

Permian and Eo-Triassic *Bakevellias* from the Maizuru Zone, Southwest Japan

By

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Abstract

The so-called *Gervillias* from the upper ? Permian and the lower Triassic in the Maizuru zone, Southwest Japan are referred to *Bakevellia* KING in the pteriform outline. The genus is divisible into several subgenera founded on musculature and dentition, that is, less anisomyarian *Bakevellia* s.s. (Permian), strongly anisomyarian or monomyarian *Neobakevellia* n. subgen. (Triassic to Cretaceous), and *Maizuria* n. subgen. (Triassic to Jurassic) characterized by crenulated posterior cardinals and "pseudocardinals".

Five new species and two indeterminable species and subspecies of these subgenera are described from the Maizuru zone, with the revision on the lower Triassic "*Gervillias*" so far described in Japan.

Introduction and Acknowledgement

The so-called *Gervillia* comprises a number of various species of biauriculate, multivincular forms, and the classification of which was repeatedly discussed by many authors, such as FRECH (1902), L. WAAGEN (1907), GILLET (1924), and COX (1940, 1954). There seems to be two views concerning the classification; FRECH emphasized the importance of dentition, and GILLET's classification was also based mainly on dentition. On the other hand, COX set importance on the external shape. The latter opinion can be traced back to L. WAAGEN, and was recently accepted by HAYAMI (1957b). In the individual or ontogenetic variations, which suggest the phylogenetic relation, the dentition is more variable than the external shape, especially in the case of the Eo-Triassic, as will be stated in the descriptions, and the writer supports the latter opinion.

The Permian and the lower Triassic "*Gervillias*" from the Maizuru zone are all of *Pteria*-form, and are referred to *Bakevellia* KING em. COX, although the dentition is considerably variable.

Before discussing the genus, the writer wishes to express his most sincere thanks to Prof. S. MATSUSHITA of Kyoto University for his encouragement throughout the study. He is also obliged to Drs. N. D. NEWELL and O. H. HAAS of American

Museum of Natural History, Dr. L. R. Cox of British Museum and Dr. L. D. KIPARISOVA of Geological Institute of U.S.S.R. for their kind informations. Further, he wishes to thank Mr. T. SHIKI of Kyoto University for kind offering of his materials and Assist. Prof. K. ICHIKAWA of Osaka City University and Mr. A. TOKUYAMA of Tokyo University for their helpful suggestions.

On the Genus *Bakevellia*

The genus *Bakevellia* was established by KING in 1848 (type: *Avicula antiqua* MÜNSTER, Permian), who separated the genus from *Avicula* (= *Pteria*) in possessing two adductor scars and two to five ligament-pits. Subsequently SCHAUROTH (1857) and FRECH (1902) included the Triassic "*Gervillia*" *costata* (SCHLOTHEIM) and allied species in *Bakevellia*, but this view was not upheld by later authors.* Cox (1940) claimed that the generic name *Bakevellia* should be employed for the whole series of *Pteria*-like "*Gervillias*" from the Upper Paleozoic to the Cretaceous. After his example NAKAZAWA (1954) and YABE (1956) adopted the generic name for the Triassic species, and HAYAMI (1957a, b) also for the Liassic ones. But as suggested by HAYAMI, there is no Mesozoic species which has so large an anterior adductor-scar as that of the Permian species; the anterior adductor-scar of the Mesozoic *Bakevellia* is very small, and situated near the apex of the umbonal cavity, or almost absent, while that of the Paleozoic *Bakevellia* in the case of the specimens of which the muscle-impressions were observed is concerned, is fairly large and subcircular in outline, lying in the interior of the anterior auricle. The degree of development of the anterior adductor may not be so important a criterion for the major division of Pteriacea as KING considered (1850, p. 166), because there are not rarely found examples possessing a distinct anterior adductor in *Pteria* (s. l.), as exemplified by *Pteria ussurica yabei* NAKAZAWA n. subsp. stated below. Nevertheless, it is justifiable to separate, at least, subgenerically the strongly heteromyalian or monomyarian *Bakevellia* from *antiqua* group, even if the former type will be found in the late Paleozoic. Here the writer proposes the subgenus *Neobakevellia* designating *B. costata* (SCHLOTHEIM) of the European Triassic as type.

It is well known that there are two types of dentition in Bakevelliidae; the one represented by *Bakevellia* s. s. consists of one to several anterior (cardinal) teeth and a few posterior (lateral) ones, and the other is typified by pseudotaxodont dentition consisting of numerous denticles along the hinge margin. Cox (1940) referred to the latter form of the pteriform *Bakevellias*, that is, *Aguileria* WHITE, 1887 (type: *A. cummingsi* WHITE) as the subgenus under *Bakevellia*. As usually considered, the latter type of dentition is certainly derived from the former from time to time. This is also inferred by the ontogeny of the species from the Maizuru zone. But there seems to be two different ways of the development of the pseudotaxodont-dentition from the *Bakevellia* or *Pteria*-dentition. One is made

* FRECH (1907) himself later treated these species as *Gervilleia*.

through the differentiation of the cardinal teeth and "pseudocardinals" posterior to the cardinals, as clearly shown by the ontogenetic development of *Maizuria* n. subgen.. The other is accomplished through crenulation along the lower margin of the ligament-area or insertion of denticles between the anterior and posterior teeth as represented by *Bakevelloides hekiensis* or *subhekiensis* (See NAKAZAWA, 1954, p. 218, pl. 5, figs. 3-8, pl. 6, figs. 1-7; TOKUYAMA, 1959, p. 150, textfig., pl. 16, figs. 1-7). "*Gervillia*" *mytiloides* (SCHLOTHIM) (CREDNER, 1851, p. 652, pl. 6, figs. 6a-f, *polydonta*) from the lower or middle Triassic in Europe and "*G.*" *shaniorum* HEALEY from the upper Triassic of Burma (1908, p. 16, pl. 2, figs. 1-9, pl. 3, figs. 27) are most probably of the first type, and may belong to *Maizuria*. The Jurassic "*G.*" *hartmanni* GOLDFUSS is also of the same group, because according to BENECK (1905, p. 126, pl. 5, fig. 4, Pl. 7, figs. 2-4), it has crenulated cardinal teeth and sockets in thin-shelled specimens, and is probably separate generically from *Aguileria* provided with similar hinge-character. *Gervillaria aliformis* (SOWERBY) is considered to belong the second group (See Woods, 1905, p. 71, pl. 9, figs. 9-11).

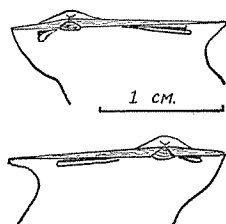
In his recent brief note on the phylogeny of the Bakevelliidae, HAYAMI (1957 a, p. 105, table) supposed the origin of *Bakevellia* to be in Pteriidae. On the other hand, KING (1850, p. 167) stated that "its resemblance to *Avicula* (= *Pteria*) is purely simulatory". SCHAUROTH (1857, p. 102) supposed the Paleozoic *Pterinea* to be the ancestor, and ICHIKAWA (1958, p. 192, fig. 7 and p. 195) considered both multivincular Bakevelliidae and the alivincular Pteriidae to be derived directly or indirectly from Leiopteriidae with duplivincular ligament. The one pit-stage of *Maizuria*, which is often found in *okuyamensis* n. sp., *kambei* n. sp. and *nara-warensis* n. sp., is very similar to *Pteria* (s.l.), and is regarded as *Pteria*-stage, suggesting its close affinity with Pteriidae. TOKUYAMA also noticed the fact that the genus *Bakevelloides* goes through the *Pteria*-stage in the juvenile and asserted the direct discendance from *Pteria*-stock. However, the question whether *Maizuria* was directly derived from *Pteria*-stock or separated from *Bakevellia*-stock, is difficult to be solved, because it cannot be neglected that on the other hand the subgenus resembles very much the Permian *Bakevellia* s.s. and the juvenile of the lower Triassic *Neobakevellia* in the immature stage. So the writer will refer to *Maizuria* as the subgenus of *Bakevellia* for the time being.

The ancestry of *Bakevellia* s.s. is another problem. Some of the Permian *Bakevellia*, such as *B. cf. ceratophaga* in JACOWLEW (1903, p. 32, pl. 2, figs. 15, 16) and *B. antiqua* in KING (1850, p. 169, pl. 14, fig. 34)* are almost identical with *Pteria* s.l. in the external shape as well as in the dentition except for multivincular ligament. It is highly probable that *Bakevellia* s.s. goes through the *Pteria*-stage

* COX suggested to the writer personally that KING's figures are probably inaccurate, and the specimens collected in the British Museum are much more like GEINITZ's figures than like those of King.

Similarly, MCCOY (1854, p. 491) stated that the specimens examined by him agree rather with the figures of GOLDFUSS than those of KING.

(alivincular stage) in the ontogenetic development. These problems will be solved after the detailed study of the late Paleozoic *Bakevellia* is carried out. At the same time it is necessary to trace how far the Pteriidae dates back. From the middle Permian in the southern Kitakami mountainland, Northeast Japan, the writer has collected Pteriid species much similar to the immature stage of *Bakevellia* s.l. (Textfig. 1). And the writer is inclined to think that *Bakevellia* originated from a little anisomyarian type of Pteriidae soon after the latter had been branched off from duplivincular "Pteroid" such as Leiopteriidae, although Bakevellidae may be polyphyletic in origin.



Textfigure 1.

Schematic sketch of Middle Permian *Pteria* s.l. sp. from Tenjinnoki formation at Tenjinnoki, Maiya-cho, Miyagi Prefecture.

Permian and Lower Triassic Bakevelliidae in Japan

From the Permian in Japan no Bakevelliid has been reported, and from the lower Triassic the following species have been described or illustrated.

Gervillia sp. indet. YEHARA (1926, p. 171, pl. 16, figs. 15-16)—Tao formation at Uonashi, Shikoku

Gervillia cf. *exporrecta* (LEPSIUS), MATSUSHITA (1927, p. 426, pl. 8, fig. 10)—Kurotaki limestone at Kurotaki, Shikoku

G. cf. *exporrecta* (LEP.), OZAKI and SHIKAMA (1954, p. 44, textfigs. 1-3)—Shionosawa limestone in Sanchu Graben, Kanto mountainland.

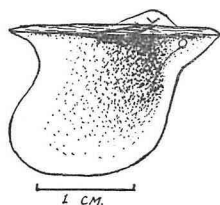
Bakevellia ussurica var. *rostrata* YABE (1956, p. 288, pl. 17, figs. 1-10)—Locality, ditto.

Beside these, "*Gervillia*" cf. *exporrecta* was reported from the Kitakami mountainland by ICHIKAWA (1951) and others, from Kyushu by SAITO and others (1958), and "*G.*" spp. from the Kitakami.

Gervillia sp. and *G.* cf. *exporrecta* from Shikoku, both of which are now deposited in the writer's institute, cannot be identified generically, because they are represented by external moulds and casts, and show none of the internal features. But the latter species is more similar externally to *B. rostrata* YABE em. NAKAZAWA discussed below rather than to *exporrecta*.

Among the figured specimens of *B. ussurica* var. *rostrata*, the one showing the hinge-characters (YABE, op. cit., pl. 17, figs. 9, 10) does not represent the same species as the others (ibid., pl. 17, figs. 1-8). The writer succeeded in clarifying the hinge-structure of the latter forms in his collection from the same limestone of the syntype. They have alivincular ligament provided with no lateral teeth,

although rudimental weak projection near the anterior end is rarely found, and they possess a distinct, circular anterior adductor-scar on the inner surface of the anterior auricle (textfig. 2 and pl. 1, figs. 1-3).



Textfigure 2.

Schematic sketch of *Pteria ussurica yabei* NAKAZAWA, new subspecies, from Shionosawa limestone.

Therefore, they should be transferred to the genus *Pteria* s.l.. *Bakevellia ussurica* Kiparisova (1938), with which the above was compared by YABE, has been later transferred to *Avicula* (= *Pteria*) by herself (1954, p. 10, pl. 1, figs. 14-18). The name *rostrata* should be limited to Bakevelliid specimens and be retained as a specific name, as the writer could not find any comparable Triassic species ever described.* For the Pteriid specimens *Pteria* s.l. *ussurica yabei*, new subspecies is here proposed (Holotype: pl. 1, fig. 1, Reg. no. JM 10628a). Subspecific diagnosis except for the internal characters is referred to in YABE's description of *rostrata*.

G. cf. exporrecta by OZAKI and SHIKAMA is undoubtedly conspecific with this subspecies, and the species from Kyushu is most probably identical.

From the Maizuru zone the following nine species and subspecies are described here.

- Permian — *Bakevellia* (*Bakevellia*) *gujoensis* NAKAZAWA, n. sp.
B. (B.) n. sp. indet.
- Eo-Triassic — *B. (Neobakevellia)* *tsuzuradaniensis* NAKAZAWA, n. sp.
B. (Maizuria) *okuyamensis* NAKAZAWA, n. sp.
B. (M.) cf. okuyamensis NAKAZAWA
B. (M.) kambei NAKAZAWA n. sp.
B. (M.) kambei dannensis NAKAZAWA, n. subsp.
B. (M.) kambei n. subsp.? indet.
B. (M.) narawarensis NAKAZAWA, n. sp.

Description of Species

Bakevelliidae KING

Bakevellia KING, 1848

Type: *Avicula antiqua* MÜNSTER

* The reconstructed shell of the lectotype in YABE (op. cit., pl. 17, figs. 9, 10; here designated) differs from *ussurica yabei* in the taller and narrower outline of the main body. The same is estimated from the writer's samples (pl. 1, fig. 4a), which have still taller and slender outline than YABE's.

Shell small to considerably large in size, pteroid, obliquely elongated, moderately convex, slightly inequivalve, the right valve less convex; auricles more or less well defined, anterior one small, posterior one large and wing-shaped; ligament area parallel sided or obtusely triangular much broader than high, marked by parallel linear striae and provided with several ligament-pits of trigonal or quadrate outline; hinge consisting of one or more cardinal teeth in front of or under the beak and one or two lateral teeth subparallel to the cardinal margin, sometimes crenulated along the lower margin of the cardinal area making pseduotaxodont denticles; muscle-scars usually anisomyarian and rarely monomyarian; pallial line consisting of a series of small impressions in large and thick-shelled species.

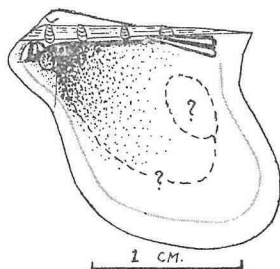
Subgenus *Bakevellia* s. s.

Bakevellia s. s. is here restricted to the Permian forms, which are small in size possessing relatively large anterior muscle-scar in the interior of the anterior auricle. Hinge consists of one or a few cardinal teeth anterior to the beak and one or two lateral teeth nearly parallel to the hinge-margin. This subgenus has not yet been found in the Mesozoic.

Bakevellia (*Bakevellia*) *gujoensis* NAKAZAWA, new species

Plate 1, Figs. 3-8, Textfig. 3.

Description.—Shell small pteroid, elongate postero-ventrally, moderately convex, a little inequivalve, the right valve less convex; longer than high ranging from 8 to 18 mm in length and from 5 to 15 mm in height; umbo subterminal, not so prominent, slightly projected above hinge-margin, located close to the anterior end of the hinge-area; anterior auricle small, subtrigonal, slightly inflated and



Textfigure 3.

Schematic sketch of right valve
of *Bakevellia* (*Bakevellia*) *gujoensis*
NAKAZAWA, new species.

markedly defined from the vaulted main body, its dorsal margin intersecting the cardinal margin posteriorly at an angle of about 45 degrees, ventral margin sinuated; posterior auricle relatively large, gradually flattened from the shell body, posterior margin gently curved, terminating with the pointed posterior end of the hinge; ligament-area narrow and nearly parallel sided, as long as about four fifths

of the shell length, provided with two to four ligament pits, among which the subumbonal one is relatively strong and trigonal in outline and other posterior ones are relatively weak, subtrigonal or subquadrate; hinge consists of two cardinal teeth radiating from the anterior end of the cardinal area and one lamellar lateral tooth in the left, three cardinals and two laterals in the right; adductors anisomyarian, anterior one small, circular, lying just under the cardinal teeth, posterior one not exactly known, but probably larger; pedal retractor-scar represented by a small pit located just in front of the apex of the umbonal cavity; pallial line preserved only at the portion close to the anterior scar; surface ornamented by regular concentric lirae, which are more widely spaced on the umbonal slope counted 11-12 in 5 mm near the venter.

Observation and comparison:—Six specimens have been procured, all of which are internal or external moulds, and four of them are nearly complete. Anterior adductor-scars are preserved in all individuals, but posterior-scar could not be confirmed. There is seen distinct impression running parallel to shell margin. At first glance it is very similar to the pallial line, but it is not so, because it is not connected with the adductor-scar. Perhaps it indicates the boundary of the nacreous layer and the outer prismatic layer similarly as sometimes impressed in the recent Pteriidae.*

The present species is distinguished from most species of *Bakevellia* s.s. in the dorsal margin of the anterior auricle which does not form a straight line with the postero-dorsal margin of the shell. It resembles mostly *B. nikitowensis* JAKOWLEW (1903, p. 35, pl. 2, figs. 19-20) from the Permian of Donetz Basin in Central Russia in general outline and the concentric sculpture, but differs in the less oblique outline and more distinctly defined anterior auricle from the main body.

Occurrence and horizon:—Upper part of the Gujo formation at Gujo, Oe-cho, Kyoto Prefecture. Late? Permian, associated with *Neoschizodus permicus* NAKAZAWA, *Costatoria kobayashii* (KAMBE), *Actinodontophora* aff. *katsurensis* ICHIKAWA, *Aviculopecten* sp., *Allorisma* sp., "*Pleurophorus*" sp., *Schelwiebella* cf. *ruber* (FRECH), *Spinomarginifera* aff. *kueichowensis* HUANG, etc.. Loc. no. KG. 3, Reg. nos. JP 10044-10047.

Bakevellia (*Bakevellia*) n. sp., indet.

Plate 1, Figures 9a-c

The species is represented by a solitary internal mould of a right valve associated with the preceding species. Shell small, moderately inflated, obliquely elongate, subquadrangular in outline with subparallel posterior and anterior shell margin, 11 mm long and 9 mm high. Judging from the internal mould umbo is only slightly salient above the hinge-margin, and both auricles obscurely defined from the body. Ligament-area parallel sided, 7.2 mm long, provided with four

* The writer indebted to Dr. T. KURODA of Zoological Institute, Kyoto University for his kind suggestion.

quadrangular ligament-pits. Hinge consists of two cardinal teeth, one cardinal socket perpendicular to the hinge-margin, and two lateral teeth, one lateral socket subparallel to the hinge-margin. Adductors probably anisomyalian; posterior scar not impressed, anterior one relatively small, oval in shape, strongly impressed just under the cardinal teeth; pedal retractor-scar incised as a small pit at the apex of the umbonal recess; pallial line seen only near the anterior adductor-scar. On the ligamental area the early stage of ontogeny is marked, when the cardinal area is very narrow and trigonal with two triangular ligament-pits and the trace of a lateral tooth under the hinge-margin.

The writer failed to find any comparable species like this which has a rather tall and quadrangular outline; it is doubtful that the specimen retains an original shape, because it must have been suffered from later external forces as in the other fossils in association. More sufficient materials are needed so as to propose a new name. Reg. no. JP. 10050.

Subgenus *Neobakevellia* NAKAZAWA, new subgenus

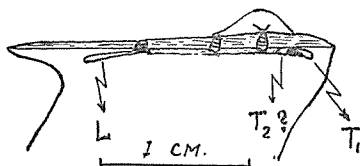
Type: *Bakevellia costata* (SCHLOTHEIM), Lower to middle Triassic, Europe

This subgenus is distinguished from the preceding one by a larger size and a degenerated anterior adductor-scar, which is very small or almost absent. Triassic to Cretaceous.

Bakevellia (*Neobakevellia*) *tsuzuradaniensis* NAKAZAWA, n. subg. and sp.

Pl. 1, Figs. 10-12, Textfig. 4

Description.—Shell small, a little inequivalve, pterioid in outline, the left valve more convex, longer than high with the ratio of about 1:1.4, and obliquely elongate with umbonal angle (obliquity) of about 40 degrees; umbo small, slightly salient above hinge-margin, situated between anterior one fourth and one fifth of the hinge-length; anterior auricle short and small, poorly defined from the body; anterior



Textfigure 4.
Schematic sketch of left valve of
Bakevellia (*Neobakevellia*) *tsuzuradaniensis* NAKAZAWA, new species.

sinuation of shell-margin very weak, ventral margin broadly rounded, rather abruptly rising up and forward to posterior margin which protrudes backward near dorsal margin; ligament-area narrow, shorter than the shell length, gradually tapering back and forward from the beak, provided with three or four subtrigonal or rarely subquadrate ligament-pits in mature individuals; hinge consisting of a

cardinal tooth acutely directed forward from the beak, one more granular tooth? and a subhorizontal lateral tooth; anterior adductor-scar weakly impressed near the apex of the umbonal cavity, posterior one and pallial line not observed, small pedal retractor-scar being seen almost at the apex of the umbonal cavity; surface nearly smooth except for weak growth-lines.

Remarks and comparison:—The above description on the external shape is made on the restored figure estimated from several crushed specimens. The internal moulds of left valves at hand indicate a solitary slender cardinal tooth, but judging from the internal moulds of the right, some of the left appear to have one more weak, triangular cardinal tooth behind the cardinal mentioned above. This species resembles the upper Triassic *Bakevellia* (*Neobakevellia*) *matsushitai* NAKAZAWA (1954, p. 214, pl. 3, figs. 1–5, 8) from Maizuru and Ayabe in the Maizuru zone in the external outline and dentition, but much smaller in size and thinner in shell-thickness and also differs by the smooth surface of the shell. *Bakevellia lata* v. HAUER (1850, p. 10, pl. 3, fig. 8) reported from the Skytic of the Alps is another allied form, but is distinguished from the present species by the longer posterior projection of the posterior auricle and the more developed cardinals perpendicular to the cardinal margin.

Occurrence and horizon:—Lower part (the Member IV) of the Narawara formation of the Yakuno group at Okuyama, Oe-cho, Kyoto Prefecture, in association with *Nuculana* sp. aff. *excavata* GOLDFUSS, *Palaeoneilo* sp. cf. *elliptica* in KIPARISOVA, *P.* sp., *Neoschizodus* cf. *laevigatus* (ZIETHEN). Loc. no. KH3a, Reg. nos. JM. 10527–10529.

Subgenus *Maizuria* NAKAZAWA, new subgenus

Type: *Bakevellia* (*Maizuria*) *kambe* NAKAZAWA, new species

The subgenus is pteroid in outline like *Bakevellia* s.s. and *Neobakevellia*, but characterized by one or two broad, transversely crenulated teeth and sockets posterior to one or two linear or subtrigonal cardinal teeth. These cardinals are separated from the subhorizontal laterals or connected with numerous denticles between them. Sometimes the cardinals are differentiated into a series of denticles (anterior denticles) making pseudotaxodont teeth together with the laterals and posterior denticles (or crenulation of cardinal margin).

In very immature stage the dentition of the subgenus consists of a strong, linear cardinal tooth subparallel to the hinge-margin and a long lateral tooth in the left valve, and a corresponding cardinal socket and one or two laterals in the right. The lower (posterior) margin of the socket is referable as a rudimentary tooth. Later, the cardinal tooth in the right grows into a distinct, stout, subtrigonal tooth and at the same time broad but weak depression and inflation appear along the cardinal margin posterior to cardinals. In mature stage these develop into crenulated teeth and sockets, which are provisionally called “pseudocardinal”, and the cardinal is also crenulated vertically, assuming as a whole somewhat

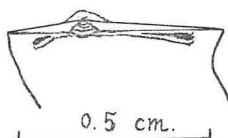
similar appearance to the pseudocardinals of Unionidae, although not identical.

Bakevellia oyogiensis NAKAZAWA (1954, p. 216, pl. 3, fig. 9, pl. 4, figs. 1-4), *B. monobensis* NAKAZAWA (ibid., p. 217, pl. 4, figs. 5-9, pl. 5, figs. 1-2) from the upper Triassic in the Maizuru zone and *B. otariensis* HAYAMI (1957, p. 53, pl. 3, figs. 2-5) from the Liassic in Kuruma district, Central Japan are included in this subgenus. Triassic to Jurassic.

Bakevellia (*Maizuria*) *okuyamensis* NAKAZAWA, n. subgen. and sp.

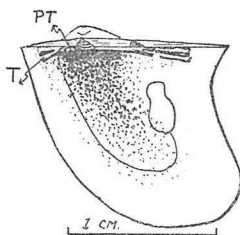
Plate 1, Figures 18-21, Textfigs. 5, 6

Description.—Shell small, pteroid, a little inequivalve, the left valve more convex, a little longer than high with the height ranging from 9 to 15 mm and the length ranging from 10 to 17 mm, the ratio being about 1:1.1 to 1.2, test thin; umbo nearly orthogyrous or slightly prosogyrous, lying between anterior one third and one fourth of the hinge-length, fairly prominent in the left but slightly salient above hinge-margin in the right; anterior auricle poorly defined, slightly depressed at the anterior extremity; posterior wing flattened and protruded posteriorly with sinuous posterior margin, well defined from the inflated body in the left, but gradually flattened from the body in the less convex right valve; hinge-



Textfigure 5.

Schematic sketch of *Bakevellia* (*Maizuria*) *okuyamensis*, showing the hinge of one-pit stage.



Textfigure 6.

Schematic sketch of *B. (M.) okuyamensis* (adult). T: cardinal tooth, PT: "pseudocardinal" tooth.

margin straight, a little shorter than shell-length; ligament-area very narrow tapering gradually towards the both sides from the beak; surface of the area flat except for near the beak, where it is fairly concave inward, and provided with usually two trigonal ligament-pits in maturity, anterior one just under the beak nearly isosceles trigonal in outline, posterior one obtusely trigonal, very weak and shallow; hinge of the left valve composed of a strong, linear cardinal tooth subparallel to margin and a weak, variable "pseudocardinal", which is more or less crenulated, and a distinct lateral, and in the right a rudimentary, ridge-like cardinal tooth posterior to a strong cardinal socket and two laterals; anterior

adductor-scar and pedal retractor-impression very weak; posterior scar rarely observable, large, gourd-like in shape; pallial line running fairly apart from the shell-margin, but usually not impressed in the internal mould; surface sculptured only by weak growth-lines.

Observation and comparison:—In immature individuals less than 6 mm in hinge-length, they have a single ligament-pit, and in that stage the “pseudocardinals” are absent or only represented by undulation of the cardinal margin, and the specimens are very similar to *Pteria* or its allies (textfig. 5 and pl. 1, fig. 17). The hinge is less developed than in the usual *Maizuria* such as *kambei* and *narawarensis*, and represent a primitive type. The species is considered to be a linking form between *Maizuria* and *Bakevellia* s.s. or *Pteria* s.l..

The species is somewhat similar to “*Gervillia*” *pannonica* BITTNER (1901, p. 90, pl. 9, figs. 18–24) from the Skytic of Bakony, “*Gervillia*” *scythica* KRUMBECK (1924, p. 180, pl. 191, figs. 22, 28; BITTNER, 1899, pl. 1, figs. 6, 7) from the Skytic of the Himalaya, and “*Gervillia*” *ursina* BÖHM (1903, p. 34, pl. 3, figs. 12, 15, 18) from the Carnic of Bear Island, in the small, pteriform outline, but is distinguished from *ursina* and *pannonica*, in broader outline and more poorly defined anterior auricle, and from *scythica*, in the sinuated posterior margin. With regard to the internal characters, it cannot be compared with *pannonica* and *scythica*, because the interiors of the latter two were not shown; *ursina* is not *Maizuria* in the hinge-characters, but belongs to *Neobakevellia*.

Occurrence and horizon:—This species is almost confined to the fine-grained facies of the Maizuru zone, and very scarce in the medium-grained facies. Obtained from the Member II and IV of the Narawara formation at Okuyama (Loc. nos. KH. 2, 14, 37) and the Hirobatake formation at Hirobatake (KH. 70), Oe-cho; the Hōnōdani formation of the Yakuno group at Nukada (Loc. nos. Y 18, 25), Yakuno-cho, Kyoto Prefecture. Reg. nos. JM. 10530–10548.

Bakevellia (*Maizuria*) cf. *okuyamensis* NAKAZAWA,

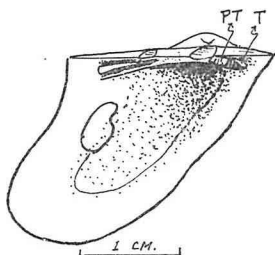
Plate 1, Figures 22, 23

Bakevellias obtained from the Shidaka formation at Shidaka, Maizuru City, which is supposed to be the deltaic facies of the lower Triassic in the Maizuru zone, are almost identical with preceding species in all essential characters, but the dentition is slightly stronger, and the anterior adductor-scar and the pallial line are more strongly impressed in the internal mould in spite of the smaller shell. It is not sure whether this phenomenon indicates a local variation corresponding to the different litho-facies or a time-variation, although the former case appears more probable. The present species occurs crowded with *Neoschizodus* cf. *laevigatus* (ZIETHEN) and *Nuculana* sp. in the granulic sandstone (Loc. no. S 1). The top of the lower Triassic?. Reg. nos. JM 10549–10557.

Bakevellia (Maizuria) kambei NAKAZAWA, n. subgen. and sp.

Plate 2, Figures 1-12, Textfig. 7

Description.—Shell small, pteriform, very inequilateral, a little inequivalve moderately convex, the left valve more inflated; longer than high, with the length ranging from 15 to 35 mm and the height from 13 to 25 mm, and the ratio being about 1.3:1, test moderately thick; umbo not so prominent, located between one third and one fourth of hinge-length from the anterior end; anterior auricle relatively large, inflated, pointed anteriorly, poorly defined from body by a very weak and narrow depression with slight antero-ventral sinuation; posterior wing large, depressed and rather steeply rising up to umbonal slope in the left, but gradually transferred to in the right, the posterior margin gently arcuate and protruded backward; obliquity about 40 degrees; ligament-area parallel sided or tapering bothwards from the beak, moderately wide or sometimes fairly narrow, shorter than the length with the ratio of about 1:1.3, provided with two or three,



Textfigure 7.

Schematic sketch of *Bakevellia*
(*Maizuria*) *kambei*. T: cardinal tooth,
PT: "pseudocardinal" tooth.

subtrigonal or subquadrate ligament-pits, the posterior one usually shallow and broad; in the typical form, hinge of the left valve consisting of a strong cardinal tooth intersecting posteriorly with margin at an acute angle and a broad, crenulated "pseudocardinal" and one or two laterals subparallel with the margin, in the right a subtrigonal or trapezoidal, not so strongly crenulated cardinal tooth, a "pseudo-cardinal" socket and two laterals; anterior ridge of cardinal socket in the right sometimes develops into tooth-like projection; pedal retractor-scar and anterior adductor-scar small, deeply incised in the umbonal cavity, posterior one large, oval, usually constricted at mid-anterior margin; pallial line well marked, consisting of a series of small impressions at the anterior half. Surface almost smooth except for weak growth-lines.

Variability.—This species is highly variable in dentition, ligament and even in the outline of the shell. The variation is recognized not only in individuals obtained from the same locality (individual variation) but also these from the different litho-facies (local variation). As for dentition and ligament, there can be discriminated three predominant forms, although many intermediate or other types are observed. In the normal form (B-type) posterior cardinals and the "pseudo-cardinals" of both valves are more or less well defined from each other and the

crenulation is stronger in the "pseudocardinals" than in the posterior cardinals; ligament-area provided with subtrigonal or trapezoidal pits is moderately broad or fairly slender (pl. 2, figs. 1, 4, 7, 8). In the second form (A-type), posterior cardinals and "pseudocardinals" are developed into a series of denticles; ligament-area is broad or moderate with subquadrate pits (pl. 2, figs. 5, 6). In another form (C-type) the dentition is rudimentary and not so developed as in the other types; ligament-area is slender with shallow and broad subtrigonal pits (pl. 2, fig. 11). Some of the A and B-types are crenulated at the ventral margin of the cardinal area between the cardinals and the laterals and consequently resemble very much *Aguileria* (pl. 2, figs. 2, 12). The frequency of these forms in one and the same locality in the coarse-grained facies, is shown in the table. As clearly indicated by the table, the individual variation in one fossil locality is in good accordance with

Table 1. Frequency of each type of *Bakevellia* (*Neobakevellia*) *kambei* in relation to lithofacies.

District	Miharaiyama			Fukumoto	
Major lithofacies	coarse-grained facies			coarse-gr. and medium-gr.f.	fine-gr. facies
Rock of fossil-locality Type	ss. (MY3)	ss. (others)	sh.	ss.	sh.
A	9 (29)	11 (29)	2	12 (22)	1
B	14 (45)	18 (47)	3	27 (51)	1
C	4 (13)	5 (13)	2	10 (19)	3
Others	4 (13)	4 (11)	0	4 (8)	1
Total	31	38	7	35	6

Coarse-, medium- and fine-grained facies are considered to correspond to littoral, a little off-shore and off-shore facies, respectively. Number in parentheses indicates percentage to total number.

that in the whole Maizuru zone, and local variation in the similar rock-facies is apparently weak, although the specimens of the Miharaiyama possess a somewhat wider ligament-area than those of the Fukumoto. In the off-shore facies, that is, the medium-grained facies consisting mainly of fine-grained sandstones with alternating shales or in the fine-grained facies composed chiefly of shales, and also in the deltaic facies predominating in conglomerates, the fossils are replaced by other species such as *B. (M.) okuyamensis*, and are too scarcely found to examine the statistical analysis. Nevertheless, in the latter three facies and in the shales of the littoral facies (coarse-grained facies), which are unfavourable for the species, the test is usually thin, dentition becomes small and primitive, ligament-area is slender, and the posterior wing has a tendency to protrude more strongly backward, and in consequence the normal form in the suitable condition (B-type) is fewer while

other types, especially the C-type, are relatively more numerous.

The variation corresponding to the course of time could not be ascertained partly because of secondary deformation, although the species is commonly found throughout the entire Eo-Triassic time.

Comparison:—In the external shape this species is very similar to *Bakevella exporrecta* (LEPSIUS) and almost indistinguishable from the latter when the interior is unknown, but the European species (FRECH, 1907, p. 13, pl. 1, figs. 5, 6) and the Himalayan species (WITTENBURG, 1908, p. 31, pl. 3, fig. 10) differ in possessing several cardinal teeth, which are probably not crenulated. The present species appears to have a more slender body in comparison with the Chinese species (KU, 1948, p. 249, pl. 1, figs. 18, 19) and the Eastern Siberian species (KIPARISOVA, 1938, p. 238, pl. 5, figs. 22, 23; 1954, p. 13, pl. 3, figs. 8–11). It is most similar to "*Gervillia*" cf. *exporrecta* described by BITTNER from the Ussuri region (1899, p. 16, pl. 3, figs. 7–16) which have later been referred to var. *linearis* O. Gordon by KIPARISOVA (1938, pl. 6, figs. 3, 4; 1954, pl. 3, figs. 10, 11), especially in the external outline, but probably less oblique. The internal details of the latter have not yet been made fully known, in spite of prevalent occurrences. From this point var. *linearis* from Ussuri is inferred to have weaker or less differentiated dentition than *kambei*.

Occurrence and horizon:—The species is one of the most prolific members of the lower Triassic fossils in the Maizuru zone, especially in the coarse-grained facies of the Fukumoto and the Miharaiyama districts. It is also found in the Shidaka group (pl. 2, figs. 8a, b). From this fact, as well as the occurrence of cf. *okuyamensis*, the writer considers the Eo-Triassic age of this group rather than the Neo-Triassic as has been thought.

The holotype-specimen (pl. 2, fig. 1, Reg. no. JM 10582) has been collected from the Gannosudani formation at Hosokubi, Oya-cho, Hyogo Pref. (Loc. no. MY 7), Reg. nos. JM 10568–10618.

Bakevella (Maizuria) kambei dannensis NAKAZAWA, new subspecies

Plate 2, Figures 13, 14

Several specimens obtained from the bluish sandy shale of the fine-grained facies at Dan near Fukumoto, Okayama Prefecture (Loc. no. F 36) are distinguishable from the preceding in having a broader ligament-area, rather developed dentition than usual *kambei*, and probably more inequivalved shell; the left is considerably more convex than the right. These differences are considered to be more than individual variation, because *kambei*, as discussed above, has a tendency to have a narrow ligament-area and primitive dentition in the similar rock-facies. Therefore, it is desirable to separate the present species as a subspecific rank. Reg. nos. JM 10607–10909.

Bakevellia (*Maizuria*) *kambei* new subspecies? indet.

Plate 2, Figures 15a-c.

1958. "*Bakevellia*" *miyanokuensis* MS., NAKAZAWA, p. 268, table, p. 271 (listed)

A single internal mould of a left valve found in a rock-slab was listed as a distinct species by the writer, mainly on the ground of the specialized, *Aguileria*-like dentition and its higher horizon (considered to be Anisian). But the later investigation reveals the fact that the species is associated with *kambei*. So it is probable that the specimen was derived from the lower horizon. Considering the high variability, it is possible to regard it as *kambei*. But the writer is now inclined to refer it to subspecies of *kambei*, because the dentition is too specialized for individual variation; the lateral teeth become very obscure by development of pseudotaxodont denticles, and the left valve seems more convex than that of *kambei*. Lower? Triassic at Miyanooku, Fukumoto, Aita-cho, Okayama Prefecture (Loc. no. F 23), Reg. no. JM. 10610.

Bakevellia (*Maizuria*) *narawarensis* NAKAZAWA, n. subg. and sp.

Plate 2, Figures 16-21

Description.—Shell small in size, oblique, roundly trapezoidal, inequilateral; left valve fairly convex, right valve a little convex; longer than high with the height ranging from 10 to 20 mm and the length from 15 to 25 mm, the ratio being about 1:1.3; umbo rather prominent, ending with prosogyrous beak, which lies between anterior one third and one fourth of hinge-length; anterior auricle not clearly defined, rounded at the anterior corner; posterior one fairly large, steeply depressed from the main body, not protruded backward, and posterior margin nearly straight forming an obtuse angle with dorsal margin; hinge not essentially different from that of *kambei*, and also fairly variable as shown in the plate (pl. 2, figs. 19-21); ligament-area shorter than shell-length with the ratio of 1:1.3-1.4, nearly parallel sided provided with usually three subtrigonal ligament-pits, anterior two of which are closely set with each other; small and weak anterior adductor-scar and pedal retractor-scar impressed in the umbonal cavity, but posterior one not marked except only one right valve (pl. 2, fig. 18a), which has a rather small muscle-scar; pallial line only seen near the anterior scar; surface almost smooth.

Remarks and comparison.—This species is characteristic in the subquadrate outline, but judging from the growth-lines and small individuals, the immature shows a pteroid outline similar to the species described above. Furthermore, some of the immature ones resemble very much *okuyamensis* in dentition as well as in outline, and still smaller left valve 4 mm long is provided with a solitary ligament-pit, and the hinge consists of a cardinal tooth and a lateral, both of which are nearly parallel with the hinge-margin, and this stage is referred to as *Pteria*-stage.

Besides the outline the present species is distinguished from *okuyamensis* by the larger size and the more specialized dentition, and from *kambei* by the more inflated left valve and less obliquity. In the quadrate outline this species is similar to *Bakevelloides hekiensis* (KOBAYASHI and ICHIKAWA) from the upper Triassic in the Maizuru zone and *Bakevellia negoensis* HAYAMI (1957, p. 54, pl. 3, figs. 6a, b) from the Liassic in Central Japan, but differs in much smaller size and the dentition. "*Gervillia*" *modiola* FRECH (1904, p. 9, textfig. 6) from the Sktic of Bakony is somewhat similar in the external shape, but more oblique, the beak situates more anteriorly, and the species possesses antero-ventral sinuation, while the anterior margin of *narawarensis* is broadly arcuate with no auricular sinuation.

Occurrence and horizon:—The distribution is limited to the south of Okuyama (Loc. nos. KH 3a-d, 7a, b) and Narawara (KH 4), Oe-cho, Kasa-gun, Kyoto Prefecture, the Member II and IV of the Narawara formation. Reg. nos. JM 10558-10567.

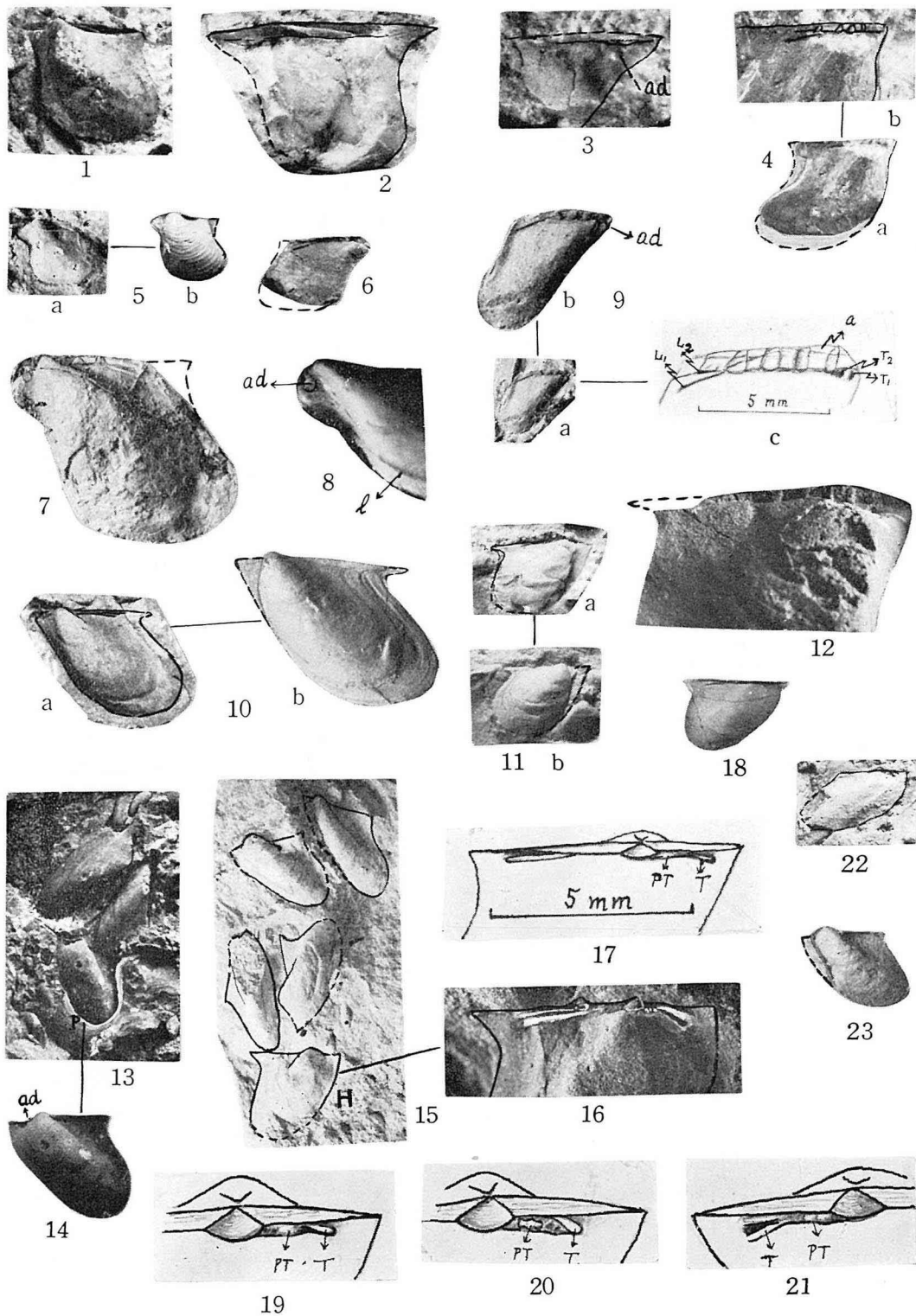
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Explanation of Plate 3

- Figs. 1-3. *Pteria* s. l. *ussurica yabei* NAKAZAWA, new subspeciesP. 5
 Shionosawa limestone at Shionosawa, Sanchu Graben, Gumma Pref., Eo-Triassic.
1. Internal mould of left valve, $\times 1$, Holotype, Reg. no. JM 10628a.
 2. Internal mould of ligament-area of left valve, $\times 1.4$, showing alivincular ligament, Reg. no. JM 10629.
 3. Interior of left valve, $\times 2$, showing an orbicular anterior adductor-scar (ad). Reg. no. JM 10635.
- Figs. 4a, b. *Bakevellia* (*Neobakevellia*) *rostrata* YABE emend. NAKAZAWA.P. 5
 From the same limestone as the preceding.
- a. Internal mould of right valve, $\times 1$. Reg. no. JM 10626a.
 - b. Enlarged ligament-area of the same, $\times 1.5$, showing multivincular ligament
- Figs. 5-8. *Bakevellia* (*Bakevellia*) *gujoensis* NAKAZAWA, new species.P. 6
 Upper part of Gujo formation at Gujo, Ōe-cho, Kyoto Pref., Late? Permian, Loc. no. KG 3.
5. Holotype, internal mould of left valve (a), $\times 1$, and clay-cast from external mould of the same (b), $\times 1$. Reg. no. JP 10044.
 6. Internal mould of right valve, $\times 1.5$. Reg. no. JP 10047.
 7. Internal mould of left valve, $\times 2$. Reg. no. JP 10048.
 8. Internal mould of anterior part of left valve, $\times 3$, showing circular anterior adductor-scar (ad) and pallial line-like impression (1) supposed to boundary between nacreous and prismatic layers. JP 10045.
- Figs. 9a-c. *Bakevellia* (*B.*) new species, indet.P. 7
- a, b Internal mould of right valve, $\times 1$ (a) and ca. 2 (b), associated with preceding species. Reg. no. JP 10050.
 - c. Sketch of hinge-area of the same, $\times 4$. T: cardinal teeth, L: lateral teeth, a: immature stage.
- Figs. 10-12. *Bakevellia* (*Neobakevellia*) *tsuzuradaniensis* NAKAZAWA, new subgenus and species.P. 8
 From the member IV of Narawara formation to the south of Okuyam, Ōe-cho, Kyoto Pref. (Loc. no. KH 3a), Eo-Triassic.
10. Holotype, internal mould of left valve (a), $\times 1$, and gypsum-cast from external mould of the same (b), $\times 1.5$. Reg. no. JM 10527.
 11. Internal mould of right valve (a), $\times 1$, and clay-cast from external mould of the same (b), $\times 1$. Reg. no. JM 10529.
 12. Internal mould of right valve, $\times 3$, showing ligament-area. Reg. no. JM 10528a.



- Figs. 13-21. *Bakevellia* (*Maizuria*) *okuyamensis* NAKAZAWA, new subg. and sp.P. 10
 From the lower part of Narawara formation to the south of Okuyama, Ōe-ch, Kyoto Pref.
13. Internal mould of several individuals, $\times 1$, showing various outline caused by secondary deformation. Reg. no. JM 10531.
 14. Internal mould of a right valve in the preceding sample, $\times 1.5$. Reg. no JM 10531a.
 15. Gypsum-cast from external mould of several individuals, $\times 1$, H: holotype. Reg. no. JM 10530.
 16. Internal mould of Holotype, $\times 2.6$. JM 10530a.
 17. Sketch of left valve of one-pit stage, $\times 6$. Reg. no. JM 10541b.
 18. Internal mould of right valve, $\times 1$. Reg. no. JM 10534.
 - 19-21. Sketch of hinge-area from clay-casts, showing various dentition, $\times 5$.
- Figs. 11, 23. *Bakevellia* (*Maizuria*) cf. *okuyamensis* NAKAZAWA.P. 11
 From Shidaka formation of Shidaka Group at Shidaka, Maizuru City, Kyoto Pref. (Loc. no. S 1), Eo-Triassic?
22. Internal mould of incomplete right valve, $\times 1.5$ Reg. no. JM 10551.
 23. Clay-cast from external mould of left valve, $\times 1.5$. Reg. no. JM 10549.

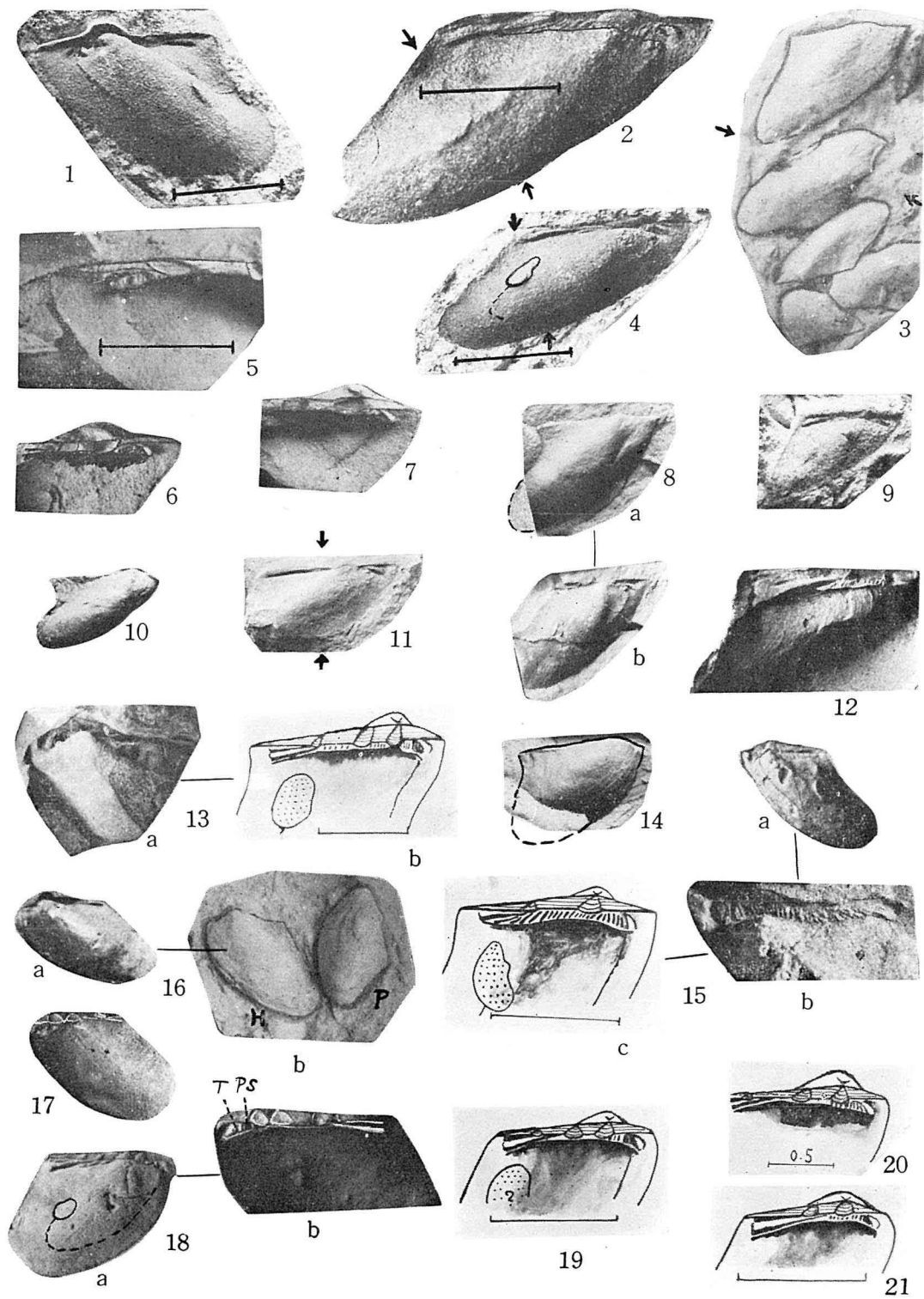
Remarks: T, cardinal tooth; PT, "pseudocardinal" tooth.

All specimens were collected by NAKAZAWA, and kept at Geological and Mineralogical Institute, University of Kyoto. Photo. by NAKAZAWA.

Explanation of Plate 4

Figs. 1-12. *Bakevellia* (*Maizuria*) *kambei* NAKAZAWA, new subgenus and species.P. 12

1. Holotype, internal mould of left valve, $\times 1.6$, Gannosudani formation of Miharaiyama group at Hosokubi, Ōya-cho, Hyogo Pref. (Loc. no. MY 7). Reg. no. JM 10582, coll. by Shiki.
2. Internal mould of right valve, $\times 2$, strongly deformed, showing pseudotaxodont dentition and relatively broad ligament-area, Kyogakubo formation to the south of Kōge, Fukumoto, Aita-cho, Okayama Pref. (Loc. no. F 4). Reg. no. JM 10598.
3. Gypsum-cast from external mould of a little deformed individuals, $\times 1$, Gannosudani formation at Shirodani, Takinoya, Yabu-cho, Hyogo Pref. (Loc. no. MY 4). Reg. no. JM 10579, coll. by Shiki.
4. Internal mould of right valve, $\times 1.7$, strongly deformed, Gannosudani formation at Kasamatsudani, Itohara, Ōya-cho, Hyogo Pref. (Loc. no. MY 8). Reg. no. JM 10583.
5. Clay-cast from internal mould of right valve, $\times 2$, Gannosudani formation at Iwai, Ōya-cho, Hyogo Pref. (loc. no. MY 2). Reg. no. JM 10577.
6. Retouched figure of clay-cast from left internal mould, $\times 1.5$, Gannosudani formation at Yuradani, Ōya-cho (Loc. no. MY 3). Reg. no. JM 10568, coll. by Shiki.
7. Clay-cast from internal mould of left valve, $\times 1.6$, locality ditto. Reg. no. JM 10571a.
8. Internal mould (b) of right valve and clay-cast from external mould (a), $\times 1$, Okadashimo formation of Shidaka group at Shidaka, Maizuru City (Loc. S 2). Reg. no. JM 10615.
9. Internal mould of right valve, $\times 2$, showing one-pit stage, Gannosudani formation at Yuradani, (Loc. no. MY 3). Reg. no. JM 10569. coll. by Shiki.
10. Clay-cast from external mould of right valve, $\times 1$, showing the outline of shell from muddy facies, Gannosudani formation at Kasamatsudani, Ōya-cho, Hyogo Pref. (Loc. no. MY''), Reg. no. JM 10585.
11. Internal mould of right valve, $\times 1$, showing hinge of specimen from fine-grained facies, Fukumoto group at Iguchi, Aita-cho, Okayama Pref. (Loc. no. F 34). Reg. no. JM 10604.
12. Internal mould of hinge-area of right and external mould of counter valve, $\times 2$, showing pseudotaxodont dentition, Gannosudani formation at Shirodani, Takinoya, Yabu-cho, Hyogo Pref. (Loc. MY 23). Reg. no. JM 10614, coll. by Shiki.



- Figs. 13-14. *Bakevellia* (*M.*) *kambei dannensis* NAKAZAWA, new subspecies.P. 14
 From undivided Fukumoto group at Dan, Aita-cho, Okayama Pref. (Loc. no. F 36).
13. Holotype, internal mould of left valve (a), $\times 1.6$, and schematic restoration of the same (b). Reg. no. JM 10607.
14. Clay-cast from external mould of right valve, $\times 1$. Reg. no. JM 10608.
- Figs. 15a-c. *Bakevellia* (*M.*) *kambei* new subspecies? indet.P. 25
 From the top of Kyogakubo formation? at Miyanooku, Fukumoto, Aita-cho Okayama Pref. (Loc. no. F 24'). Reg. no. JM 10610.
- a: Internal mould of left valve, $\times 1$, b: enlarged hinge-area, $\times 2.8$,
 c: Schematic figure restored from the same, $\times 2.7$.
- Figs. 16-21. *Bakevellia* (*M.*) *narawarensis* NAKAZAWA, new subg. and sp.P. 15
 From Member II and IV of Narawara formation to the south of Okuyama, Ōe-cho, Kyoto Pref. (Loc. nos. KH 3, 4, 7).
16. Internal mould of left valve, Holotype, (a) and gypsum-cast from external mould of holotype and another specimen (b), $\times 1$. Reg. no. JM 10558a, c.
17. Internal mould of left valve, $\times 1$, Reg. no. JM 10558b.
18. Internal mould of right valve (a), $\times 1$, and clay-cast of the same (b), $\times 1.4$. Reg. no. JM 10559.
- 19-21. Schematic sketch of several specimens, showing various dentition.

All specimens are kept at Geological and Mineralogical Institute, University of Kyoto; specimens without indication coll. by NAKAZAWA. Photo. by NAKAZAWA.