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# Late Neogene Planktonic Foraminiferal Zones of the Shizukawa Group, West of Mt. Fuji, Japan

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## Introduction

At the dawn of the history of geology in Japan, NAUMANN (1885) proposed the term "Fossa Magna" for a geotectonic graben that divides Honshu, main land of the Japanese Islands, into two portions, Southwest and Northeast. Since then, the Fossa Magna has been essentially recognized and investigated in more detail by many authors. This zone which seems to have been formed initially in the latest Oligocene or earliest Miocene period is filled up with Neogene Tertiary strata of complex structure, covered with Quaternary volcanoes (including Mt. Fuji). Fossil records of the Fossa Magna region have been sporadic and fragmentary, so that the information about geologic ages of the strata in the region has been quite inadequate and inaccurate.

Just east of and along the Itoigawa-Shizuoka Line (YABE, 1918), which bounds sharply the western margin of the Fossa Magna, the Neogene deposits are well developed and their total thickness seems to attain to some ten thousands meters (see Fig. 1). Among those developed in the southwestern portion of the Fossa Magna the uppermost marine sediments, accompanied by many pyroclastic insertions, are called the Shizukawa Group, slightly modified from AKIYAMA's (1957 b) definition. The group is distributed along the Fujikawa (River Fuji) which runs approximately from north to south in the west of Mt. Fuji and flows into the Pacific Ocean. The area of the study is around Nakatomi-chô, Minamikoma-gun, Yamanashi Prefecture, and it presents the northernmost distribution of the Shizukawa Group; further north, no exposure of marine sediments is found, partly on account of the cover by Quaternary volcanoes. Marine Tertiary strata in the northern Fossa Magna region seem to have been formed in an oceanographic realm different from the southern one.

Rather continuous occurrence of planktonic Foraminifera is recognized throughout the Shizukawa (=Fujikawa) Group of the area. It allows us to make zoning of the Group, referring to the universal scheme. The consequent assignment of the age to latest Miocene to early Late Pliocene may be younger than current opinions for the Shizukawa Group; for example, IKEBE and CHIJI (1971) or IKEBE *et al.* (1973) assigned it to middle to late Miocene in their correlation chart of the Japanese Tertiary. The present new information may affect a number of previous arguments on the tectonics and paleogeography of the southern Fossa Magna and further of the Japanese Islands.

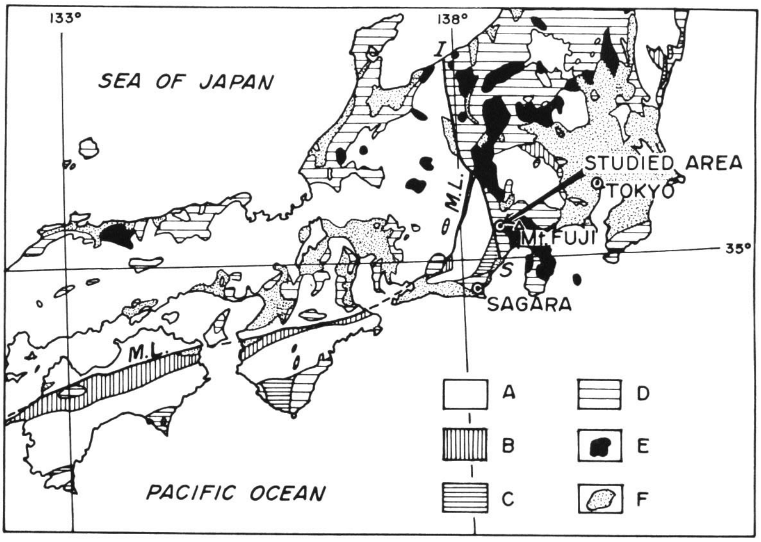



Fig. 1. Location map
*I–S*: Itoigawa-Shizuoka Line which bounds the western margin of the Fossa Magna, *M. L.*: Median Tectonic Line, A: pre-Tertiary complexes, B: Sambagawa belt (moderate-temperature high-pressure metamorphic rocks), C: probably Paleogene rocks, D: Neogene rocks, E: Quaternary volcanoes, F: Quaternary sedimentary deposits.

Another important objective of this paper is to document in detail the faunal compositions of planktonic Foraminifera from the Shizukawa Group as a northernmost representative of the late Cenozoic faunas of the subtropical Northwestern Pacific region; the serial work on these faunas has been conducted and published by the senior author and his colleagues since 1971. Systematics and paleontological discussion will be given in the near future when the serial work is completed.

The present study was initiated by the junior author for his graduation thesis and also as a part of the group survey on geology of the Fujikawa region. He is indebted to Dr. Yujirô OGAWA of Nihon University and collaborators there, and to Dr. Yukinori FUJITA of Tokyo University of Education, for their valuable suggestions. He expresses his cordial thanks to Mr. and Mrs. Chûji HOSHINO of Nakatomi-chô for providing him with the field facilities. The manuscript was reviewed by Miss Reiko FUSEJIMA of the National Science Museum.

## Geology of the Area Studied

On the geology of the region along the Fujikawa, a fairly detailed study was begun by OTUKA (1932) and was continued until his death in 1950. He left a manuscript which was apparently a summary of his works on the Shizukawa Group and the adjacent strata. The manuscript was published in 1955 by his disciples.

Later, the geology along the upper course of the Fujikawa was investigated more precisely by MATSUDA and MIZUNO (1955), AKIYAMA (1957 b) and MATSUDA (1958), who all focussed their attention upon the "Shizukawa Group" and its subjacent part of the Nishi-yatsushiro Group which are developed in two areas, one around Minobu-chô on the south and the other around Nakatomi-chô on the north. According to these authors the Shizukawa Group around Nakatomi-chô represents merely the northern end of its distribution, and its total thickness is much thinner than those in southern areas. Besides the thinner thickness the geologic structure is simply homoclinal, dipping westwards, although the uppermost portion, i. e., mainly the Akebono Conglomerate, forms a local syncline. These conditions are very convenient for biostratigraphic investigation.

The previous lithostratigraphic works, particularly of AKIYAMA (1957 b) and MATSUDA (1958, 1961), are summarized in a correlation chart (Table 1) where the successions are based on the data from the Minobu-chô area, but those from the Nakatomi-chô area are also indicated on the right-hand side for correlation. Most prominent differences between the above two authors concerning the geology of the Nakatomi-chô area may be the definition of some lithostratigraphic units and the presence of an unconformity within the Shizukawa (="Fujikawa") Group. Before a biostratigraphic work is commenced, these problems ought to be solved through exhaustive field survey and time-parallel planes must be traced by laboratory work such as planktonic foraminiferal study.

The results of our geologic survey around Nakatomi-chô are shown in a geologic map (Fig. 2) and are correlated with previous ones in Table 1. Summarized descriptions of lithostratigraphy are given below (details will be reported on another opportunity).

*Nishi-yatsushiro Group*:— Synonymous with the one defined by AKIYAMA (1957 b) who re-designated the upper boundary on the basis of description of MATSUDA and MIZUNO (1955), although only the upper part is treated in this paper.

*Wadaira Tuff* (*Formation*):— Synonymous with the Wadaira Tuff Member of MATSUDA and MIZUNO (1955). Composed of light gray to pale green dacitic volcanic breccia (often tuff breccia), and coarse- to fine-grained tuff.

*Deguchi Tuffaceous Sandstone* (*Formation*):— Designated by MATSUDA and MIZUNO (1955) as the Deguchi Tuffaceous Sandstone and Mudstone Alternation Member, but their Kami-isshki Volcanic Breccia Member is included in this formation here. Composed mainly of irregular alternation of fine- to medium-grained sandstone and mudstone, both tuffaceous, accompanying andesitic olive-colored tuff beds. While the alternation in the middle part is rich in mudstone layers, tuff and tuffaceous sandstone layers become dominant upwards or northwards. Near the base of this formation the Kami-isshiki Member is developed so well as to make a key bed, below which mudstone is recognized in several places. The mudstone conformably covering the Wadaira Formation is probably the real basal portion of the Deguchi.

Table 1. Correlation chart

| AKIYAMA (1957) | | | | MATSUDA (1958,1961) | | | | | This Paper | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SHIZUKAWA Group | AKEBONO F. | AKEBONO Cg. M. | | FUJIKAWA Group | AKEBONO F. | AKEBONO Cg. M. | | L.P. | SHIZUKAWA Group | | AKEBONO Cg. F. |
| | | KAWADAIRA Ms. M. | | | | SHIZUKAWA Ss. M. | | Early Pliocene | | IITOMI F. | KAWADAIRA Ms. M. |
| | | OSOZAWA Ss. M. | | | | | | | | | OSOZAWA Cg.Ss. M. |
| | HARA F. | KARASUMORI-YAMA Tf.Br. | TEUCHI-ZAWA Cg. M. | | AIMATA F. | KARASUMORI-YAMA Pr.M | | | | | KARASUMORI-YAMA Tf.Br.M. |
| | | UMEDAIRA Ss. M. | | | | | | | | | HAYAKAWA-BASHI Ms. M. |
| | | HAYAKAWABASHI Ms. M. | | | | | | | | | |
| | | MITSUISHI Tf.Br. M. | | | | | | | | | MITSUISHI Pr. M. |
| | | | | | | | | | | | NAKANOSAWA Cg. M. |
| | MINO-BU | HAGIIZAKA Alt.M. | KAJIWARA Ms. M. | | TAKATORI M. | HAGII Alt.M. | MINOBU F. / HARA Ms. M. | | | HARA Ms. F. | |
| | | SHIONOSAWA Cg.M. | | | | MARUTAKI Cg.M. | | | | | |
| | SHIMOBE F. | | | | | YAGISAWA Ms.M. | | | | | |
| | | HADAKA-JIMA Alt.M. | | | | KOUTSUBUNA Pr.M. | | | | | |
| | | UENOTAIRA Tf. M. | | | SHIMOBE F. | UENOTAIRA Alt. M. | | Late Miocene | | | |
| | | DAIGO Alt. M. | | | | TAKENOSHIMA Alt. M. | | | | | |
| | | TAKENOSHIMA Ss. M. | | | | | | | | | |
| NISHI-YATSUSHIRO G. | DAIGO-YAMA F. | BYŌBU-IWA Tf. M. | | NISHI-YATSUSHIRO G. | TOKIWA F. | BYŌBU-IWA Tf. M. | | | NISHI-YATSUSHIRO G. | | BYŌBU-IWA Tf. F. |
| | | DEGUCHI Tf.Ss. & Ms. Alt. M. | | | | DEGUCHI Tf.Ss. M. | | | | | DEGUCHI Tf.Ss. F. |
| | | KAMI-ISSHIKI Vol.Br.M. | | | | KAMI-ISSHIKI Vol.Br.M. | | | | | KAMI-ISSHIKI Vol.Br. M. |
| | ICHINOSE F. | WADAIRA Tf. M. | | | | WADAIRA Tf. M. | | | | | WADAIRA Tf. F. |
| | | KANZAKA Ms. M. | | | | KANZAKA Ms. M. | | | | | unsurveyed |
| | | FURUSEKI-GAWA Basic Vol. M. | | | FURUSEKI-GAWA F. | | | | | | |

G: Group, F: Formation, M: Member; Ms: mudstone, Alt: alternation of mudstone and sandstone; Ss: sandstone, Cg.Ss: conglomeratic sandstone, Cg: conglomerate, Tf.Ss: tuffaceous sandstone, Tf: tuff, Tf.Br: tuff breccia, Vol.Br: volcanic breccia, Basic Vol: basic volcanics.

*Kami-isshiki Volcanic Breccia Member*:— Designated by MATSUDA and MIZUNO (1955). Composed of volcanic breccia to tuff breccia, in which two-pyroxene andesite fragments are firmed with the coarse- to fine-grained tuff matrix. The member occurs very close to the basal boundary of the Deguchi Formation.

*Byôbu-iwa Tuff* (*Formation*):— Approximately synonymous with the Byôbu-iwa Tuff Member of MATSUDA and MIZUNO (1955), but our opinion somewhat differs from theirs about the upper portion, as revealed by the comparison of geologic maps. Generally composed of dark green pumiceous tuff, with dacitic volcanic breccia characterized by light green dots, particularly in the lowermost horizons. In some places, especially west of the Fujikawa, tuffaceous sandstone or alternation of tuffaceous sandstone and mudstone is developed, suggesting a lateral change to the subjacent Deguchi Formation which is conformably covered by this formation in general. The mudstone often contains Foraminifera, as exemplified by our samples F1 and F2, taken from a river cliff opposite to Yôkaichiba.

*Shizukawa Group*:— The name was given by TANAKA (1930) and was frequently used by OTUKA (e. g., 1939, 1955). Synonymous with the one defined by AKIYAMA (1957 b). MATSUDA (1961) adopted the name, Fujikawa Group of INOUE (1934), who applied it for the strata developed in the lower course of the Fujikawa, after he pursued its southern extension down to the vicinity of the mouth of the Fujikawa. However, his correlation has not been warranted yet by time-stratigraphic evidence, and the priority of nomination must be considered.

*Hara Mudstone (Formation)*:— Synonymous with the Hara Mudstone Member of MATSUDA and MIZUNO (1955) and with the Kajiwara Mudstone Member of AKIYAMA (1957 b), who applied unwisely the name Hara to the superjacent formation. Composed of dark bluish gray massive mudstone, containing Foraminifera throughout, and with andesite pebbles scattered at middle to lower hoirzons. Thin layers less than 5 cm in thickness of fine-grained sandstone or white tuff are often intercalated at upper horizons. In some places around the uppermost horizons, particularly west of Yôkaichiba, rubble conglomerate-like facies is developed, containing many cobbles to pebbles of several kinds of andesite, microfossil-bearing tuffaceous sandstone, rather soft mudstone, and so on. Although the very contact could be seen only at a locality north of Kami-inuma, this formation seems to rest on the Byôbu-iwa Tuff Formation of the Nishi-yatsushiro Group. An east-west trend of structure prevailed in the Nishi-yatsushiro Group changes quickly to the north-south trend of the proper Shizukawa Group within the Hara Mudstone which may be incompetent for folding.

*Iitomi Formation*:— Proposed by the Fujikawa Research Group (1976, in press) for the alternating pyroclastic and clastic strata, which are divided into the following six members in ascending order.

*Nakanosawa Conglomerate Member*:— This Member is newly proposed by the present authors to represent approximately the lower portion of the Mitsuishi Tuff Breccia Member of AKIYAMA (1957 b), for the reason that the middle to upper portion consists almost entirely of volcanic breccia or tuff breccia without clastic layers, differing from the lower one.

Type locality: Along a stream west of Yôkaichiba, Nakatomi-chô. Maximum thickness measures about 135 m.

Major lithofacies is conglomeratic, composed of angular to round cobbles or even boulders of two-pyroxene andesite and hornblende-augite andesite. Irregular-shaped blocks of rather soft mudstone, microfossil-bearing sandstone and coarse-grained tuff occur in association; sometimes they are as large as boulder. Matrix varies from place to place, such as tuff, sandy mudstone, and even alternation of tuffaceous sandstone and mudstone. Some huge blocks lying upon the clastic matrix show distinct load casts. The bedding planes are sometimes oblique or even perpendicular to the adjacent strata below (Hara Mudstone Formation) and above (Mitsuishi Member). These structural and lithological characteristics are especially conspicuous in the basal part of the Nakanosawa Member, and suggests a seemingly unconformable relation to the underlying Hara Formation. At the very contact, however, the boundary does not show any noticeable trace of erosion. Looking at the matrix lithology of the Nakanosawa Member and the frequent insertion of conglomerate in the uppermost part of the Hara Mudstone, one can suggest that the change of lithofacies was gradational but somewhat rapid. The observed continuity of sedimentation may be substantiated by paleoenvironmental and stratigraphical analyses of the Foraminifera contained, as will be shown later.

In the upper half of the Member, a few thick beds of mudstone are developed containing a considerable number of planktonic Foraminifera, as represented by Samples H22, H23 and H24 from three different horizons of the mudstone at the type locality.

*Mitsuishi Pyroclastics Member*:— Designated by AKIYAMA (1957 b) as the Mitsuishi Tuff Breccia Member, though his definition includes the beds equivalent to the Nakanosawa Member in the lower portion.

Composed mainly of probably dacitic and glassy tuff and tuff breccia with the matrix of also glassy tuff. The brecciated rocks are dacite or hornblende two-pyroxene andesite, euhedral green hornblende phenocrysts of which characterize the lithology of this Member, along with the glassy aspect of the tuff and the matrix. Below the base of this Member is developed graded bedding caused by alternation of conglomeratic tuff containing hornblende crystals and mudstone, each unit being 2 to 4 m in average thickness. It extends over some 30 m stratigraphic thickness. The presence of the graded bedding suggests a conformable relation between the Mitsuishi Pyroclastics Member and the Nakanosawa Conglomerate Member.

*Hayakawa-bashi Mudstone Member*:— Synonymous with the one named by AKIYAMA (1957 b). Composed mainly of dark bluish gray mudstone intercalated with whitish sandy tuff beds less than 5 cm in thickness. While tuffaceous conglomeratic sandstone to pebble conglomerate containing mulluscan shell fragments and tuff breccia beds are included at some horizons, the basal part consists of alternating mudstone and pyroclastics, similar to the feature of the underlying Mitsuishi Member, suggesting a conformable relation with the latter.

*Karasumori-yama Tuff Breccia Member*:— Synonymous with the member named by AKIYAMA (1957 b). To the south of and around Yogosawa, the Member consists of volcanic breccia, tuff breccia or tuff, in which subangular fragments of hornblende andesite are predominant, and is intercalated with mudstone and sandstone both containing molluscan shell fragments. On the other hand, lavas, volcanic breccia, tuff breccia and tuff, all of two-pyroxene andesite, are developed in the southern area, namely, from around Ushiro-yama to Mitsuishi, for making a prominent topographic ridge along the strike.

*Osozawa Conglomeratic Sandstone Member*;— Approximately synonymous with the Osozawa Sandstone Member of AKIYAMA (1957 b), though he regarded it as the basal member of his Akebono Formation. Named by the Fujikawa Research Group (in press). Composed mainly of blackish, massive and tuffaceous pebble conglomerate to coarse-grained sandstone, in which molluscan shells or their fragments are frequently

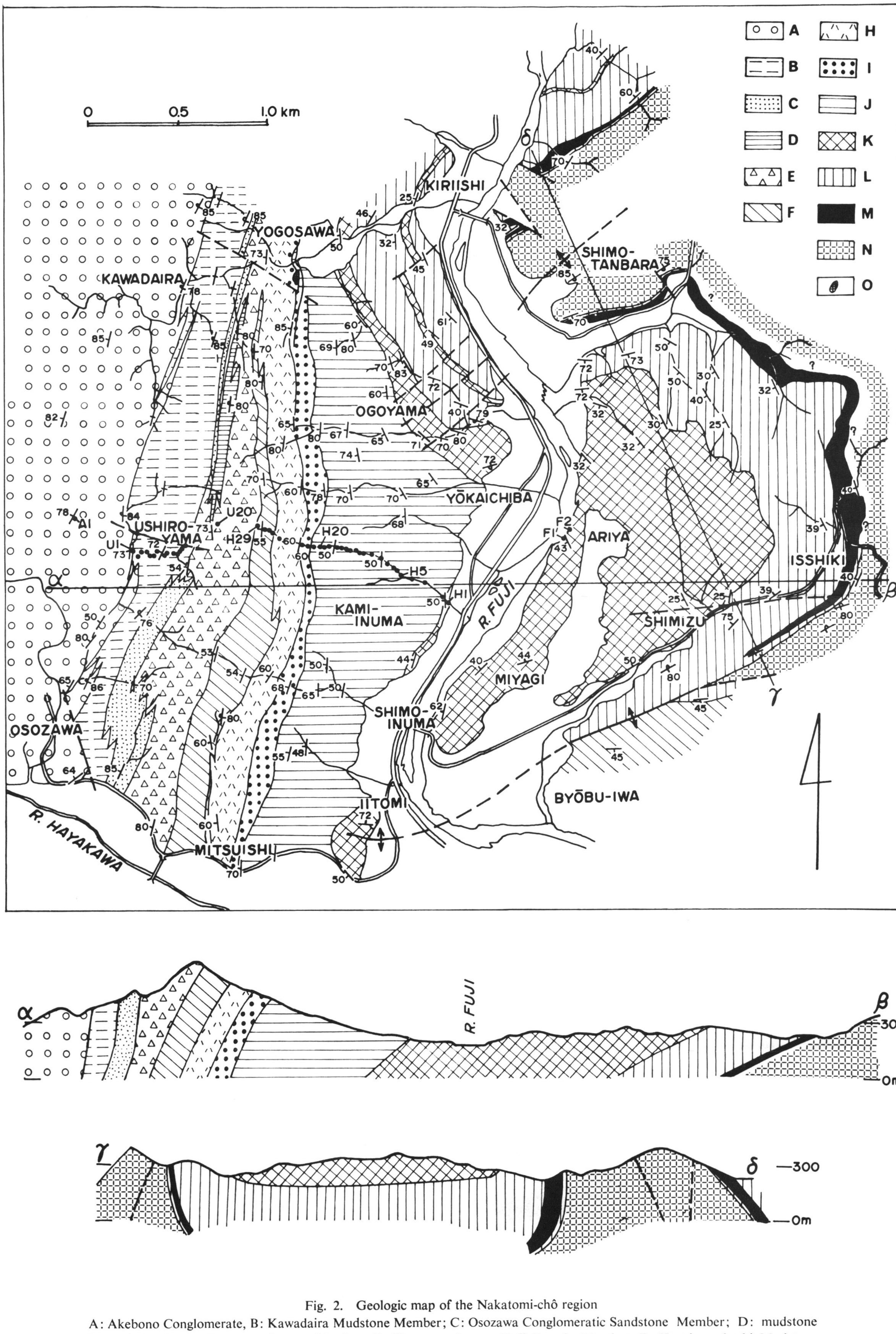



Fig. 2. Geologic map of the Nakatomi-chô region

A: Akebono Conglomerate, B: Kawadaira Mudstone Member; C: Osozawa Conglomeratic Sandstone Member; D: mudstone intercalation in the Karasumori-yama Member, E: Karasumori-yama Tuff Breccia Member, F: Hayakawa-bashi Mudstone Member, H: Mitsuishi Pyroclastics Member; I: Nakanosawa Conglomerate Member (the above-mentioned six members belong to the Iitomi Formation), J: Hara Mudstone, K: Byôbu-iwa Tuff, L: Deguchi Tuffaceous Sandstone; M: Kami-isshiki Volcanic Breccia Member, N: Wadaira Tuff, O: intrusive body of two-pyroxene andesite. Sampling localities along the H- and U-routes are roughly shown by thick dots. [Erratum: The area hatched around Byôbu-iwa must belong to the Byôbu-iwa Tuff]

contained. The Member occurs as two bodies, the one in the north is lenticular and the other in the south is thicker, separated by Ushiro-yama. The southern body interfingers with, or grades into, part of the Karasumori-yama Member, although the latter is usually underlain by the Osozawa Member.

*Kawadaira Mudstone Member*:— Synonymous with the one named by AKIYAMA (1957 b) who, however, united it with the Osozawa and the Akebono Members into the Akebono Formation. Composed mainly of dark bluish gray sandy mudstone, sporadically containing molluscan shells. While pumiceous tuff and tuffaceous sandstone including granitic pebbles are inserted in the northern area, the Member in the southern area consists of massive mudstone. Particularly around Yogosawa this Member is also accompanied by thin beds of tuff breccia or volcanic conglomerate which resembles the Karasumori-yama Member in lithology, and by shell-bearing pebble conglomerate to coarse-grained sandstone which grades upward into sandy mudstone.

*Akebono Conglomerate* (*Formation*):— Approximately the same as the Akebono Conglomerate of OTUKA (1955) and the Akebono Conglomerate Member of AKIYAMA (1957 b) and of MATSUDA (1961). Composed mainly of conglomerate and often inserted with sandstone or sandy mudstone layers. The conglomerate consists of round large pebbles to cobbles, often boulders, of pre-Tertiary hard sandstone, slate, granitic rocks, volcanic rocks, and green tuff (in the order of amount), all of which are rather loosely cemented by granitic sandstone matrix. The conglomerate tends to decrease its particle size toward the base as seen typically along the Hayakawa River. Besides this vertical transition, some lateral change to the Kawadaira Member through such a final transitional facies as sandy mudstone with scattered pebbles can be seen in the south of Ushiro-yama or at about 600 m north of Kawadaira.

As the foregoing brief descriptions suggest, no remarkable stratigraphic gap can be expected between the upper Nishi-yatsushiro Group (Kawadaira Tuff) and the top of the Shizukawa Group (Akebono Conglomerate), even though a local unconformity might be inferred between the Iitomi and the Hara Formations. Unlike AKIYAMA (1957 b), MATSUDA (1961) attached more importance to the hiatus between his Hara Mudstone Member and overlying members. However, this "hiatus" seems to be accompanied by no large scale interruption of sedimentation, so it can be ascribed to overlapping of superjacent strata, especially the Akebono Conglomerate, upon the underlying strata. The overlap becomes remarkable toward the north. The famous clino-unconformity at Teuchizawa just north of the area shown in Fig. 2 may be explained by the same phenomenon.

With the Teuchizawa unconformity as one of the evidences, OTUKA (1939 et seq.) proposed the Ooigawa Orogenic Movement which should form prominent folding with east-west trending axes of the strata below the Iitomi Formation; on the contrary, the Iitomi and Akebono Formations show a simple structure, apparently a homocline, having a north-south strike with a steep westward dip.

According to AKIYAMA (1957 b) and MATSUDA (1958), however, this drastic change of geologic structure from the Nishi-yatsushiro Group to the Shizukawa Group brought about no large scale unconformity all over the region. It is possible that such an unconformable phenomenon as seen around Teuchizawa gave a stronger impression because of the rather rapid thinning-out of the Hara Mudstone toward the north, in addition to the overlap of overlying strata.

After OTUKA (1939) correlated "the Clino-unconformity" along the Fujikawa region with the one between the Sagara and the Kakegawa Groups in western Shizuoka Prefecture, he regarded the Ooigawa Orogeny as one of the major crustal movements which affected the Japanese Islands. The clino-unconformity between the Sagara and the Kakegawa Groups was also denied by UJIIÉ (1958, 1962), who considered that the folding in the Sagara Group was formed during the period of continuous deposition of the superjacent part of the Kakegawa Group. Although the mechanism of folding is similar in the Sagara-Kakegawa region and in the Fujikawa region, dating by planktonic Foraminifera (see p. 89) gives evidently different ages for the two regions, hence the "Ooigawa Orogeny" becomes meaningless all the more.

## Sampling Routes and Treatment of Materials

From the field work throughout the area, two routes were selected for sampling rock materials for the foraminiferal investigation; namely, Ushiro-yama route (U-route) and Hara route (H-route). U-route was chosen so as to represent the upper part of the Shizukawa Group (from the basal portion of the Akebono Conglomerate through the Karasumori-yama Tuff Member of the Iitomi Formation), and H-route to represent the lower portion (from the Hayakawa-bashi Mudstone Member of the Iitomi Formation through the Hara Mudstone). Within the total stratigraphic thickness (ca. 1500 m) for sampling, a gap about 170 m thick exists between the two routes, owing to a topographic ridge composed of very hard pyroclastic rocks of the Karasumori-yama Tuff Breccia Member. The route map and the resultant columnar sections are shown in Figs. 3 and 4. Besides 20 samples from U-route and 29 samples from H-route, two additional spot samples were collected from the uppermost horizons of the Byôbu-iwa Tuff, uppermost member of the Nishi-yatsushiro Group. Almost all samples collected are muddy rock; sandy samples were avoided as much as possible, for the reason of difficulty in preservation of foraminiferal specimens.

To prepare the samples for the study, 100 gr. was extracted first from more than 1 kg of each rock sample which was crushed beforehand by a jaw crusher, and then macerated effectively by the so-called naphtha (petroleum benzene)-method that was briefly explained by UJIIÉ and HARIU (1975). When we failed to get 200-odd planktonic foraminiferal specimens not much deformed and suitable for identification from the first 100 gr., we increased the amount of the sample to be treated. Nevertheless, the samples from the upper portion of the sequence, i. e., the upper part of the Kawadaira Mudstone Member, did not provide sufficient numbers of planktonic Foraminifera for the quantitative analysis, although some of the specimens were useful for biostratigraphic research as seen in Samples U4 and U5 for examples.

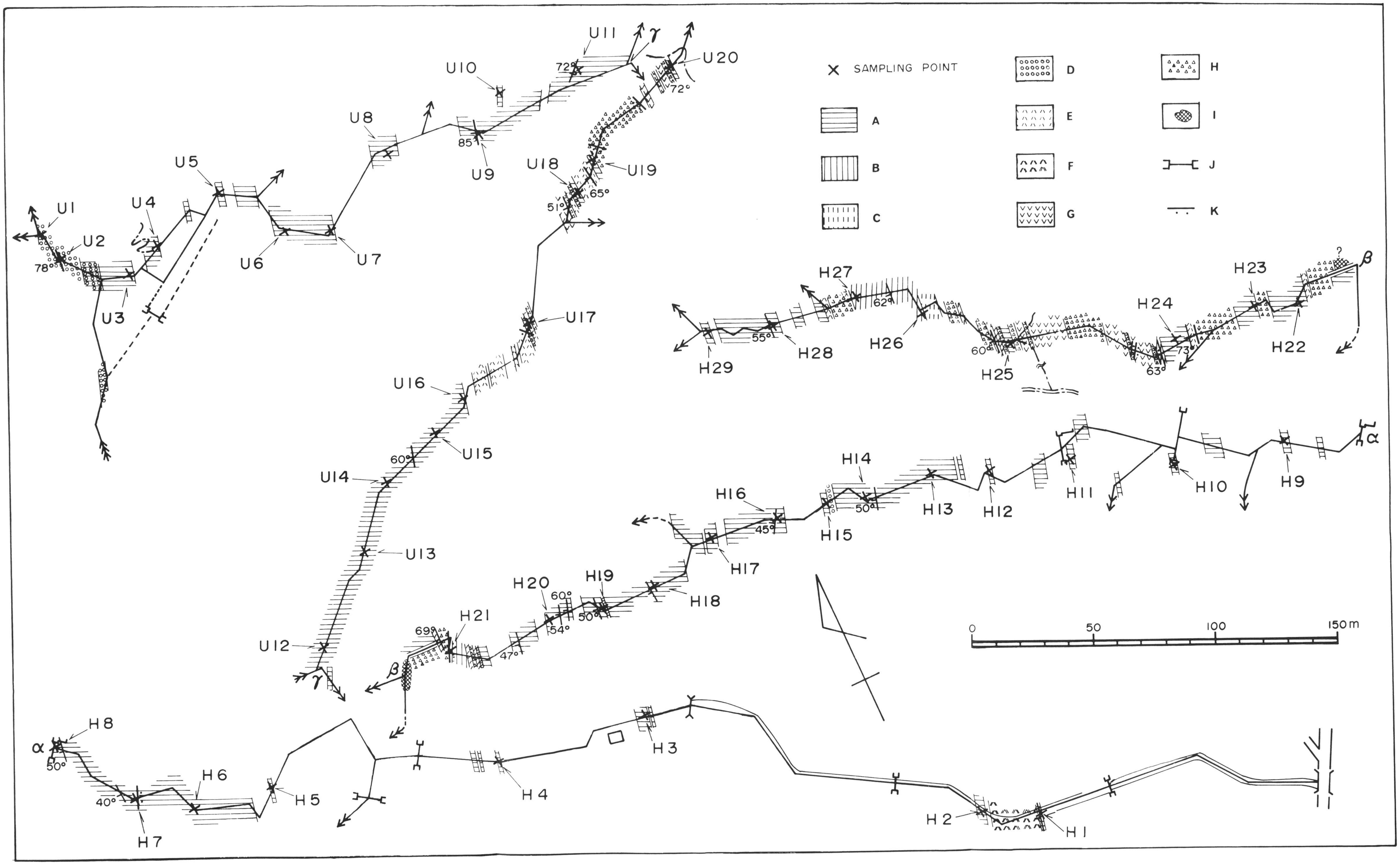



Fig. 3. Sampling localities along a stream at the north of Inuma (Hara or H-route) and and another stream southeast of Ushiro-yama (U-route). Original scale of the route maps is 1/500. A: massive mudstone to sandy mudstone, B: mudstone-rich alternation, C: sandstone-rich alternation, D: conglomerate, E: greenish andesitic tuff, F: whitish pumiceous tuff, G: thick whitish and dacitic tuff with glassy aspect, H: tuff breccia, I: andesite dyke, J: dam, K: fall.

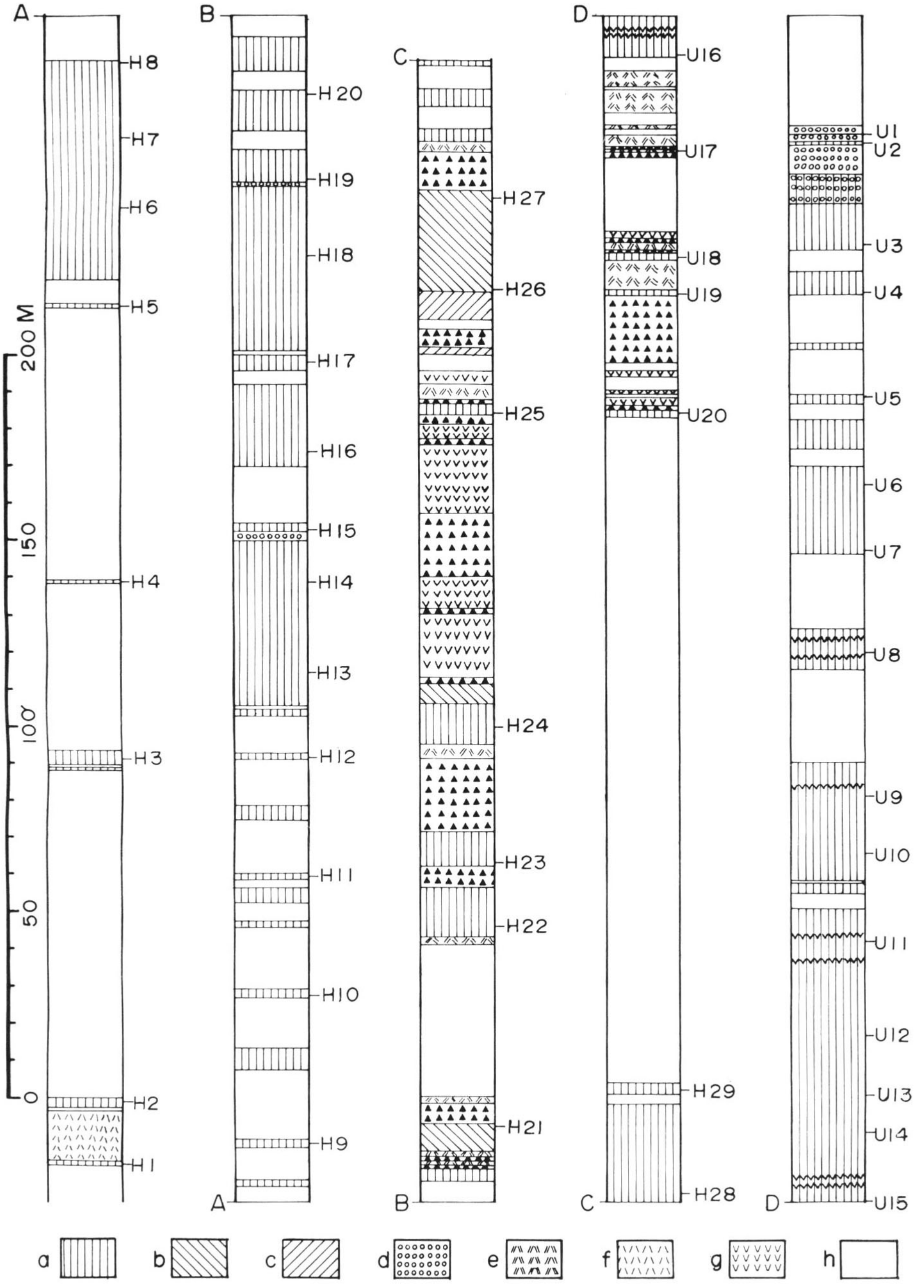



Fig. 4. Geologic columnar sections along the H- and U-routes, showing sampling horizons. a: massive mudstone to sandy mudstone, b: mudstone-rich alternation, c: sandstone-rich alternation, d: conglomerate, e: greenish andesitic tuff, f: whitish pumiceous tuff, g: thick whitish and dacitic tuff with glassy aspect, h: lack of exposure; solid triangles: tuff breccia.

## Results of Planktonic Foraminiferal Study

Among 51 samples 24 were used in our study of paleoenvironmental changes through the sequence obtained from U- and H-routes. To indicate the changes we employed the terms "Foraminiferal Number", "Planktonic Ratio", and "Planktonic Foraminiferal Number" which is also a function of the former two. As seen in Fig. 5,

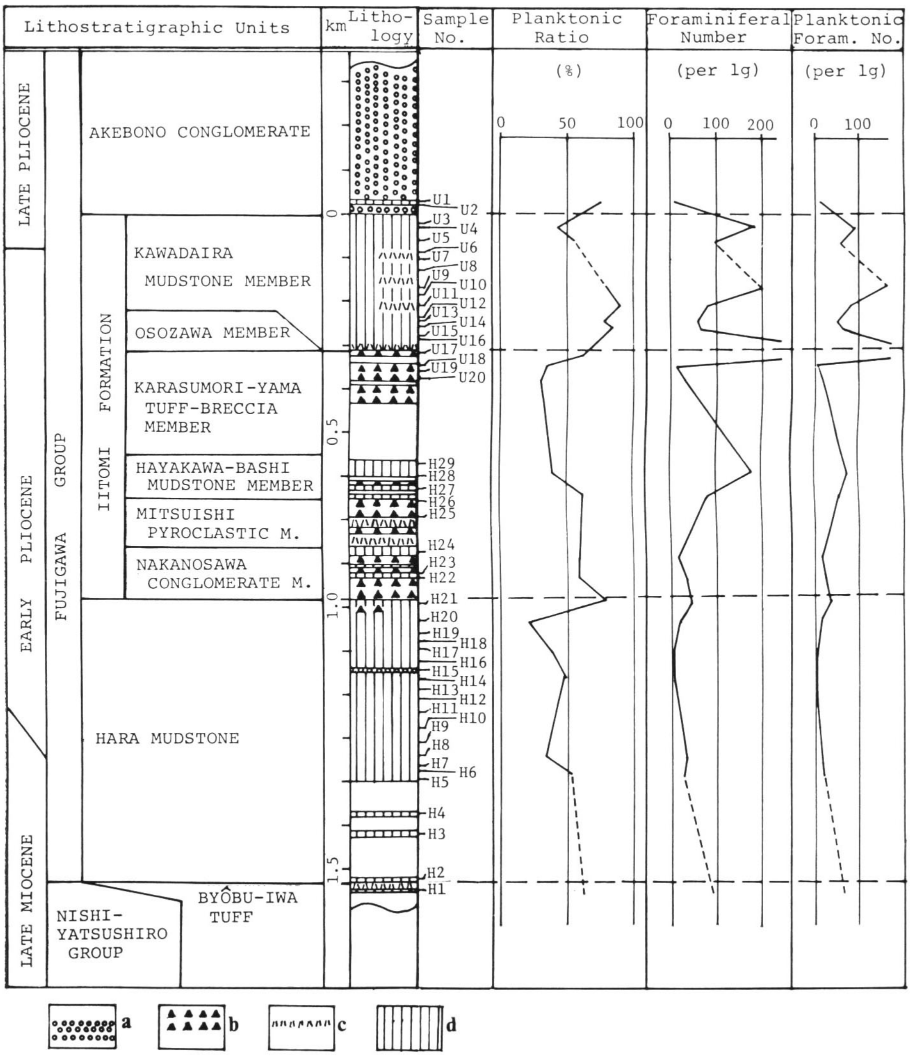



Fig. 5. A composite columnar section showing sampling horizons, and stratigraphic changes of "Planktonic Ratio", "Foraminiferal Number", and "Planktonic Foraminiferal Number". a: conglomerate, b: pyroclastics except for whitish tuff, c: whitish tuff, d: muddy facies.

Table 2. Occurrence chart of planktonic Foraminifera

| | Byôbu-iwa Tuff | Hara Mudstone | | | | | | | | | | | | | Nk | Iitomi Formation Hy | Kr | Kw | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F2 | H2 | H3 | H6 | H7 | H8 | H9 | H11 | H12 | H14 | H16 | H18 | H20 | H22 | H24 | H26 | H17 | U11 | U5 | U4 |
| 1. *Globigerina angustiumbilicata* Bolli | | | 3 | | 1? | | 3 | | | | | | | 1 | | | | | | |
| 2. *G. bulloides* d'Orbigny | | | | 4 | | | | | | | | | | | | | | | 2 | 1 |
| 3. *G. parabulloides* Blow | 6 | | | | | | | | | | | | | | | | | | | |
| 4. *G.* aff. *parabulloides* Blow | | | 6 | | 20 | 7 | 5 | | | | | | | | 1? | | | 2? | | |
| 5. *G. foliata* Bolli | | 5 | 17 | 10 | 3 | 4 | 5 | | 1 | 2 | 11 | | | 3 | | 8 | 15 | 24 | 9 | |
| 6. *G.* cf. *foliata* Bolli | | 6 | | 1 | 27 | | 14 | 11 | 20 | 12 | 6 | 3 | | | | | | 2? | 10 | |
| 7. *G. falconensis* Blow | 5 | | 5 | 4 | 2 | 1 | 2 | 33 | 6 | 20 | 18 | 2 | 2 | | | 17 | 1 | 3 | | 1 |
| 8. *G. nepenthes delicatula* Brönnimann & Resig | | | 1? | | | 5 | | | 4 | 6 | 3 | 5 | 3 | 5 | 1 | | | | | |
| 9. *G. nepenthes nepenthes* Todd | 1 | 1 | | 6 | 11 | 45 | | 30 | 49 | 36 | 25 | 47 | 47 | 13 | 11 | 1 | 6 | 7 | | |
| 10. *G. nepenthes nepenthes*, var. A | | | | 3 | | | 7 | 11 | 47 | 26 | 13 | 24 | 30 | 12 | 6 | 7 | | 10 | | |
| 11. *G. decoraperta* Takayanagi & Saito | 2 | 9 | 3? | | 3 | | 4 | 13 | 6 | 5 | 6 | 7 | 5 | 14 | 2 | | 4? | 11 | 5 | 2 |
| 12. *G. calida praecalida* Blow | | | | 2 | 3 | | | 1 | | | | | | | 1 | 1? | | | | |
| 13. *G.* spp. | 1 | | 3 | 1 | 3 | | | 1 | | | 1 | | | | 2 | | | | | |
| 14. *Globigerinoides bollii* Blow | 1 | | | | | 2 | | 7 | | 1 | 1 | 10 | 10 | 3 | 18 | 5 | 2 | 7 | 5 | |
| 15. *G.* aff. *emeisi* Bolli | | | 5 | | 2 | | | 3 | 7 | 13 | 2 | 3 | | | 7 | 3 | 2 | | | |
| 16. *G. extremus* Bolli & Bermúdez | | | 6 | | | | | | | 2 | | 15 | 13 | 11 | 6 | 9 | 5 | 1 | 13 | 10 |
| 17. *G. obliquus* Bolli | | | | | | | 1 | 1 | 4 | 1 | 8 | 42 | 10 | 4 | 19 | 7 | 20 | 5 | 11 | 6 |
| 18. *G. quadrilobatus* (d'Orbigny), *s.l.* | 9 | 25 | 16 | 13 | 23 | 17 | 22 | 19 | 1 | 1 | 2 | 2 | 2 | 5 | 5 | | 3 | 15 | 8 | 3 |
| 19. *G. quadrilobatus sacculifer* (Brady) | 8 | 7 | 16 | 23 | 8 | | 5 | | | 3 | 14 | 3 | 2 | 33 | 14 | 35 | 17 | 17 | 1 | 5 |
| 20. *G.* cf. *quadrilobatus trilobus* (Reuss) | | 2 | 1 | | | 3 | 1 | 3 | | | | | | | | | | | 2 | |
| 21. *G. ruber* (d'Orbigny), type A | 1 | 4 | 8 | 4 | 2 | 2 | 1 | | | | | | | 2 | | | | | | |
| 22. *G. ruber* (d'Orbigny), type C | 4 | 2 | 7 | 17 | 5 | 3 | 7 | | | | | | 3 | | | | 2? | | 2 | 5 |
| 23. *G. ruber* (d'Orbigny), type B | | | | | 1 | 3 | 7 | | | | | | | | | | | | | |
| 24. *G. conglobatus* (Brady) | | | | | 1 | | | | 1 | 2 | | 2 | | | | 1? | | | | |
| 25. *G.* aff. *tenellus* Parker | | | | | 2 | 4 | 3 | 2 | 2 | | 7 | | | 2 | 2? | | | 2 | | |
| 26. *G. parkerae* Bermúdez | | | | | | | | | | | | | | | | | | 1 | | |
| 27. *Globigerinita glutinata* (Egger) | 9 | 31 | 39 | 34 | 27 | 8 | 24 | 12 | 12 | 19 | 16 | 22 | 11 | 19 | 15 | 19 | 6 | 20 | 9 | |
| 28. *G.* aff. *glutinata* (Egger) | | 1 | | 2 | | | | | | | | 1 | 1 | 2 | | | | | | |
| 29 *G. uvula* (Ehrenberg) | | | 1? | 2 | 2 | | 1 | | | | 2 | | | | | | | | | 2 |
| 30. *G.* ? spp. | 3 | | | | | | | | | | 1? | 3 | 1? | | 1 | | | 4? | | |
| 31. *Orbulina universa universa* d'Orbigny | 17 | 34 | 32 | 9 | 28 | 25 | 32 | 33 | 36 | 4 | 12 | 2 | 9 | 22 | 32 | 15 | 45 | 18 | 3 | 13 |
| 32. *O. universa suturalis* Brönnimann | 8 | 22 | 4 | 3 | 1 | 5 | 2 | 1 | 1 | 2 | 2 | 1 | 5 | | 2 | 7 | 3 | 8 | | |
| 33. *O. parkerae* Brönnimann & Resig | 5 | 3 | 1 | | | | | | | | 1 | | | 2 | | | 2 | 2 | | |
| 34. "*Candeina amicula* Takayanagi & Saito" | | 4 | 1 | | | | | | 2? | 4 | 3 | | | 6 | 2 | 3 | 1 | 2 | 1 | 2 |
| 35. *Prosphaeroidinella parkerae* Ujiié | | | 2 | 1 | | 2 | | 2 | | | 2 | 1 | 1 | 1 | | | 1? | 1? | | |
| 36. *Sphaeroidinellopsis seminulina kochi* (Caudri) | | | 2 | | | 1 | | | | | | | | 1 | | | | 1 | | |
| 37. *S. seminulina seminulina* (Schwager) | 2 | 6 | 3 | 2 | 3 | 20 | 2 | 11 | 5 | 8 | 4 | 4 | 12 | 6 | 5 | 1 | 4 | 8 | 1 | 5 |
| 38. *S. subdehiscens subdehiscens* (Blow) | | 5 | 3 | 6 | 5 | 9 | | 14 | 10 | 12 | 7 | 8 | 6 | | 3 | 4 | 2 | 3 | 5 | 5 |
| 39. *S. subdehiscens paenedehiscens* Blow | | | | | | | | | 1 | | 1? | | | | | 2 | | | | 4? |
| 40. *Sphaeroidinella dehiscens immatura* (Cushman) | | | | 1?? | | | 3 | 4 | 2 | 2 | 3 | 1 | 8 | 3 | 4 | 1 | 2 | 3 | 2 | |
| 41. *S. dehiscens dehiscens* (Parker & Jones) | | | | | | | | | | | | | | | | | 2 | | | |
| 42. *Globoquadrina altispira* (Cushman & Jarvis) | 1 | 12 | 9 | 3 | 5 | 3 | 8 | | | | | 1 | | | | 10 | 2 | | 1 | |
| 43. *G. altispira*, var. | | | | | 4 | 2 | | | | | | | | | | | | 1 | | |
| 44. *G. globosa* Bolli | | | 2 | 2 | 1 | | | | | | 2 | 1 | | | | 1? | 1 | | | |
| 45. *G. dehiscens advena* Bermúdez and var. | | 4 | 1 | | 1 | | 6 | 4 | 6 | 2 | 18 | 7 | 5 | 14 | 7 | 10 | | 1 | | |
| 46. *G. dehiscens dehiscens* (Chapman, Parr & Collins) | 6 | 11 | 2 | 9 | 11 | | 7 | 6 | 6 | | 3 | 1 | 3 | 4 | | 1 | | 4 | | |
| 47. *G.* cf. *larmeuii* Akers | | | | 3 | 1? | | | | | | | | 1? | 1 | | | | | | |
| 48 *G.* ? cf. *conglomerata* (Schwager) | | | | 7 | 2 | 1 | | | | | | | | 1? | | | | | | |
| 49. *G.* ? spp. | 1 | 7 | 1 | 1? | 1 | | | | | | | | | | | | | 4 | | |
| 50. *Globorotalia* (*Turborotalia*) *acostaensis* Blow, *s.s.* | 114 | 83 | 3 | 15 | 118 | 14 | 13 | 5 | 6 | 4 | 5 | 14 | 1 | 9 | 4 | 1 | 33 | 6 | 10 | 23 |
| 51. *G.* (*T.*) *acostaensis humerosa* Takayanagi & Saito | 3 | 8 | | | | | 2 | 1 | 2 | 3 | 6 | 1 | | | | | 5 | 5 | | |
| 52. *G.* (*T.*) *acostaensis pseudopima* Blow | 3 | 3? | | | | 2 | | 1 | | 1 | | | | | | | | 1? | | |
| 53. *G.* (*T.*)? *pachyderma* (Ehrenberg) | | | | | | | | | | | | | | | | | 12? | | | 48 |
| 54. *G.* (*T.*) *tosaensis* Takayanagi & Saito | | | | | | | | | | | | | | | | | | | 1? | 3 |
| 55. *G.* (*T.*)*tosaensis*/*crassaformis ronda* Blow | | | | | | | | | | | | | | | | | | 1 | | |
| 56. *G.* (*T.*) *crassaformis* (Galloway & Wissler), *s.l.* | | | | | | | | | | | | | | | | | | | 2 | 13 |
| 57. *G.* (*T.*) aff. *inflata* (d'Orbigny) | | | | | | | | | | | | | | | | | | | 4 | 3 |
| 58. *G.* (*T.*) *obesa* Bolli | | | | | | | | 1 | | | | | | | | 1 | 1 | | | |
| 59. *G.* (*T.*) *scitula* (Brady), *s.l.* | 1? | | 1? | | 7 | | | | | | | | | | | | | | | |
| 60. *G.* (*T.*) sp. A | | | | 9 | 5 | | | | | | | 1 | | | 1 | | | | | |
| 61. *G.* (*T.*) ? sp. A | | | | | | | | 11 | | 2 | | | | | | | | 4 | | |
| 62. *G.* (*T.*) spp. | 1 | | | | 1 | 1 | | | | | | | | | | | 1 | | | |
| 63. *Globorotalia* (*Globorotalia*) *crassula viola* Blow | | | | | | | | | | | | | | | | | | | 4 | |
| 64. *G.* (*G.*) aff. *cibaoensis* Bermúdez | 3 | | 5 | 3 | | | | 11 | 3? | 5 | | 2? | 5 | | 1 | | 8 | | | |
| 65. *G.* (*G.*) *cultrata* (d'Orbigny), *s.l.* | 1 | | 3 | 1 | | | 1 | 4 | 18 | 2 | | | 4 | 3 | | 1 | | 1 | | |
| 66. *G.* (*G.*) *tumida* (Brady) | | | | | | | | | | | | | | | | 1? | | | 5 | |
| 67. *G.* (*G.*) *tumida*, var. | | | | | | | | | | | | | | | | | 22 | | | |
| 68. *G.* (*G.*) sp. A | | 11 | | | | 3 | 2 | 8 | 2 | | 2 | 2 | | 5 | 1 | 6 | 15 | 5 | | 1 |
| 69. *G.* (*G.*) cf. *praehirsuta* Blow | 2 | | | | | 2 | | | | | | | | | | | | | | |
| 70. *G.* (*G.*) spp. | 1 | | 1 | | | | 2 | | | | | | | | | | | | 1 | |
| 71. *Globigerinella siphonifera* (d'Orbigny) | 2 | 1 | 2? | | 6 | | 3 | | | | 2? | | | 4 | | 1 | 2 | 1 | 2 | |
| 72. *Pulleniatina obliquiloculata praecursor* Banner & Blow | | | | | | | | | | | | | | | | | | 1 | | |
| 73. Gen. et sp. indet. | 1 | 3 | 3 | | | 1 | 7 | | 1 | 1 | 1 | | | | 8 | | 1 | 2 | 1 | 1 |
| Total Number of Specimens | 222 | 310 | 218 | 201 | 246 | 195 | 202 | 264 | 261 | 201 | 210 | 238 | 200 | 211 | 181 | 179 | 248 | 214 | 120 | 156 |

Nk: Nakasosawa Conglomerate Member, Hy: Hayakawa-bashi Mudstone Member, Kr: Karasumori-yama Tuff Breccia Member, Kw: Kawadaira Mudstone Member.

which also shows a composite columnar section, "Foraminiferal Number", i. e., the calculated number of planktonic and benthonic foraminiferal specimens per 1 gr. of rock sample, remarkably varies with horizon. It may be noticeable that the Hara Mudstone contains rather scarce individuals in spite of its fine-grained lithology and that the Kawadaira Mudstone Member is rather rich in Foraminifera irrespective of its stratigraphic position below the Akebono Conglomerate which is the final regression facies of the Shizukawa Group.

"Planktonic Ratio" means a relative frequency of planktonic foraminiferal tests to total amount including planktonics and benthonics. A high value of this Ratio suggests that open-sea conditions have prevailed, as indicated for Recent seas by authors (e. g., UJIIÉ, 1973). Stratigraphic change of this Ratio in the Shizukawa Group is much less variable than that of "Foraminiferal Number" and maintains rather high values throughout. Such high ratios are duly expected from the stratigraphic change of "Planktonic Foraminiferal Number" per 1 gr. of rock sample, which coincides well with the change of "Foraminiferal Number" in suggesting that planktonics predominate over benthonics. It is more noteworthy that the Ratio does not decrease but slightly increases across the boundaries between the Hara Mudstone and the Nakanosawa Conglomerate Member, between the Karasumori-yama Tuff Breccia Member and the Kawadaira Mudstone Member, and between the Kawadaira Member and the Akebono Conglomerate. At these boundaries, a shallowing sea might be inferred from rather superficial interpretation of the lithofacies changes. However, we would like to suggest that open-sea conditions prevailed throughout the period of deposition from the uppermost Nishi-yatsushiro Group to the major part of the Fujikawa Group until the beginning of the Akebono Conglomerate.

Table 2 is the occurrence chart of planktonic foraminiferal taxa at 20 localities of the total 51; other localities are omitted because of the scarcity or lack of Foraminifera, and of much deformed specimens, if any. As a result, 67 taxa were distinguished from 4,277 individuals. Their taxonomy and paleogeographic significance will be described and discussed when the serial work on the Upper Neogene materials from the subtropical northwestern Pacific is completed. In the present paper, we only give the following three facts.

1) The base of the Pliocene as defined by the boundary between N. 19 and N. 18 of BLOW's (1969) zonation based on planktonic Foraminifera can be traced at the middle of the Hara Mudstone (between Samples H8 and H9) by the initial appearance of *Sphaeroidinella dehiscens immatura* which succeeded the single occurrence of its ancestor, *Sphaeroinellopsis subdehiscens subdehiscens*; the intermediate form, *S. subdehiscens paenedehiscens*, coexists with early representatives of *immatura*.

2) The N. 19/N. 21 boundary designated by the initial appearance of *Globorotalia tosaensis* is found in the upper portion of the Kawadaira Mudstone Member (Sample U5), even though some specimens of this species still retain primitive morphology. Thus, the portion above U5 and the overlying Akebono Conglomerate can be assigned to Upper Pliocene.

3) We could not recognize the bases of N. 18 and N. 17, which are defined respectively by the initial appearance of *Globorotalia tumida* and that of *Gr. plesiotumida*, like many of the cases in the subtropical northwestern Pacific region (i. e., Deep Sea Drilling Sites 292 and 296 in the Philippine Sea, UJIIÉ, 1975 a; Shimajiri Group in Miyako-jima, Ryukyu Islands, UJIIÉ and OKI, 1974; Sagara Group in western Shizuoka Prefecture, UJIIÉ and HARIU, 1975, and so on). The absence of the bases of N. 18 and N. 17 may be ascribed partly to rare occurrence of the *Gr. tumida* lineage in the region, even if the lineage became common there after Late Pliocene. Apart from the reason of indistinguishable N. 18 and N. 17, it is reasonably assumed that the lower Hara Mudstone and the underlying Byôbu-iwa Tuff represent a time interval equivalent to that from N. 18 to N. 17, judging from the faunal compositions of planktonic Foraminifera contained therein. Below the Byôbu-iwa Formation, no significant unconformity has been reported yet throughout the Nishi-yatsushiro Group down to the Furuseki Formation (see Table 1). If it is true that *Lepidocyclina* or *Miogypsina* indicating N. 8 or N. 9 of upper Lower or lower Middle Miocene occurs in the lower part of the Nishi-yatsushiro Group as reported though without any description nor illustration by NISHIMIYA (1970) and CHIJI and IKEBE (1973), a great time-stratigraphic gap must be expected between the Byôbu-iwa Tuff and the Kanzaka Formation. The problem should be solved through precise investigation on these larger Foraminifera and the associated planktonic forms. In connection with this matter, we should like to point out that the major portion of the Sagara Group in Shizuoka Prefecture ranges from N. 19 to N. 14 (UJIIÉ and HARIU, 1975) and that below an unconformity lies the *Lepidocyclina*-bearing Megami Formation containing planktonic Foraminifera of N. 8 (UJIIÉ, 1975 b).

In conclusion, we assign the Shizukawa Group in the vicinity of Nakatomi-chô to uppermost Miocene throughout lower Upper Pliocene, referring to the global scheme of planktonic foraminiferal biostratigraphy. Previous dating of the geologic age of the Group was based only on a few molluscan fossils obtained mainly from the Osozawa Conglomeratic Sandstone Member. While OTUKA (1934, 1938) considered them to be characteristic to the Pliocene strata (e. g., Kakegawa Group) on the Pacific coast of Southwest Japan, AKIYAMA (1957 a, b) correlated the Shizukawa Group with the Sagara Group by these molluscs, particularly *Amussiopecten iitomiensis* (OTUKA). AKIYAMA's correlation roughly agrees with our conclusion, except for the dating of the Sagara Group. Previously the Sagara Group was believed to represent the typical Upper Miocene stage in Japan, but recently it has been revealed by planktonic Foraminifera that its upper portion includes Lower Pliocene (UJIIÉ and HARIU, 1975).

Our new dating of the Shizukawa Group and its correlation with upper part of the Sagara Group including the basal part of the Kakegawa Group may influence future studies of Cenozoic tectonics and paleogeography in the southern Fossa Magna region and its adjacent region, where the Sagara and Kakegawa Groups are developed.

## References

AKIYAMA, M., 1957 a. *Amussiopecten iitomiensis* (OTUKA) and its allies from Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, (25): 31–39, pls. 6, 7.

AKIYAMA, M., 1957 b. The Neogene strata along the upper course of the Fujikawa River, Yamanashi Prefecture, Japan. *Jour. Geol. Soc. Japan*, **63** (747): 669–683. [In Japanese with English abstract]

BLOW, H. W., 1969. Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. *Proc. 1st Internat. Conf. Plankt. Microfossils, Geneva 1967*, **1**: 199–422, 54 pls.

CHIJI, M. & N. IKEBE, 1973. Some problems on the geological age of "*Lepidocyclina-Miogypsina* Zone" and *Miogypsina-Operculina* Zone" in Japan. *Mem. Geol. Soc. Japan*, (8): 77–84. [In Japanese with English abstract].

Fujikawa Research Group, 1976 (in press). On the geologic structure of the Neogene Tertiary along the River Fuji. *Mem. Geol. Soc. Japan.* [In Japanese].

IKEBE, N. & M. CHIJI, 1971. Notes on top-datum of *Lepidocyclina* sensu lato in reference to planktonic foraminiferal datum. *Jour. Geosci., Osaka City Univ.*, **14** (2): 19–52.

IKEBE, N., Y. TAKAYANAGI, M. CHIJI & K. CHINZEI, 1972. Neogene biostratigraphy and radiometric time scale of Japan. *Pacific Geol.*, (4): 39–78.

INOUE, H., 1934. Geological study of the district along the lower course of the River Fuji. *Jour. Geogr.*, **46** (539): 18–43. [In Japanese].

MATSUDA, T., 1958. Late Tertiary stratigraphy and development of folding in the upper Fuji River valley, Yamanashi Prefecture, central Japan. *Jour. Geol. Soc. Japan*, **64** (754): 325–345. [In Japanese with English abstract].

MATSUDA, T., 1961. The Miocene stratigraphy of the Fuji River valley, central Japan. *Ibid.*, **67** (785): 79–96. [In Japanese with English abstract].

MATSUDA, T. & A. MIZUNO, 1955. Stratigraphical study on the Nishiyatsushiro Group (Miocene) in the area of the upper stream of the Fuji, Japan. *Ibid.*, **61** (717): 258–273. [In Japanese with English abstract].

NAUMANN, E., 1885. Über den Bau und Entstehung der japanischen Inseln.

NISHIMIYA, K., 1970. In explanatory text of the geological map of Yamanashi Prefecture, issued by the Yamanashi Prefectural Government. [In Japanese].

OTUKA, Y., 1934. On some fossils from the northern foot of Mt. Minobu and from the Hayakawa Tuffite of Hakone. *Jour. Geol. Soc. Japan*, **41** (492): 562–568. [In Japanese].

OTUKA, Y., 1938. Geological study of the Huzimi-yama fault scarp in southwestern part of Yamanashi Prefecture. *Geogr. Rev. Japan*, **14** (12): 969–984. [In Japanese].

OTUKA, Y., 1939. Tertiary crustal deformation in Japan. Jubl. Publ. Comm. Prof. Yabe's 60th Birthday, 481–519.

OTUKA, Y., 1955. Shizukawa Group and Tertiary crustal movements in Japan. *Bull. Earthq. Res. Inst.*, **33** (3): 449–469. [In Japanese with English abstract].

TANAKA, M., 1930. Topography of the Koma mountainland west of the Kofu basin. Jubl. Publ. Comm. Dr. T. Ogawa's 60th Birthday, Geol. Ser., 549–557. [In Japanese].

UJIIÉ, H., 1958. Geological structure of the Sagara-Kakegawa sedimentary basin. Proc. Symp. "Japanese Neogene", by Geol. Soc. Japan, 1–7. [In Japanese].

UJIIÉ, H., 1962. Geology of the Sagara-Kakegawa sedimentary basin in central Japan. *Sci. Rep. Tokyo Kyoiku Daigaku, sec. C*, **8** (75): 123–188.

UJIIÉ, H., 1973. Sedimentation of planktonic foraminiferal shells in the Tsushima and Korea Straits between Japan and Korea. *Micropaleontology*, **19** (4): 444–460.

UJIIÉ, H., 1975 a. Planktonic foraminiferal biostratigraphy in the western Philippine Sea, Leg 31 of DSDP. *Init. Rep. D. S. D. P.*, **31**: 677–691, 3 pls.

UJIIÉ, H., 1975 b. An Early Miocene planktonic foraminiferal fauna from the Megami Formation, Shizuoka Prefecture. *Bull. Natn. Sci. Mus., ser. C*, **1** (3): 83–92, 3 pls.

UJIIÉ, H. & S. HARIU, 1975. Early Pliocene to late Middle Miocene planktonic Foraminifera from the type section of the Sagara Group, central Japan. *Ibid.*, 1 (2): 37–54, 3 pls.
UJIIÉ, H. & K. OKI, 1974. Uppermost Miocene-Lower Pleistocene planktonic Foraminifera from the Shimajiri Group of Miyako-jima, Ryukyu Islands. *Mem. Natn. Sci. Mus.*, (7): 31–52, pls. 1–6.

## Explanation of Plates

(All figures $\times$100)

### Plate 1

(a: spiral view, b: umbilical view, c: edge and apertural view)

Fig. 1. *Globigerina nepenthes nepenthes* TODD.
Typical specimen representing the latest occurrence in Shizukawa Group; Micropaleontology Collection, Natn. Sci. Mus. 1082; from Sample 11 (Kawadaira Mudstone Member of the Iitomi Formation).

Fig. 2. *Sphaeroidinellopsis subdehiscens paenedehiscens* BLOW.
Micropal. Coll. N. S. M. 1083; from Sample H12 (Hara Formation).

Figs. 3 & 5. *Sphaeroidinella dehiscens immatura* (CUSHMAN).
Micropal. Coll. N. S. M. 1084 and 1085, respectively; both from Sample H11 (Hara Mudstone).

Fig. 4. *Sphaeroidinella dehiscens immatura* (CUSHMAN).
Earliest occurrence in the Shizukawa Group; Micropal. Coll. N. S. M. 1086; from Sample H9 (Hara Mudstone).

Fig. 6. *Sphaeroidinellopsis seminulina* (SCHWAGER), s. l.
Latest occurrence of typical specimen in the Shizukawa Group, umbilical view; Micropal. Coll. N. S. M. 1087; from Sample U4 (Kawadaira Mudstone Member).

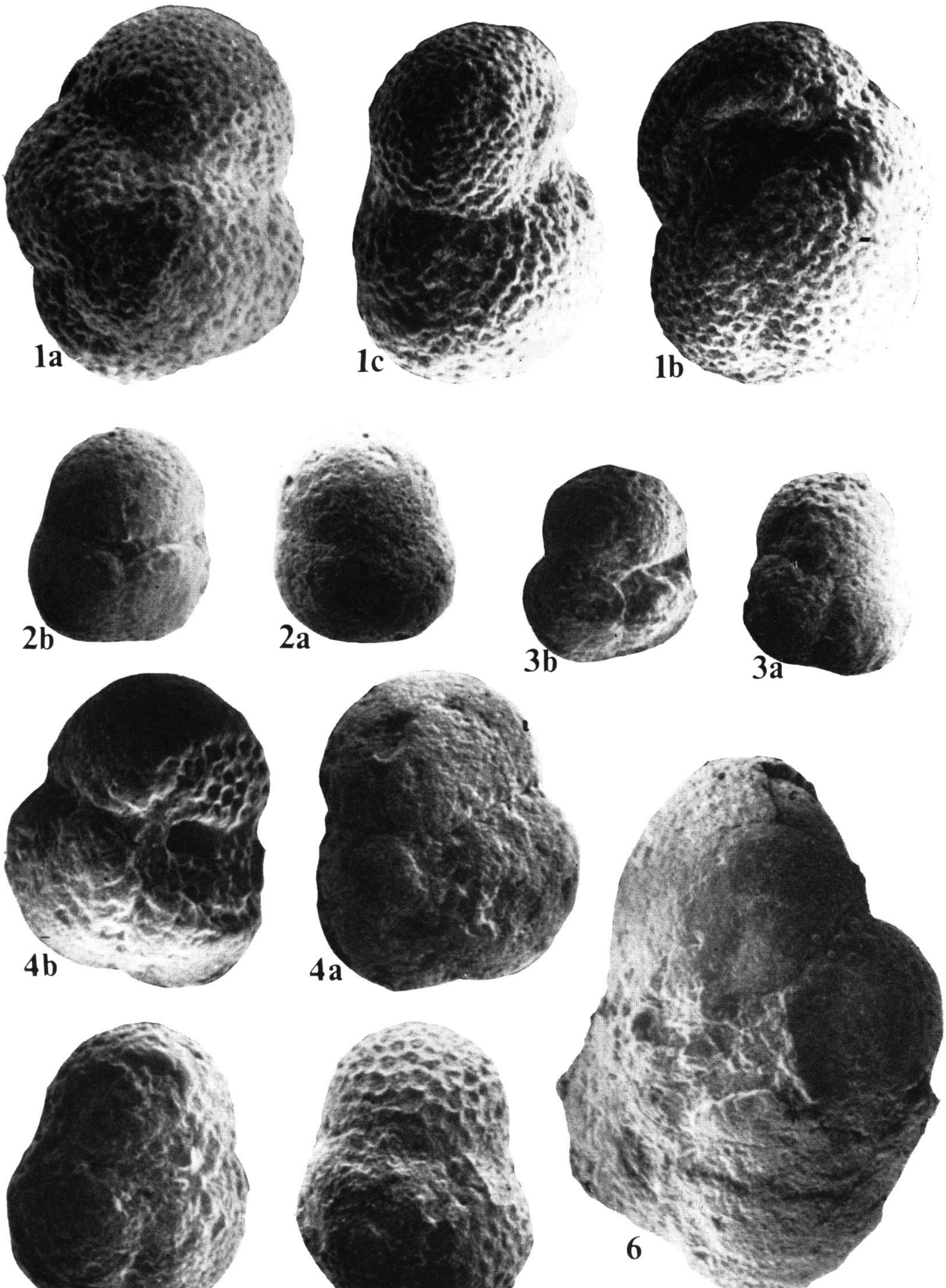
### Plate 2

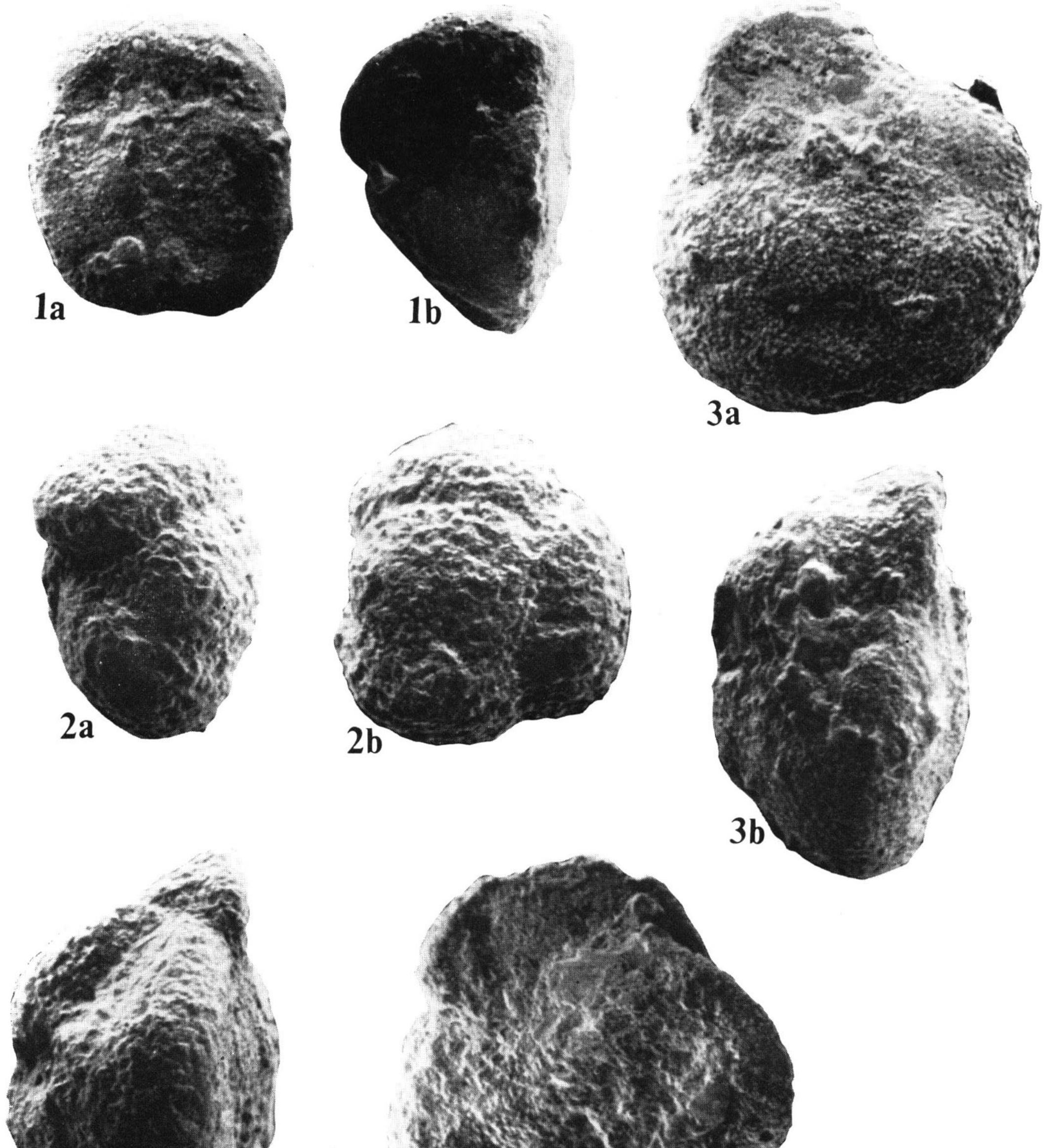
(a: spiral view, b: edge and apertural view, except for Fig. 2 where they are reverse)

Fig. 1. *Globorotalia* (*Turborotalia*) *crassaformis* (GALLOWAY and WISSLER), s. l.
Associated with *Gr. tosaensis*; Micropal. Coll. N. S. M. 1088; from Sample U4 (Kawadaira Member)

Fig. 2. *Globorotalia* (*Turborotalia*) aff. *inflata* (D'ORBIGNY)
Somewhat similar to *Gr. orientalis* MAIYA, SAITO and SATO, 1976, and associated with *Gr. tosaensis*; Micropal. Coll. N. S. M. 1089; from Sample U4.

Figs. 3 & 4. *Globorotalia* (*Turborotalia*) *tosaensis* TAKAYANAGI and SAITO
Earliest occurrences in the Shizukawa Group; both with somewhat acute periphery at the final chamber and with not so clearly opened umbilicus as is in the typical form; Micropal. Coll. N. S. M. 1090 and 1091, and from Samples U4 and U5, respectively.

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