Memoir of the Fukui Prefectural Dinosaur Museum 2: 43–49 (2003)

BIVALVE AND CHAROPHYTE FOSSILS FROM THE TETORI GROUP: A CLUE TO STRATIGRAPHIC CORRELATION OF LATE MESOZOIC NON-MARINE DEPOSITS BETWEEN JAPAN AND CHINA—A PRELIMINARY WORK

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ABSTRACT

Species of bivalve and charophyte are collected from mudstone of the Cretaceous Okurodani Formation of the Tetori Group, in Shokawa Village, Gifu Prefecture. The bivalve is identified as *Megasphaerioides okurodaniensis* gen. et sp. nov. The new genus is related to *Sphaerioides* described in China, but differs from the Chinese genus in size and pallial sinus. *Mesochara* sp. (charophyte) is first reported from Japan. Charophyte is to be useful for correlation of non-marine deposits between the Chinese and Japanese, and worthy for further study.

Key words: bivalve, charophyte, China, Cretaceous, Okurodani Formation, Shokawa Village

小松俊文・陳　金華・王　后飛（2003）手取層群から産出した二枚貝と車軸藻化石：日本と中国における中生代後期非海成堆積物の層序対比の手がかり—予察．福井県立恐竜博物館紀要 2：43–49.

岐阜県荘川村に分布する手取層群の白亜系大黒谷層から二枚貝化石と車軸藻化石が採集され，二枚貝化石は *Megasphaerioides okurodaniensis* gen. et sp. nov. と同定された．この属は中国で記載された *Sphaerioides* 属と関係があると思われるが，殻サイズや套線湾入の特徴が中国の標本と異なっている．*Mesochara* sp. は日本で初めて記載される車軸藻化石である．車軸藻化石は中国と日本の対比をおこなう上で重要であり，今後，さらに研究を行なう必要がある．

INTRODUCTION

Biostratigraphic correlation of the Jurassic to Cretaceous systems in Japan and China and comparisons of benthic fossil assemblages have been studied by many paleontologists and geologists since the early twentieth century (Kobayashi and Suzuki, 1937, 1939, 1942; Yang, 1975; Kobayashi, 1983; Tamura 1990). However, in those days, there were difficulties in joint research with Chinese paleontologists and to have field investigation in China. Furthermore some type materials were lost during the World War II. These unfortunate conditions have raised different taxonomic schemes between both countries, which are prevented further investigation.

Chinese late Mesozoic deposits are largely terrestrial, and yield abundant non-marine fossils. Poverty of ammonites and other marine fossils makes the precise global correlation of these deposits difficult. Only some microfossils, such as ostracods and charophytes, are common with European and Russian strata, and are used for correlation.

The Jurassic to Cretaceous systems in Japan consist of ammonoid-bearing marine deposits and non-marine deposits. The former can be correlated globally, while the latter yields non-marine or brackish water bivalve taxa which are common in China. They are “keys” for detailed stratigraphic correlations of the Chinese deposits with those of Europe and other parts of the world. To establish correlation between Japanese non-marine strata and those of China, taxonomy of non-marine macrofossils should be reexamined in comparison with the Chinese material. Based on the study, macro- and microfossil biostratigraphy of the Japanese non-marine sediments should be established.

The Jurassic to Cretaceous Tetori Group distributed in the Hokuriku and Hida areas is suitable for this purpose of the study, since the group yields both marine and non-marine

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fossils abundantly, and many of the non-marine species are common with the Chinese forms, as Tamura (1990) reported. Many of the bivalve genera found in the Tetori Group were comparable with those originally described in China. However, most of these forms, including "*Sphaerioides*" sp. and "*Nakamuranaia*" sp. (=*Nagdongia* sp.), have not yet been studied in detail and are never compared with Chinese species.

As for the microfossils, charophyte (gyrogonite) seems to be useful for biostratigraphic correlations. Late Cretaceous (Cenomanian) charophyte fossils were reported for the first time from the Mifune Group of central Kyushu by Iwasaki and Sakamoto (1983) in oral, and two genera *Stellatochara* and *Sphaerochara* were illustrated by Iwasaki (1994). From various localities of the Early Cretaceous formations in the Inner Belt of the Southwest Japan, including the Tetori Group, Iwasaki and Tamura (1990) reported occurrence of three genera of two families: Clavatoraceae: "*Clavator*" sp.; Characeae: ?*Praechara* sp., *Raskyella* sp., besides of the two genera from the Mifune Group. None of these reports, however, includes systematic descriptions.

In this paper, we describe a genus of bivalve new to science, which hitherto assigned to "*Sphaerioides*" sp., the genus originally described from China, and also the first occurrence of a species of the charophyte genus *Mesochara*, both from the Okurodani Formation of the Tetori Group.

GEOLOGIC FRAMEWORK

The Tetori Group is composed of the Kuzuryu, Itoshiro and Akaiwa subgroups in ascending order (Maeda, 1952, 1961), and is widely exposed in Shokawa Village, Gifu Prefecture (Fig. 1). The Kuzuryu Subgroup is divided into the Ushimaru and overlying Mitarai formations (Matsukawa and Nakada, 1999). The Ushimaru Formation consists of alternating beds of sandstone, whose grain size is varying, and mudstone, and abundantly contains brackish-water bivalves, such as *Myrene* (*Mesocorbicula*) *tetoriensis*, *Tetoria yokoyamai*, and *Crassostrea tetoriensis* (Maeda, 1952; Matsukawa and Nakada, 1999; Komatsu et al., 2002). The Mitarai Formation characterized by marine mudstone yields abundant bivalves (Maeda, 1952; Hayami, 1959a, b, 1960; Komatsu et al., 2001) and the ammonite, *Lilloetia* sp., suggesting the Jurassic (Sato and Kanie, 1963).

The Itoshiro Subgroup is divided into the Otaniyama, Okurodani and Amagodani formations (Matsukawa and Nakada, 1999). The Otaniyama and Amagodani formations are mainly composed of sandstone. The Okurodani Formation consists of alternating beds of sandstone and mudstone. The upper part of the Otaniyama and Okurodani formations yield brackish-water and freshwater molluscs, such as *Myrene* (*Mesocorbicula*) *tetoriensis*, *Tetoria yokoyamai*, *"Nakamuranaia"* sp. and *Vivipulus* sp. The Okurodani Formation is regarded as about 135±7Ma (Neocomian) in age based on F-T method (Gifu-ken Dinosaur Research Committee, 1993), though neither the exact locality nor stratigraphic horizon sampled were given in their paper. Fossil localities of this paper are situated at Okurodani and Kobudani, Ogamigo, in the northern part of Shokawa Village.

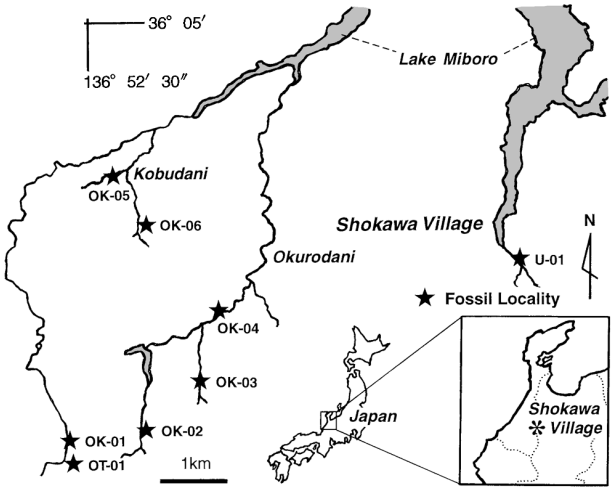

FIGURE 1. Map of Shokawa Village, showing the localities of molluscan and charophyte fossils.

In the Shiramine area, Ishikawa Prefecture, these non-marine molluscs are also found in alternating beds of sandstone and mudstone of the Kuwajima Formation of the Itoshiro Subgroup (Tamura, 1990) and the Akaiwa Formation of the Akaiwa Subgroup. The Kuwajima Formation is correlated to the Okurodani Formation (Kusuhashi et al., 2002).

SYSTEMATIC PALEONTOLOGY (BIVALVIA)

Superfamily CORBICULACEA? Gray, 1847
Family PISIDIIDAE? Gray, 1857
Genus MEGASPHAERIOIDES nov.

Type species.— *Megasphaerioides okurodaniensis* sp. nov.

Diagnosis.— Like *Sphaerioides*, but shell much larger and has a clearly sinuate pallial sinus; test thick; umbo prosogyrous, placed anteriorly; hinge as formulated: AI AIII 3a 3b PI PIII / AII 4b PII, cardinal teeth very small and thin, 3a and 3b slightly continuous, lateral teeth well developed, anterior and posterior pedal retractor scars clearly impressed.

Remarks.— Tamura (1990) listed and illustrated "*Sphaerioides*" sp. from the Itoshiro and Akaiwa subgroups, Tetori Group. However he did not systematically describe and did not compare with the Chinese materials.

Sphaerioides is commonly found in the late Mesozoic non-marine deposits from the northeast China, and is characterized by small shell (up to 3 cm long) and developed large lateral teeth. *Megasphaerioides* is different from *Sphaerioides* in very

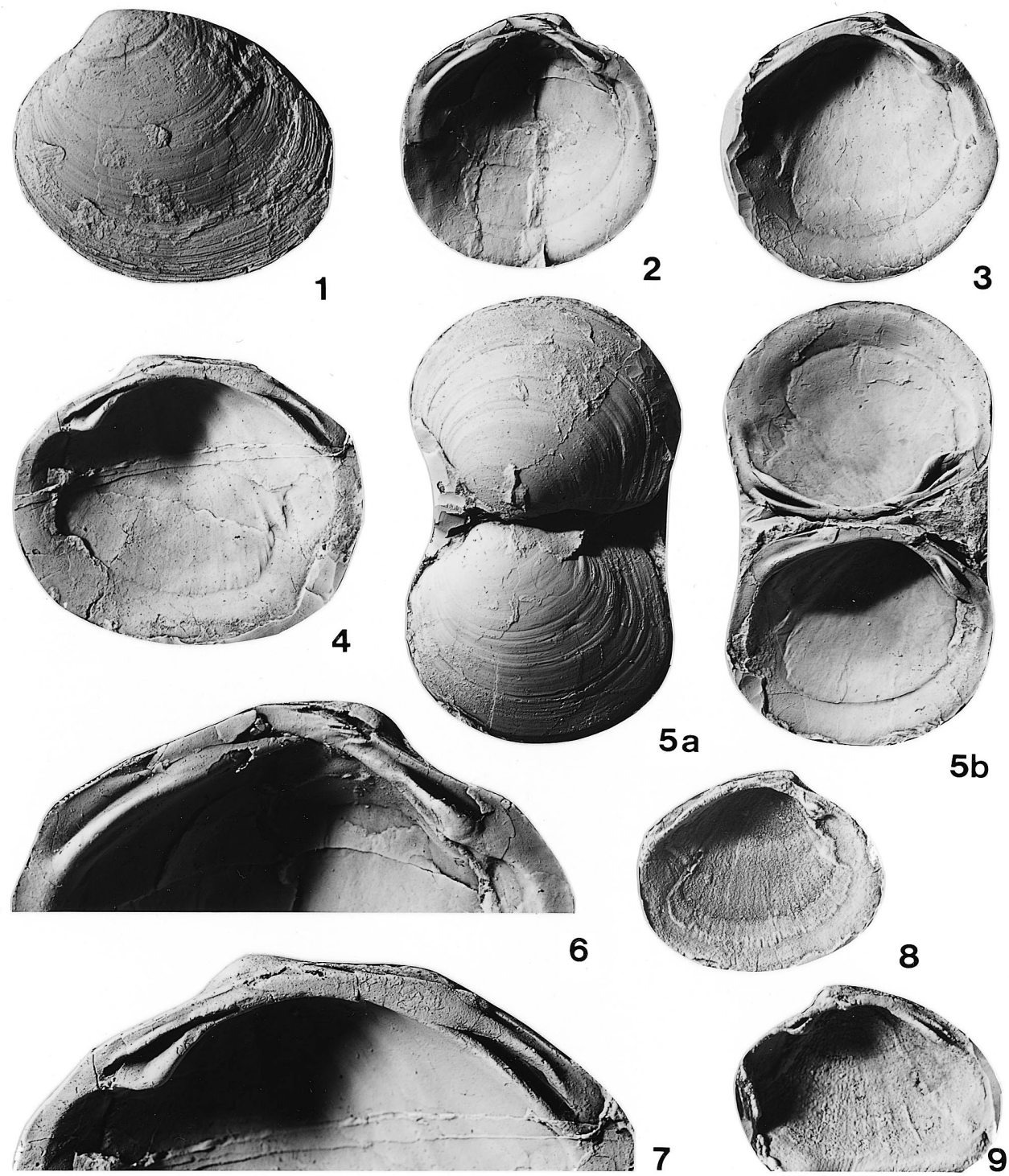

FIGURE 2. **1**–**7**. *Megasphaerioides okurodaniensis* gen. et sp. nov. from the Lower Cretaceous Okurodani Formation in Shokawa Village, Gifu Prefecture. All specimens are rubber cast. **1**. Left external cast, paratype (KMSP2202), x1.0, locality OK-04. **2**. Left internal cast, paratype (KMSP2203), x1.0, locality OK-04. **3**. Left internal cast, paratype (KMSP2204), x1.0, locality OK-05. **4**. Right internal cast, paratype (KMSP2205), x1.0, locality OK-04. **5**. Holotype (KMSP2201), x1.0, locality OK-04. **5a**. External cast of articulated valves. **5b**. Internal cast of articulated valves. **6**. Left internal cast, paratype (KMSP2203), x2.5, locality OK-04. **7**. Right internal cast, paratype (KMSP2205), x2.5, locality OK-04. **8**–**9**. *Sphaerioides yixianensis* (Gu) from the Lower Cretaceous Dongdaling Formation in Xingfu Village, Muleng district, the eastern Heilongjiang Province, China. **8**. Left internal cast, no.81947 in Nanjing Institute of Geology and Palaeontology, Academia Sinica, x2.0. **9**. Right internal cast, no. 81943 in Nanjing Institute of Geology and Palaeontology, Academia Sinica, x2.0.

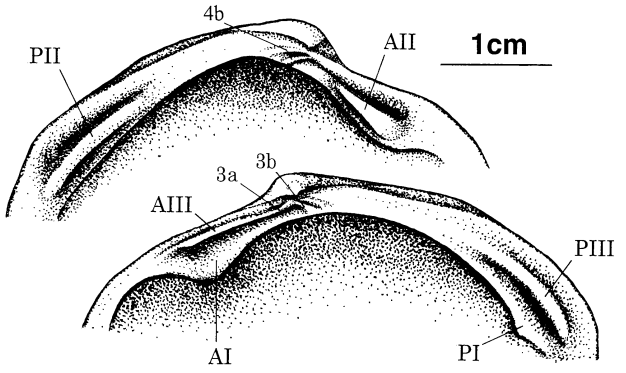

FIGURE 3. Hinges of *Megasphaerioides okurodaniensis* gen. et sp. nov. P: posterior lateral teeth, A: anterior lateral teeth.

TABLE 1. Measurements of specimens of *Megasphaerioides okurodaniensis* gen. et sp. nov.

Specimen	Length (mm)	Height (mm)	Thickness (mm)
Holotype (KMSP2201) right external mould specimen	46.0	38.5	8.50
Paratype (KMSP2202) left external mould specimen	55.3	47.0	14.0
Paratype (KMSP2203) left internal mould specimen	46.3	44.5	/
Paratype (KMSP2204) left internal mould specimen	46.3	44.5	/
Paratype (KMSP2205) right internal mould specimen	60.0+	50.0+	/

large shell and clear pallial sinus, although the lateral teeth of *Megasphaerioides* and *Sphaerioides* are much the same. Gu et al. (1997) also stated that Japanese "*Sphaerioides*" sp. is not congeneric with the Chinese *Sphaerioides*.

However, taxonomical position of *Sphaerioides* has been unfortunately truly confused in China. Gu et al. (1997) reported *S. yixianensis* and *S. changmaensis*, and redescribed diagnosis of *Sphaerioides* based on *S. yixianensis* [= *S. luanpingensis* described by Yu and Zhang (1984)], and show the dentition as formulated: AI AIII 3a 3b 5b PI PIII / AII 2b 4b PII. But their description does not correctly show characters of hinge structures. Especially, cardinal 5b is absent in type materials (ex. nos. 81943, 81953 in Nanjing Institute of Geology and Palaeontology, Academia Sinica) and cardinal 2b is unclear (ex. nos. 81947, 81950). Furthermore, their synonym lists of *S. yixianensis* and *S. changmaensis* include some different species.

Kobayashi and Suzuki (1937) reported *Batissa antiqua* from the Itoshiro Subgroup in the Izuki, Fukui Prefecture. *B. antiqua* is similar to *M. okurodaniensis* in outline. However, long and thin lateral teeth of holotype are morphologically different from that of *M. okurodaniensis*, although only part of lateral teeth is found.

Keen (1969) diagnostically described that the hinge structure of family Pisidiidae shows lateral teeth in both valves and not more than two small cardinals. Generally the hinges of *Pisidium* and *Sphaerium* show AI AIII 3a 3b PI PIII / AII 2 4b PII (Herrington, 1962). However the cardinal teeth 2 of *Megasphaerioides* is not developed. Furthermore the present genus characterized by thick test and obvious pallial sinus is quite different from the other genera of Pisidiidae. The pedal retractor scars are not also found in the family.

MEGASPHAERIOIDES OKURODANIENSIS sp. nov.
(Figs. 2.1–7, 3; Table 1)

"*Sphaerioides*" sp. Tamura, 1990, p. 6, 9, 15, 34, pl. 12, figs. 1-3.

Sphaerioides sp. Gifu-ken Dinosaur Research Committee, 1993, pl. 5, figs. 1, 2.

Materials.— The holotype (KMSP2201) and four paratypes (KMSP2202–2205) are mould specimens corrected from the Okurodani Formation at Okurodani and Kobudani, Shokawa Village, Gifu Prefecture.

Repository.— Department of Earth Science, Kumamoto University.

Diagnosis.— Same as for the genus.

Description.— Shell suborbicular to subelliptical in outline, larger than high, inflated; surface marked numerous growth lines; umbo moderate in prominence, incurved anteriorward, placed at about two-fifth of length from anterior end; antero-dorsal margin nearly straight; postero-dorsal margin slightly convex; anterior, posterior and ventral margins smoothly arcuate; escutcheon clearly delimited by an angular ridge; lunule indistinct; hinge plate narrow, provided small cardinal teeth; 4b bifid and straight; 3a slightly continuous from the lateral teeth AIII to cardinal 3b; 3b and 4b comparably short and thin; anterior lateral teeth shorter than posterior laterals, placed closely to the anterior cardinal teeth; AI thick and slightly rounded; AII subtriangular, highly elevated; AIII comparably thin and sharp; posterior laterals slightly arched in shape; PI and PII long, fairly thick and highly elevated; PIII thin and shorter than PI and PII; possession of several fine threads and striae parallel to the cardinal teeth on the hinge plate; adductor muscle scars comparatively strong, posterior adductor scar flabelliform, much larger than anterior one, anterior adductor scar suborbicular in shape; pedal retractor scars placed on the upper inner sides of each adductor scar; pallial line angularly and shallowly sinuated.

Measurements.— Length, height and thickness of specimens are given in Table 1.)

Occurrence.— Type materials are found in sandstone and mudstone of the Okurodani Formation of the Itoshiro Subgroup,

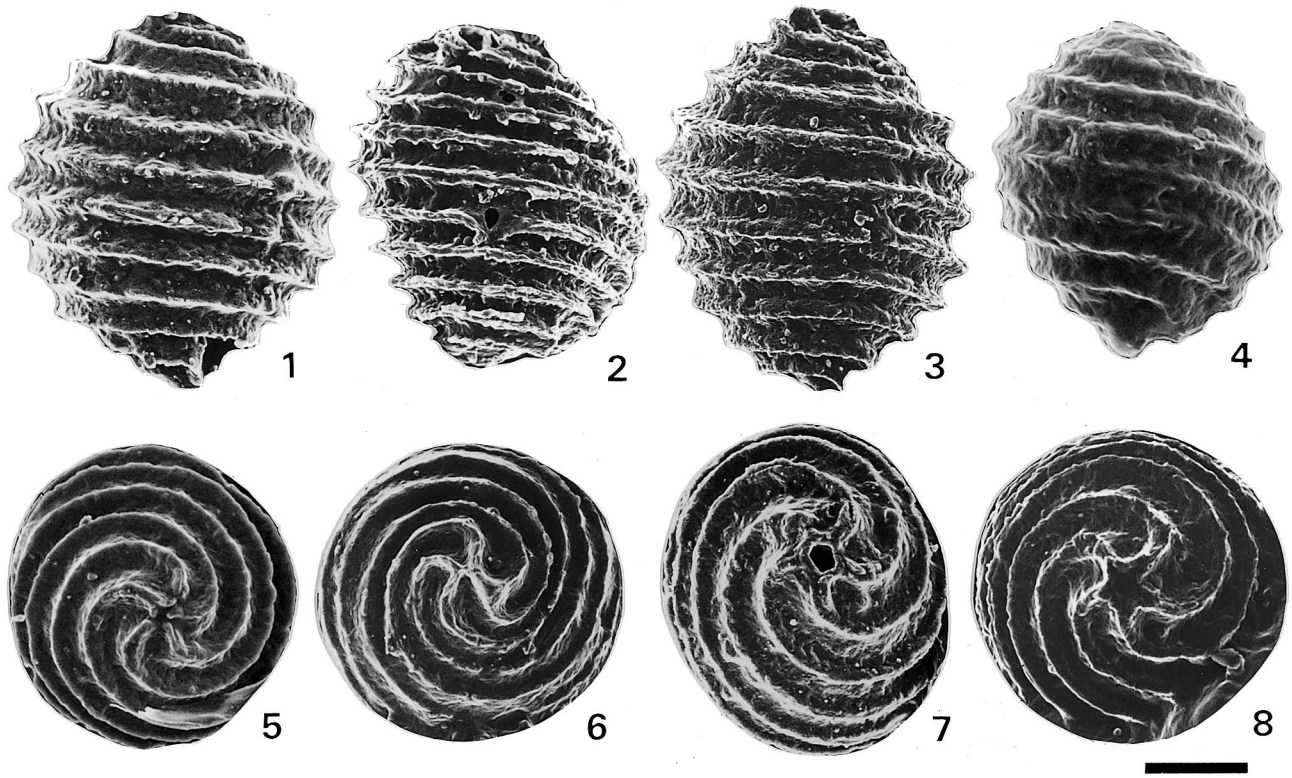

FIGURE 4. **1–8**. *Mesochara* sp. indet. from the Lower Cretaceous Okurodani Formation at locality OK-06 in Shokawa Village, Gifu Prefecture. All specimens are external rubber cast. scale bar = 100 μm. **1–4**. Lateral view (KMSP2210–2213). **5–6**. Apical view (KMSP2214–2215). **7–8**. Basal view (KMSP2216–2217).

Tetori Group at Okurodani and Kobudani, Ogamigo, Shokawa Village, Gifu Prefecture (Fig. 1), The sandstone and mudstone yield *Megasphaerioides okurodaniensis, Myrene* (*Mesocorbicula*) *tetoriensis, Tetoria yokoyamai* and *Nippononaia tetoriensis* (OK-02), and rarely contain articulated *M. okurodaniensis* and *in situ* preserved "*Nakamuranaia*" sp. (OK-03). Frequently *M. okurodaniensis* forms mono-specific shell concentrations (OK-01, 04, 05). Gifu-ken Dinosaur Research Committee (1993) reported *Sphaerioides* sp. obtained from the Otaniyama and Okurodani formations, in Okurodani. Tamura (1990) reported "*Sphaerioides*" sp. from the Kuwajima Formation of the Itoshiro Subgroup, in Shiramine and Oguchi Villages, Ishikawa Prefecture. (pl. 12, figs. 1, 2a, 2b, 3). The lower part of the Akaiwa Subgroup commonly yields the present species at Yanagidani, Ichinose, Shiramine Village, Ishikawa Prefecture.

SYSTEMATIC PALEONTOLOGY (CHAROPHYTA)

Family CHARACEAE
Genus MESOCHARA Grambast, 1962
Mesochara sp. indet.
(Fig. 4)

Material.— These specimens (KMSP2210–2218) are preserved as mould specimens.

Repository.— Department of Earth Science, Kumamoto University.

Description.— Gyrogonites small, ellipsoid, ranging 300–330 μm in length and 260–280 μm in width; seven to nine convolutions in lateral view, spiral cells concave, intercellular ridges narrow and sharp, in apical area no obvious depression zone and the spiral cells continue evolving onto summit without change in width and thickness; spiral cells joint at summit in a point or zigzag line; summit slightly protruding; basal opening small and pentagonal.

Discussion.— This species is similar to *Mesochara voluta* originally described as *Chara voluta* from the Jurassic Morrison Formation in Wyoming, USA (Peck, 1937). But its specific determination is difficult at present, because the materials are not only slightly deformed and limited in number, but also represented by gyrogonites of ill-preserved wall.

Occurrence.— All materials are obtained from black mudstone of the Okurodani Formation at locality OK-06 (=KO-2: 36° 03′ N, 136° 53′ E, Cook et al., 1998). These specimens are abundantly found (5–15 individual/cm^2) in vertebrate-bearing

bed containing fish, turtle, dinosaur, bird, gastropods (*Viviparus onogoensis*) and bivalve ("*Nakamuranaia*" sp.). This bed yields gyrogonites characterized by spherical and large, about 600 μm in diameter, and by 11–13 spiral ridges in a lateral view; hence they may be assigned to the species different from *Mesochara* sp.

ACKNOWLEDGMENTS

We would like to thank Dr. Hiroshige Matsuoka (Kyoto University) and Mr. Shizuo Shimojima (Educational Department of Shokawa Village) for their cooperation in collecting fossils, Dr. Haruyoshi Maeda (Kyoto University) and Prof. Kiyotaka Chinzei (Osaka-gakuin University) for their valuable comments. We are also grateful to the Educational Department of Shokawa Village for their kind assistance during fieldwork. This study was partly supported by a Grant-in-Aid for Encouragement of Young Scientists from the Ministry of Education, Science and Culture of the Government, Japan (no. 14740300) and the National Natural Science Foundation of China (nos. 40172003, 49672006), the project of Ministry of Science and Technology, China (G2000077700). Komatsu, T. acknowledges, with thanks, the Post-Doctoral Program of Nanjing Institute of Geology and Palaeontology, Academia Sinica for supports and helps in China.

REFERENCES

Cook, E., S. Isaji and M. Manabe. 1998. Preliminary results of a taphonomic study of a vertebrate accumulation from the Tetori Group (Lower Cretaceous) of Japan. Paleontological Research 2: 47–52.

Gifu-ken Dinosaur Research Committee. 1993. Report on the dinosaur excavation in Gifu Prefecture, Japan. Gifu Prefectural Museum, Gifu, 46pp. (in Japanese)

Grambast, L. 1962. Classification de l'embranchement des charophytes, -Naturalia Monspel. Ser. Bot., 14: 63–86.

Gu, Z. W., Z. S. Li and X. H. Yu. 1997. Lower Cretaceous bivalves from the eastern Heilongjiang province of China. Science Press, Beijing, 301pp.

Hayami, I. 1959a. Late Jurassic Hipodont, Taxodont and Dysodont Pelecypods from Makito, Central Japan. Japanese Journal of Geology and Geography 31: 135–150.

Hayami, I. 1959b. Late Jurassic Isodont and Myacid Pelecypods from Makito, Central Japan. Japanese Journal of Geology and Geography 31: 151–167.

Hayami, I. 1960. Jurassic Inoceramids in Japan. Journal of the Faculty of Science, University of Tokyo, Section 2, 12: 277–328.

Herrington, H. B. 1962. A revision of the Sphaerioidae of North America (Molusca: Pelecypoda). Miscellaneous Publications, Museum of Zoology, University of Michigan 108: 1–74.

Iwasaki, Y. 1994. Fossil charophytes of the Mifune Group; pp. 54–58 *in* M. Tamura (ed.), Reports on the Scientific Research of the Mifune Group, Mifune Dinosaurs. Kumamoto Nichinichi Press and Kumamoto Broadcasting Co. 108 pp. (in Japanese)

Iwasaki, Y., and M. Tamura. 1990. Cretaceous charophyte from the Southwest Japan. Abstracts of the 1990 Annual Meeting of the Palaeontological Society of Japan: 55. (in Japanese)

Keen, M. 1969. Pisidiidae; N669–670 *in* R. C. Moore and C. Teichert (eds.), Treatise on invertebrate paleontology, Part N, 2(3), Mollusca 6, Bivalvia. The Geological Society of America, Boulder, and the University of Kansas Press, Lawrence, 432 pp.

Kobayashi, T. 1983. Studies on the Mesozoic non-marine facies in Japan and Eastern Asia, Part II. Journal of Geography 92: 53–74.

Kobayashi, T., and K. Suzuki. 1937. Non-marine shells of the Jurassic Tetori Series in Japan. Japanese Journal of Geology and Geography 14: 33–51.

Kobayashi, T., and K. Suzuki. 1939. The brackish Wealden fauna of the Yoshimo beds in Prov. Nagato, Japan. Japanese Journal of Geology and Geography 16: 213–224.

Kobayashi, T., and K. Suzuki. 1942. On fossil beds in the Cretaceous Sungari series in Manchoukuo. Journal Faculty Science Imperial University, Tokyo, Section 2, 6 (5) : 75–90.

Komatsu, T., R. Saito and F. T. Fursich. 2001. Mode of occurrence and composition of bivalves of the Middle Jurassic Mitarai Formation, Tetori Group, Japan. Paleontological Research 5: 121–129.

Komatsu, T., K. Chinzei, M. S. Zakhera and H. Matsuoka. 2002. Jurassic soft-bottom oyster *Crassostrea* from Japan. Palaeontology 45: 1037–1048.

Kusuhashi, N., H. Matsuoka, H. Kamiya and T. Setoguchi. 2002. Stratigraphy of the late Mesozoic Tetori Group in the Hakusan Region, central Japan: an overview. Memoirs of the Faculty of Science, Kyoto University, Series of Geology and Mineralogy, 59: 9–31.

Maeda, S. 1952. A stratigraphical study on the Tetori Series in the upper Shiokawa district in Gifu Pref. Journal of the Geological Society of Japan 58: 145–153. (in Japanese with English abstract)

Maeda, S. 1961. On the geological history of the Mesozoic Tetori Group in Japan. Journal of the College of Arts and Sciences, Chiba University 3: 369–426. (in Japanese with English abstract)

Matsukawa, M. and K. Nakada. 1999. Stratigraphy and sedimentary environment of the Tetori Group in its central distribution based on nonmarine molluscan assemblages. Journal of the Geological Society of Japan 105: 817–835. (in Japanese with English abstract)

Peck, R. E. 1937. Morrison charophyta from Wyoming. Journal of Paleontology 11: 83–90.

Sato, T., and Y. Kanie. 1963. *Lilloetia* sp. (ammonite Callovienne) de Mitarai au bassin de Tetori. Transactions and Proceedings of the Palaeontological Society of Japan, New

Series 49: 8.
Tamura, M. 1990. Stratigraphic and palaeontologic studies on non-marine Cretaceous bivalve faunas in southwest Japan. The Memoirs of the Faculty of Education, Kumamoto University 39: 1–47. (in Japanese with English abstract)
Yang, S. Y. 1975. On a new non-marine pelecypod genus from the upper Mesozoic Gyeongsang group of Korea. Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 100: 177–187.
Yu, J. S., and K. Zhang. 1984. Bivalvia (Mollusca); pp. 33–65 *in* Tianjin Institute of Geology and Mineral Resources (ed.), Palaeontological Atlas of North China II Mesozoic Volume. Geological Publishing House, Beijing. (in Chinese with English abstract)