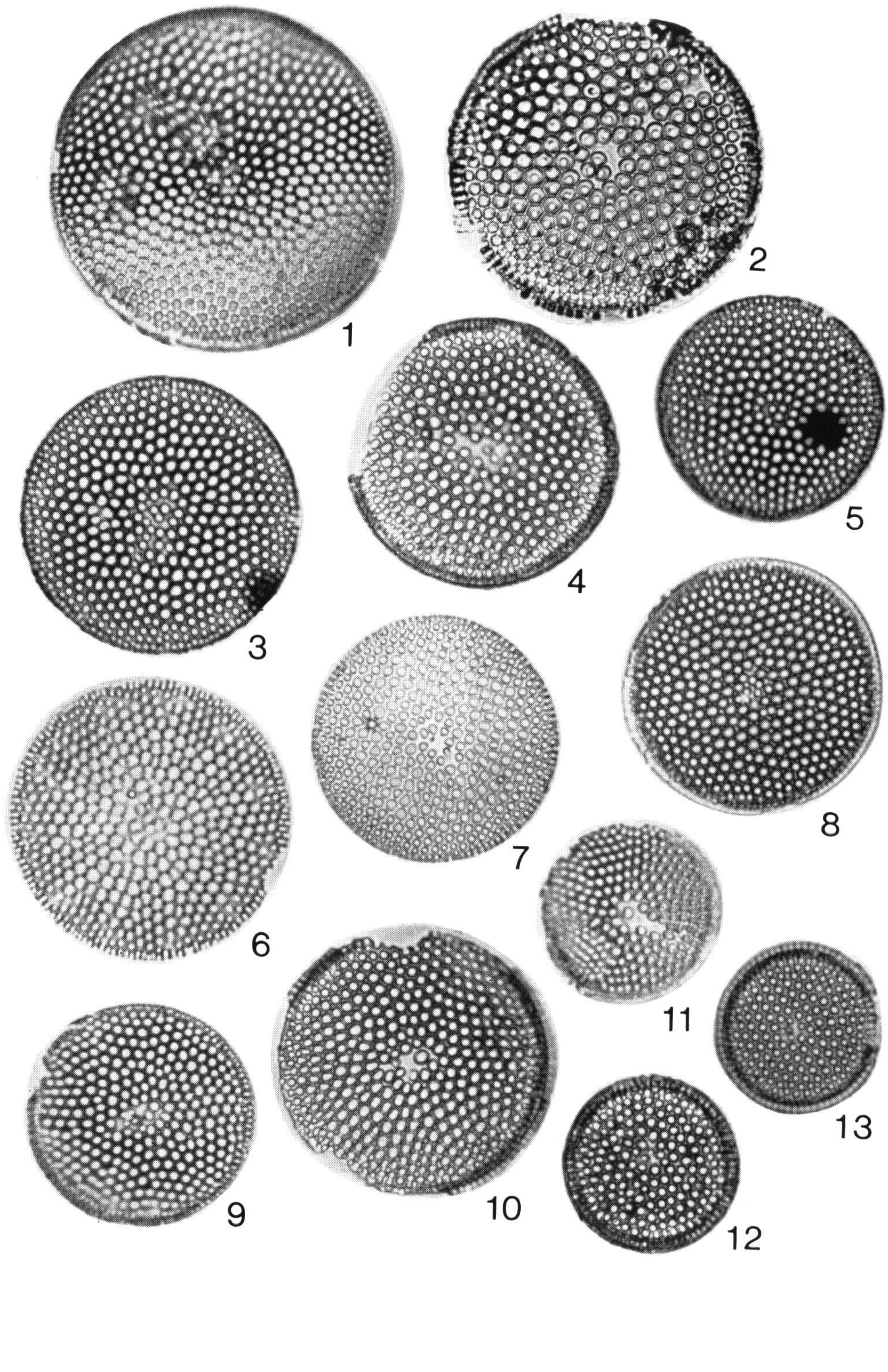
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