8. Geological Age of the Yosida-mura Shell-beds of Kagosima-ken, Kyûsyû. I.*

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I.

In the two short papers, "On Some Brachiopods from Kagosima-ken, Kyûsyû"¹⁾ and "On Some Fossil Mollusca from Kagosima-ken, Kyûsyû"²⁾ K. Hatai and the writer several years ago dealt with molluscan and brachiopod remains collected by S. Endo from the shell-beds exposed at Unoki and Kuwanomaru, both in Yosida-mura, Kagosima-ken, and situated very close to each other. The shell beds belong to one and the same horizon in the basal part of a tuff formation, which is as a whole massive, but more or less distinctly stratified in sandy and pebbly parts.

The brachiopods from these two localities are few in number; nevertheless, they represent 4 distinct species, 3 species of the genus *Pictothyris* and 1 species of *Kikaithyris*; namely, *Pictothyris picta* (Dillwyn), *P. elegans endoi* Yabe and Hatai, *P. fortipicta* Yabe and Hatai, and *Kikaithyris hanzawai* (Yabe). *P. picta* is a living species which ranges back to the Pliocene, *P. elegans endoi* is a new subspecies of the living *elegans*, and *P. fortipicta* is a new species yet found from no other places, either living or fossil, while *Kikaithyris hanzawai* is a species hitherto known only from Taiwan and Ryûkyû Islands and confined to the Ryûkyû limestone. While *Kikaithyris* is now a monotypic genus, *Pictothyris* has one more living species, *P. laquaeformis* Yabe and Hatai, which is not represented in the Yosida-mura shell-beds. The 4 species of *Pictothyris* and a *Kikaithyris* mark a distinctive feature to the present fossil fauna.

Kikaithyris hanzawai is a characteristic fossil of the Ryûkyû limestone,

* For the present study, the writer spent about a month in March and April, 1945, in southern Kyûsyû, accompanied by Mr. T. Mihara, graduate of the Institute of Geology and Palaeontology, Tôhoku Imperial University, whom he wishes to express his hearty thanks for constant help; thanks are also extended to his families Mihara and Mita of Tyôhu near Simonoseki for the facilities given and courtesies shown in various ways to the writer during the trip.

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1) Jour. Geol. Soc. Japan, Vol. XLVIII, No. 575, 1941.

2) Ibid.

and has been found in no other formation until now; its occurrence in the Yosida-mura shell-beds suggests approximate contemporaneity of these two formations.

On the other hand, the molluscan remains of the Yosida-mura shell-beds are fairly numerous, representing 39 species of bivalves, 2 species of scaphopods, and 36 species of univalves, altogether 77 species as listed below. Some 15 species of the (19.5% of the total) are not known living in the present seas; if brachiopods be taken into account, this percentage arises up to 23. The figure, be 20 or 23, indicates the late Pliocene age of the shell-beds.

List of the Fossil Mollusca from the Yosida-mura
Shell-Beds (K. Hatai ident.)

	Unoki	Ku- wano- maru		Unoki	Ku- wano- maru
<i>Aloides venustus</i> (GOULD)	×	—	<i>P. nipponensis</i> KURODA	×	—
<i>A. scaphoides</i> (HINIS)	—	×	<i>P. cf. chosonica</i> KURODA	×	—
<i>A. problematica</i> (MARTIN)	×	—	<i>Plicatula horrida</i> DUNKER	×	—
<i>Anomia cytaeum</i> GRAY	?	×	<i>Pinna atropurpurea</i> SOWERBY	×	—
<i>Arca uwaensis</i> (YOKOYAMA)	×	—	<i>Pseudamysium intuscostatus</i>		
<i>Barbatia fusca</i> (BRUGUIERE)	×	×	YOKOYAMA	×	—
<i>B. decussata</i> (SOWERBY)	—	×	<i>Spondylus anacanthus</i> MAWE	×	—
<i>B. yokoyamai</i> NOMURA	×	—	<i>Solen gouldii</i> CONRAD	×	—
<i>Cardita cumingiana</i> DUNKER	—	×	<i>Solecurtus divaricatus</i> LISCHKE	×	—
<i>C. variegata</i> BRUGUIERE	—	×	<i>Venericardia ferruginea</i> (CLESSIN)	×	×
<i>Chama aspersa</i> REEVE	×	×	<i>A. ferruginosa</i> (ADAMS and		
<i>Codakia divergens</i> (PHILIPPI)	×	—	REEVE)	×	—
<i>Crassatellites nanus</i> (ADAMS and	×	×	<i>Volsella trailli</i> (REEVE)	×	—
REEVE)			<i>Venus puerpera</i> LINNAEUS	—	×
<i>Dentilucina civica</i> (YOKOYAMA)	×	×	<i>V. foveolata</i> SOWERBY	×	—
<i>Dosinia cf. japonica</i> (REEVE)	—	×	<i>V. toreuma</i> GOULD	×	—
<i>Lima cf. ohshimensis</i> SOWERBY	×	—	<i>Dentalium hexagonum</i> GOULD	×	—
<i>Lucina acutilineata</i> CONRAD	×	—	<i>D. weinkauffi</i> DUNKER	—	×
<i>Nucula tenuis</i> MONTAGU	×	—	<i>Ancilla albocallosa</i> LINNAEUS	×	—
<i>Nuculana cf. takaoensis</i> OTUKA	×	—	<i>Cancellaria cf. taiwanensis</i>		
<i>Pecten kikaiensis</i> NOMURA and	×	—	NOMURA	×	—
ZINBO			<i>Calliostoma sagamianum</i> YOKO-		
<i>P. tokyoensis</i> TOKUNAGA	×	—	YAMA, var.	—	×
<i>P. naganumanus</i> YOKOYAMA	×	—	<i>C. unicum</i> (DUNKER)	—	×
<i>P. quadriliratus</i> LISCHKE	—	×	<i>Chrysallida caelata</i> (A. ADAMS)	×	—
<i>P. vesiculosus</i> DUNKER	×	×	<i>Chlorostoma rustica</i> (GOULD)	×	—
<i>P. lursei</i> BAVAY	×	—	<i>Clavatula consimilis</i> (SMITH)	×	—

<i>Clavus jeffreysii</i> (SMITH)	×	—	<i>O. mustellina</i> LAMARCK	—	×
<i>C. nivaloides</i> (YOKOYAMA)	×	—	<i>Natica janthostoma</i> DESHAYES	×	—
<i>Columbella burchardi</i> DUNKER	×	×	<i>Phos senticosus</i> LINNAEUS	×	—
<i>Conus coronatus</i> GMELIN	—	×	<i>Pseudoraphitoma naganumaensis</i>		
<i>Cyclostrema micans</i> A. ADAMS	×	—	OTUKA	×	—
<i>Cypraea vitellus</i> LINNAEUS	—	×	<i>Pustullaria caputserpentis</i>		
<i>Erato callosa</i> (ADAMS and REEVE)	×	—	(LINNAEUS)	×	—
<i>Ficus ficoides</i> (LAMARCK)	×	—	<i>Puncturella hirasei</i> OTUKA	×	—
<i>Hemifusus ternatanus</i> (GMELIN)	×	—	<i>Polinices</i> cf. <i>didymus</i> (BOLTEN)	×	—
<i>Iravadia annulata</i> (DUNKER)	×	—	<i>Siliquaria cumingii</i> MÖRCH	×	×
<i>Lienardia gainesi</i> (PILSBRY)	×	—	<i>Solidula strigosa</i> GOULD	—	×
<i>Mitra flammea</i> QUOY	×	—	<i>Terebra</i> cf. <i>dussumieri</i> KIENER	×	—
<i>Nassarius eximius</i> (H. and A. ADAMS)	×	—	<i>Turcica imperialis</i> A. ADAMS	×	—
<i>Natica concinna</i> DUNKER	×	×	<i>Trophon subclavatus</i> YOKOYAMA	×	—
<i>Oliva ispidula</i> (LINNAEUS)	—	×	<i>T. cf. nipponicus</i> YOKOYAMA	×	—
			<i>T. birileffi</i> LISCHKE	×	—

The Ryûkyû limestone with an extended distribution over Taiwan and the Ryûkyû Islands³⁾ does not extend into southern Kyûsyû, its northernmost extension being on Kikai-zima, where S. Hanzawa found a rich fossiliferous limestone, hereafter to be called the Kamikatetu limestone, of the formation on the plateau surface above Kamikatetu; this locality yielded him abundant fossils of mollusca,⁴⁾ brachiopoda,⁵⁾ corals⁶⁾ and bryozoa. Of the molluscan remains, S. Nomura and N. Zinbo discriminated 74 species of bivalves, 1 species of scaphopod, and 126 species of univalves,—201 species in total, including 22 new species. The percentage of apparently extinct forms to the total number is 13.7, being far less than in the case of the Yosida-mura shell-beds; the two authors regarded provisionally the Kamikatetu limestone fauna as old as the early Pleistocene. These figures 13.7 and 19.5 or 23, alone taken into consideration, the Yosida-mura shell-beds are likely to be somewhat older than the Kamikatetu limestone.

Corals are very rare in the Yosida-mura shell-beds,⁷⁾ being represented

3) S. Hanzawa: Topography and Geology of the Riukiu Islands. Sci. Rep. Tôhoku Imp. Univ., Ser. II (Geol.), Vol. XVII, 1935.

4) S. Nomura and N. Zinbo: Marine Mollusca from the Ryûkyû Limestone of Kikai-zima. Ibid., Vol. XVI, No. 2, 1934.

5) H. Yabe: Brachiopods of the Genus *Pictothyris* Thomson, 1927. Ibid. Vol. XV, No. 3, 1932.

6) H. Yabe and M. Eguchi: Deep-water Corals from the Riukiu Limestone of Kikai-zima, Riukiu Islands. Proc. Imp. Acad., Vol. VIII, No. 9, 1932.

7) M. Eguchi: On Two Species of Simple Corals from Kagosima-ken, Kyûsyû. Jour. Geol. Soc. Japan, Vol. XLVIII, No. 575, 1941.

merely by three specimens of small simple corals. Two of these specimens belong to *Deltocyathus orientalis* Duncan, a species with an extended distribution from the Japanese seas through the Malayan waters and Indian ocean far westward to the Mediterranean Sea; it has a geological range from the Pliocene to the Recent. Another specimen with worn surface is certainly a form of *Heteropsammia*, identical with or closely similar to *H. ovalis* Semper, now living in the seas from Japan to the Malay archipelago. These two species are common in the Kamikatetu limestone; however, they have no significant bearing on the question now in concern.

The molluscan fauna of the Kamikatetu limestone and the Yosida-mura shell-beds have only a few species in common. This is rather striking in relation to their approximate contemporaneity; perhaps, it is due to the circumstances that the Yosida-mura shell-beds are shallow water clastic sediments of an enclosed bay, probably larger and more open than the present Kagosima Bay, while the Kamikatetu limestone is a member of a thick limestone complex, the Ryûkyû limestone, and is in itself a shallow-water deposit around coral reefs. In addition, Yosida-mura lying far north of Kikai-zima, it is quite natural that the molluscan fauna of the former has many molluscs of northern type and that of the latter is rich in tropical forms, lacking northern types.

As already pointed out in the paper on this molluscan fauna, its elements of particular interest are *Pecten tokyoensis* Tokunaga, *P. naganumanus* Yokoyama, *Pseudoraphitoma naganumaensis* Otuka, and *Pseudoamysium intuscostatum* Yokoyama. *Pecten tokyoensis* is one of the most characteristic fossils of the Pleistocene Narita beds (s. l., including the Tokyo beds), and *P. naganumanus* that of the Uppermost Pliocene Naganuma bed. The latter species and *Pseudoraphitoma naganumaensis* are two characteristic forms common to the Naganuma beds and the present shell-beds, while *Pecten kikaiensis* and *Kikaithyris hanzawai* are common to the Kamikatetu limestone and the present shell-beds. *Pecten intuscostata* is an extinct species known from the Pleistocene Miyata shell-beds of Miura peninsula and the Pleistocene Upper Musasino of the province of Kazusa; it also occurs in the Pliocene Kosiba beds near Kanazawa, Musasi province. These fossils indicate that the Yosida-mura shell-beds can not be much older than the Ryûkyû limestone with *Pecten naganumanus* and *Kikaithyris*; the two formations may be approximately contemporaneous, both being youngest Pliocene.

The Massive tuff of Yosida-mura, with the shell-beds in its basal part, is directly underlain by another of tuff and tuffaceous shale, which is thin-layered

in part. The stratification of the two formations is almost parallel, though they are separated by a distinct, small-scale erosion-unconformity. Whatever the magnitude of the time-gap may be, it is, at any rate, evident that the former is younger than the latter formation.

K. Yamaguchi, Professor of the Matue High School, who devoted himself throughout more than a score of years to the geological and petrological researches of the region around the Kagosima Bay and the volcano Sakurazima, found fossil plant leaves in the second, that is to say lower, formation from various places within Yosida-mura and its annexed districts. These plant fossils have been studied by S. Endo who subsequently visited these localities and made a large collection: according to his printed report as well as verbal communication, the material he examined is fairly rich; nevertheless, it comprises only a few species, showing the simplicity of the fossil flora in its composition. The plants specifically distinguished by him are:

<i>Acer diabolicum</i> Blume	<i>Prunus</i> sp.
<i>A. pictum</i> Thunberg	<i>Quercus</i> sp.
<i>Carpinus laxiflora</i> Blume	<i>Salix</i> sp.
<i>Fagus crenata</i> Blume	<i>Stewartia pseudocamellia</i> Maximowicz
<i>Juglans</i> sp.	<i>Tilia japonica</i> Simonk
<i>Larix</i> sp.	<i>Ulmus parvifolia</i> Jacquin
<i>Picea hondoensis</i> Mayr	<i>Zelkova serrata</i> Makino

Of 14 species listed above, 9 species are specifically identified, while the remaining 5 species are indeterminable due to bad preservation. The trees here specified are all now living in Japan.

Aside of very simple composition, this fossil flora has another remarkable aspect, in *Zelkova* and more particularly *Fagus*-leaves overwhelming the other in number, so as Endo pronounced "The original forests which supplied the fossil leaves to the plant beds can be regarded as almost pure beech forests". Further on he stated "The trees of *Fagus crenata* now are living in the mountains of Kyûsyû and growing at the altitude of about 1000 m or more; they do not at present exist in southern Kyûsyû, except Mt. Takakuma. In the main island, Honshû, they now enjoy a luxuriant growth in the Cfb conditions of Köppen climate formula, while the fossil localities mentioned above are in his Cfa climatic field; it involves therefore a climatic change from Cfa to Cfb occurred there between geological date indicated by the fossil flora and the present day". This conclusion by Endo deserves special attention.

8) S. Endo: A Pleistocene Flora from Kagosima, Kyûshû, Japan. Jour. Geol. Soc. Japan, Vol. XLVI, No. 547, 1939.

An additional note may be of need in this connection, namely that the plant beds occasionally contain marine fossils; Endo found generically indeterminable echinoids and bivalves of the genus *Lucina* at Haginozyô, Sigetomi-mura and an echinoid identified by S. Nisiyama with *Brisopsis latifrons* Agassiz, a living species of the Japanese seas, at Gotanda, Yosida-mura, in association of plant leaves in the deposits. The deposition of the plant beds certainly took place under a calm water of lagoons near sea-shore, and not in mountain lakes.

As to the geological age of the fossil flora, Endo had no hesitation about its Pleistocene age; this is a conclusion quite natural and reasonable, seeing that its composition is of living species only, without association of any exotic or extinct ones.

The lower formation entombs a fossil flora with a younger aspect and the upper a fossil fauna with an older aspect.