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INTRODUCTION AND ACKNOWLEDGEMENTS

Marine sediments assigned to the Pleistocene and Neogene are well developed and have extensive distribution in the Japanese Islands. These deposits have been studied stratigraphically, structurally and paleontologically as well as from other views by many persons in Japan and our knowledge concerning the characteristics of the Neogene as well of earlier and later ages are rather well known. However, with regard to the interrelationship of the stratigraphic units of the different sedimentation basins there yet remain many problems as will be discussed in this article.

For the purpose of expressing the interrelationship of the stratigraphic units of the different sedimentation basins several methods have been offered such as, the standard chronology of Europe, the Letter Nomination proposed by Ikebe (1931), the stages initiated by Makiyama (1940) and several proposed by Takai (1939), number indications used by Hatai (1936) and Kitamura (1959), larger chronological units offered by Yabe and Aoki (1923), subdivisions recognized by Matsumoto (1923) based upon mammals and stratigraphic breaks, and the cycle phase recently published by Hatai (1960). Although there are a number of methods proposed, each seem to have their own defects, from which it appears that a natural interrelation of the stratigraphical units of the different sedimentation basins still remains vague.

Expressed in a previous article (Hatai, 1960) was that the cycle phase which involves marine transgression and regression, volcanism and diastrophism, sequence of fauna and flora and based upon historical geology may be favorable for a natural interpretation of the interrelationship of the stratigraphical units established in different sedimentation basins. In this article the writer attempts to extend the cycle phase and to incorporate the method for reconsideration of the Mizuho Period of Yabe and Aoki (1923) which involves drawing of its limits or delimination of the Mizuho Period (=Japanese Neogene) from earlier and later chronological subdivisions of the Cenozoic Era.

At this place the writer expresses his thanks to the many persons who have assisted him in the field or in the laboratory with concern to the present work.

MIZUHO TŌ

It was clearly pointed out by Yabe and Aoki (1923) that a significant unconformity separates the Mizuho-Tô or Period from the next younger Shikishima Period. This break is reported from many places in the Japanese Islands. It is not merely an erosional surface but marks a period of diastrophism and the strata above and below it are frequently discordant in their dips and strikes. This boundary marks a change in the fauna and flora, marine and terrestrial, and is threefold, being geostructural, paleontological and climatological as well as lithological. Such a break signifies and separates the Mizuho from the Shikishima Period in the Japanese Islands, but whether it can be correlated with the boundary between the Pliocene and Pleistocene in northern Italy is another problem and will be discussed in later pages although reference to it had already been given by Hatai (1958).

An example of the paleontological break mentioned above is noted in the differences of the mammalian fauna above and below the boundary, *Stegodon orientalis* Owen occurs below the line but does not cross it, whereas *Stegodon akashiensis* Takai is known from above, and *Elephas* occurs from above but not from below. *Metasequoia* ranges up to the boundary but does not cross it. The rich molluscan fauna just above the boundary in the Boso Peninsula, Chiba Prefecture (Hatai, 1958) points to a cold water environment and the pollen to a cold climate (Sohma, 1961) whereas that just below it represents a moderate thermal and climatic (Sohma, 1960) condition. That the geostructure below and above the break is significant can be known from the extensive erosion unconformity, folding and fault movements below but not so pronounced above, angular contacts at certain places with nearly horizontally disposed strata above, and where the succession of the strata is continuous there is indicated a rapid down-sinking. The break is also a lithological one as suggested by the differences in lithology of the formations above and below the break, those below showing intimate relationship downwards and those above indicating analogous features upwards. The climatological differences below and above the break may also be significant in that below there is generally, so far as known, a moderate climatic condition indicated by the fauna and flora, whereas above there is evidence for a cold climate represented where fossils are unknown by extensive distribution of well developed deposits of conglomerate.

Thus as already pointed out by Yabe and Aoki (1923) and again repeated in the above lines there is a significant break between the formations referred to Mizuho and Shikishima time, and this unconformity delimits the former. However, another problem is the lower limit of the Mizuho Period as also viewed from geostructure, paleontology, marine transgression and regression, and volcanism. The lower limit of the Mizuho is found in a continuous sequence of strata in the northern part of Kyushu and in the Chichibu Basin in Saitama Prefecture, whereas elsewhere in the Japanese Islands there is a significant unconformity as will be described below. And the formations between the two major unconformities are all referable to the Mizuho Period, those above the younger major break correspond to Shikishima or younger and those below and which belong to the Tertiary System to the Takachiho and Akitsu Periods, which were designated as representing the Japanese Paleogene by Yabe and Aoki (1923).

The final phase of the Takachiho Period was marked by extensive marine regression accompanied with local outburst of volcanism, uplift and diastrophism (folding, faulting) succeeded with subaerial denudation and followed with another phase of rather extensive volcanism, marine transgression and subsidence. Paleontological evidence shows that the marine fauna above and below this just mentioned stratigraphical break is remarkably different. *Stegolophodon*, *Eostegodon*, *Rhinoceros* and other land mammals appear for the first time just above the break but not below it. Tropical to subtropical marine faunas extend widely over the Japanese Islands and comprise elements different from the last phase of the Takachiho Period in having *Lepidocylina nipponica* Yabe, *Echinolampas yoshiwarai* P. de Loriol, *Nanaochlamys notoensis* (Yokoyama), *Cultellus otukai* Tanai and Ogasawara, abundant other kinds of bivalves and univalves, *Tanakura tanakura* Hatai, and many other marine fossils. *Periploma besshoense* Yokoyama which is common during the Takachiho Period does not extend up into the Mizuho where it is replaced by *Periploma yokoyamai* Makiyama. Volcanic rocks are extensively distributed just above the break as the andesites of the Natori group in the Sendai Area, the rhyolites in the Yunagaya group in the Joban Area, the effusives in Akita-, Aomori-, Iwate-, and Yamagata Prefectures, and pyroclastics in those mentioned prefectures as well as in the San-in Area. All such eruptives are associated with marine sedimentaries which yield fossils and are situated above the break defining the Takachiho-Mizuho boundary.

Where the strata are in a continuous sequence from Takachiho to Mizuho as in northern Kyushu and the Chichibu Basin already mentioned, in the latter area the last phase of the former period is indicated by uplift succeeded with rapid down-sinking of the latter, and volcanism accompanied the movement. In the former area the last phase of the Takachiho Period is indicated by pyroclastic sediments admixed in the Sari formation and its uplift but not complete rising above sea-level followed with rapid subsidence and shifting of the sedimentation basin and also the first indication of *Dosinia* in the area. This uplift succeeded with down-sinking without complete elevation above the sea-level corresponds to the break indicated elsewhere in the Japanese Islands, the movement being analogous but incomplete in one and complete in the other, all associated geological phenomena being similar.

From the above lines it is evident that the Mizuho Period is bounded above and below by significant breaks indicated by geostructure, paleontology, volcanism, marine regression and subsequent transgression, instability of the sedimentation basin, and is of extensive distribution throughout the Japanese Islands. Thus it is clear that the Mizuho Period can be delimited from both younger and older formations in a reasonable and very favorable way, regardless of minor changes incorporated due to the recent advances in stratigraphy, geostructure, paleontology and other branches in geosciences. As stated by Yabe and Aoki (1923), minor stratigraphical breaks are included within the Mizuho Period. These minor stratigraphical breaks include different grades and among them the one separating early from late Mizuho and the one in the upper part of the early Mizuho may be worthy of comment since they are also rather significant, though less than the ones separating the Mizuho from both younger and earlier formation.

Since a brief outline of the significant breaks separating the Mizuho Period from others has been given in the foregoing lines, in the following will be given more details on the unconformity distinguishing and separating, the Mizuho from the next younger Shikishima Period and evidences characterizing the latter phase of the Mizuho and the early one of the Shikishima. Although opinions may diverge it is not the purpose of this article to give explanations to the views hitherto expressed concerning the boundary between the so-called Neogene and Pleistocene ages as used by the different workers in Japan. Because of page limitation discussions will be concentrated to express the writer's view on the problem already outlined in earlier pages.

Post-Mizuho pre-Shikishima Boundary. The formations younger than the Mizuho Period have been included into the Shikishima Period by Yabe and Aoki (1923), a name which was proposed by them for their fourth division of the Cenozoic Era. They stated that block movement took place at the end of the Mizuho Period before deposition of the formations of the Shikishima Period.

The marine formations of the Shikishima are well developed in the Boso Peninsula, Chiba Prefecture, but elsewhere in the Japanese Islands they are restricted to local areas, generally fringing the coast of the present Islands, whereas the lacustrine sediments of the same age have more continuous distribution but are less fossiliferous and not so well studied as to their geology and paleontology. Since geology in Japan has progressed considerably since the proposal of the Shikishima Period certain changes become necessary, but the basic reasons for the initiation of the term remains valid.

Before entering into discussions on the Mizuho Period it is first necessary to show the relation between the different stratigraphical units of the two periods where they are in contact with one another. For this purpose will be given an outline of the formations of the two periods.

In the Sendai Area the moderate climate indicating molluscan fauna bearing Dainenji formation is superposed with unconformity by the Aobayama formation of early

Shikishima age. The latter comprises conglomerate of considerable lateral extension and is thought to be a product of a cold climate as is the Yamajari gravels widely distributed in southwest Japan.

In the northern part of the Miura Peninsula, Kanagawa Prefecture the Byobugaura formation of Shikishima age lies with notable unconformity upon the Naganuma formation of late Mizuho age, and in the Boso Peninsula, Chiba Prefecture on the opposite side of Tokyo Bay the Sasage-Nagahama-Mandano and Kasamori formations named in the order from west to east lie upon the Iwasaka-, Ichijuku-, Kakinokidai and Chonan formations in the same order of arrangement, the former set are of early Shikishima age and the latter of late Mizuho age (Hatai, 1958). The relation is an unconformity in the western part of the Peninsula and a conformity in the central to eastern part. There being indicated uplift and subaerial denudation in the western part associated with slight folding, whereas in the eastern part the relation is continued deposition from Mizuho to Shikishima but with remarkable change in climatological conditions inferred from the marine molluscan fauna from the formations above and below the boundary. The differences in lithology of the group of formations above and below the inferred boundary are contrasting as in the case of the Miura Peninsula above refered to.

In Shizuoka Prefecture the Shikishima-Mizuho is analogous with the one mentioned for the Sendai Area in the deposits of the former comprising conglomerates and that of the latter marine sediments. In this area the Kuroiwa conglomerates cover the Tsuchisawa formation with unconformity as do the Ogasayama conglomerates with the subjacent Soga formation. This same relation may be the Kunosan conglomerates lying upon the Kunosan shell-beds.

In the northern part of the Chita Peninsula, Aichi Prefecture the tilted and truncated late Mizuho lacustrine Agé formation is covered with horizontal deposits of the marine Noma formation and on the opposite side of Isé Bay, the late Mizuho Agé formation is covered with unconformity by the Kentoyama gravels of early Shikishima age. The Kentoyama gravels correspond to the Rengeji formation of similar lithology and which covers the Kuwana group with unconformity. In the vicinity of Nagoya City, the Shiroyama and Yagoto formations of early Shikishima age are superjacent to the Higashiyama formation with unconformity, and in the northern part of Mie Prefecture, the Rengeji formation (gravels) covers the Yokkaichi formation with unconformity.

The stratigraphic relation as outlined above also occurs in Tokushima Prefecture where the early Shikishima gravels cover the Moriyama formation (lacustrine) with unconformity, and in the northern part of Shikoku the Yakeotoge gravels of early Shikishima age are unconformable with the lacustrine deposits of late Mizuho age. In Oita Prefecture, the Tsuruzaki formation covers the Takio formation with local unconformity, while in the western part of Kyushu the early Shikishima Kitaarima formation covers the Oya formation also with unconformity.

The stratigraphic relation of early Shikishima and late Mizuho formations along the Pacific and Setouchi coasts of eastern and southwestern Japan are remarkably similar, showing almost everywhere an unconformity, except in the Boso Peninsula where the sediments are continuous only in the central to eastern parts. Another locality of where the strata are continuous from late Mizuho to early Shikishima may be Lake Biwa, where the deposits of lacustrine sediments are continuous, but *Metasequoia* is found only in the lower part in association with a flora different from that of the upper part, which indicates a cold climate.

The Yashiroda formation which is superjacent to the Uonuma formation with unconformity in the Echigo oil-fields has its correlatives distributed in Yamagata-, Akita-, and Aomori Prefectures facing the Japan Sea, but in most cases no formal names have

been given to the early Shikishima deposits in those areas. Such relation of unconformity between late Mizuho and early Shikishima formations also are known from southwestern Hokkaido.

From the foregoing it becomes evident that the stratigraphical relationship of early Shikishima and late Mizuho formations is an unconformity everywhere except in two well known localities of the Boso Peninsula and Lake Biwa.

Mizuho Marine and Terrestrial Facies. In the larger parts of the Japanese Islands after a long period of terrestial conditions, which is a land stage, there occurred widespread subsidence associated with local volcanism and the transgression of tranquil marine waters over the eroded land surface. This first marine transgression marks the beginning of the Mizuho Period. Commencing with local or regional volcanism and marine transgression there was brought into the Japanese Islands a new marine fauna comprising *Nephrolepidina*, specifically abundant and remarkably sculptured variously large size Pectinidae (*Gloripallium*, *Lyropecten*, *Chamys*, etc.), vicaryid and vicaryellid gastropods, biparitite ribbed *Anadara*, a rich *Pitar* fauna, *Astriclypeus* and *Echinolampas* echinoid fauna, rather simple but characteristic bryozoans and others, whereas on the then existing land there appeared *Stegolophodon*, *Eostegodon*, *Bunolophodon*, *Brachyodus*, *Rhinoceros* and other mammals and the flora was dominated with *Comptoniphyllum-Liquidambar* and others.

This tropical to subtropical fauna and flora existed in the Japanese Islands until the end of the middle "Miocene" during which time there occurred replacement in vertical sequence and in lateral extension. From the beginning to end of the Natori group which is early to middle "Miocene", there can be recognized a gradual change in the faunal composition, that is to say, in its elements and physical conditions indicated therefrom. This gradual change was from tropical or subtropical towards but not wholly subtemperate to temperate.

Although the components of the faunal assemblage show change according to latitude, depth of sedimentary environment and to bottom control, the same features can be recognized throughout the Japanese Islands where sediments of early to middle "Miocene" age are distributed. A remarkable difference in the components of the faunal assemblage is most distinct when geosynclinal and epicontinental facies are compared with one another. Those of the latter are rather uniform throughout whereas those of the former owing to the contrasting paleoecological conditions of the sedimentation basin inclusive of lithofacies control of the marine fauna is more simple in the construction.

Concerning the vertical replacement in faunal facies it is known that *Nephrolepidina* is replaced with *Miogypsina* and then with *Operculina* added. The first mentioned characterizes the Burdigalian and the first phase of the Mizuho Period whereas *Eulepidina*, typical of the Aquitanian is pre-Mizuho in age. The second mentioned genus from stratigraphical position may belong to Vindobonian, occupying its lower part whereas the second and third mentioned combined may be situated in the upper part of the same stage. *Astriclypeus ambigenus* Nisiyama and *Echinolampas Yoshiwarai* P. de Loriol and *Moira obessa* Nisiyama, three characteristic extinct echinoids with extensive distribution in the early Mizuho show different vertical ranges, the last mentioned being confined to the *Miogypsina* zone, the first from *Nephrolepidina* to *Miogypsina*, and the second from *Nephrolepdina* to probably the end of middle "Miocene" time. Among molluscan fossils which may have longer vertical ranges than the larger foraminifers, *Nanaochlamys notoensis* (Yokoyama) is confined to the *Nephrolepidina-Miogypsina* time, *Gloripallium* may be found from early to middle "Miocene", *Lyropecten* evidently in the same range, whereas *Miyagipecten* is situated in a position higher than *Placopecten* and both in lower Mizuho. *Vicarya* so far as the Mizuho Period is concerned occurs only from its lower part. The mammals already mentioned in earlier lines are situated in the early part of the Mizuho,

whereas *Desmostylus* and *Desmostylella* may occur in a higher position in the early Mizuho. The mentioned flora is commonly found in positions corresponding to early Mizuho in age.

The end of the middle "Miocene" age in the Japanese Islands is marked by the abrupt extinction of nearly all of the species of marine molluscs characterizing the early part of the age, and no larger foraminifers are known to occur from horizons corresponding to the later phase of the said age. This shows that the distinction of the middle "Miocene" from later deposits based upon faunal and floral components is in good accordance with the crustal movements (diastrophic and volcanic) of the post-middle "Miocene" and pre-late "Miocene", as will be mentioned in later lines.

Into the lower half of early Mizuho time are included the Togarian-, Miyoshian-, Iwami-otan-, and Fujinan stages of Tai (1959), stages 1-IV of Kitamura (1959), the Togarian and Hiramakian stages of Takai (1939) are situated in the lower part of early Mizuho, the majority of the formations included into the 1m, mm, and mu of Otuka (1939), the 1 mm, 1 m, mm and a part of um of Tomita and Sakai (1939), the horizons numbered 0–3 by Hatai (1937), and the equivalents of the above mentioned.

That terrestrial conditions had existed at the time of the first marine transgression of the Mizuho Period is well evidenced by the strata distributed in the Sen-nan district in the south of Sendai City. In this area the lignite-bearing Kaneyama formation which lies upon the older rocks with unconformity is succeeded upwards and or laterally with coarse clastics and pyroclastics from which *Eostegodon pseudolatidens* Yabe, *Stegolophodon miyokoae* Hatai, *Comptoniphyllum naumanni* Nathorst and other plants were yielded (=Tsukinoki formation) and interfingers with the Takadate andesite. The latter interdigitates with the Moniwa member of the Hatadate formation. This stratigraphic sequence clearly shows that land conditions prevailed during early Mizuho time and are contemporaneous with the marine facies (=Hatadate formation). This analogous relationship may also be noticed in the classical area in Gifu Prefecture, where the coal-bearing Nakamura formation (=Kaneyama formation) is succeeded upwards with the Hiramaki formation (=Tsukinoki formation), which is well known for its rich yield of mammals and said to interfinger in part and to be contemporaneous in other parts with the marine sediments rich in fossils of molluscs, corals, foraminifers and others. The interrelationship of the terrestrial and marine sediments in these remote areas is remarkably similar and the fossils, mammals and marine invertebrates yielded from them are the same so far as the more important ones are concerned. Another similar relationship is known from the Tsuyama Basin in Okayama Prefecture, and from its marine facies there have been recorded fossils similar to the Gifu and Sendai areas.

That the middle "Miocene" formations treated in this article can be separated from those of late "Miocene" was already stated in a previous article (Hatai, 1960). The two ages are separated from one another either by unconformity representing a period of crustal deformation associated with volcanism, development of a land stage (Paleo-Sendai Lake of Hanzawa, 1953) along the Pacific border of the Japanese Islands where previously there existed an epicontinental sea, a much more moderate fauna with remarkable decrease in number of extinct species in geosynclinal areas, and considerable modification of the paleogeographical features. The strata above this break or boundary and included into the late "Miocene" are the Kitaura formation and its equivalents in the geosynclinal areas bordering the Japan Sea, the terrestrial Shirasawa formation and its correspondents in the area previously occupied with the epicontinental seas, and worthy of mention is that marine formations of this age are almost lacking in western and southwestern Japan where the land conditions were outstanding at this time.

Compared with middle "Miocene" faunas and floras, that of the late "Miocene" can be distinguished particularly by the remarkable decrease in number of extinct species,

abrupt lowering in number of tropical or subtropical elements, increase in subtemperate to temperate components, and in the increase in modern species. Further, stratigraphically the formations of this age are bounded above and below by unconformities associated frequently with volcanism and distrophism sometimes on small scale. Marine regression was an extensive feature immediately before uplift and erosion followed with subsidence in geosynclinal areas and depression in continental areas where the paleo-Sendai Lake was deposited, and this uplift was frequently associated with volcanism. The end of the late "Miocene" was also marked with marine regression and shifting of the sedimentation basins in the geosynclinal areas, associated with volcanism in continental areas, and accompanying these movements was local volcanism in various parts of the Japanese Islands where deposits of this age are distributed. This crustal movement and associated phenomena marks and separates the lower from the upper Mizuho, or the late "Miocene" from early "Pliocene", and is a land stage of short duration and distribution more restricted than during the Takachiho-Mizuho break, evidenced from the mammalian fauna, paleogeographical features and extension of the unconformity separating them.

With the opening of the upper Mizuho Period there commenced local volcanism in many parts of the Japanese Islands associated with gradual subsidence leading to the development of extensive lignite fields in northern Japan and in some other areas. This continued subsidence resulted in the marginal portions of the Japanese Islands being flooded with shallow seas except in geosynclinal areas or exceptionally confined deeply subsiding geosynclinal basins as in northern Boso Peninsula. These seas merely fringed the Japanese Islands where distributed and brought into those areas a marine fauna having two different aspects. One is purely southern as shown by the Kakegawa fauna and the "Pliocene" fauna of Kochi Prefecture, whereas one is purely northern in aspect as exemplified by the Tatsunokuchi fauna which is distributed northwards of the Sendai Area, and as would be expected a mixed fauna is found in the central part of Japan being composed of warm water intermingled with cool water species of marine molluscs and other organisms. Because these seas merely fringed then the Japanese Islands it is evident that the present day outline of the region had already been initiated at this time and was only modified by subsequent phenomena.

That the boundary between Mizuho and Shikishima is significant had already been mentioned in the earlier pages of this article and repetition may be unnecessary at this place. However, it may be pointed out that the marine fauna occurring from the last phase of the Mizuho Period so far as known to date are all indicative of moderate thermal conditions, a very moderate marine fauns, very few extinct speceis, much restricted distribution as sediments, and lacustrine deposits of extensive distribution and correlative with the late Mizuho Period is known from southwest Japan as already stated in earlier pages.

As stated in the foregoing pages it appears that we are without adequate knowledge concerning the chronological ranges of the marine organisms included into certain range zones previously recognized by authors, we inadequately know the exact stratigraphic levels of their respective epibole, lateral or vertial change in which have been described as assemblages or assemblage-zones, we have no published standard control sections either lithologically or paleontologically, and what we think we know concerning them suggests the pre-maturity of the data upon which discussion on correlation and biostratigraphical classifications have been advanced. However, we are more or less informed of the general characters of the geology, components of the sporadically yielded fauna from different formations, general areal distribution of the mapping units in different parts of the Japanese Islands and of the approximate chronological positions they hold within the geological column of the Japanese Islands as well as their approximate position as regards the stand-

ard European chronology.

To overcome the mentioned difficulties and to advance views concerning the interrelationship of the formations of different sedimentation basins with one another, Hatai (1960) held that the cycle phase suggested by him, would prove to be of some importance. This cycle phase involves various criteria and is broad enough to cover minor details of stratigraphy and paleontology. Since the cycle phase does not involve the thickness of the stratigraphic units or their number, it reserves sufficient room for the physical interpretation of the respective sedimentation basins and the succession and nature of the components of the fauna found from them.

Classification. The problem concerning usage of the Mizuho in place of Neogene, the Shikishima for Pleistocene, and Akitsu and Takachiho for Japanese representatives of the Eocene and Oligocene respectively, may be in need of consideration. Since the position of the Aquitanian stage in the Miocene or in the Oligocene is a current problem yet unsettled, the lower boundary of the Neogene in Europe remains in doubt. Should the Aquitanian be refered to the Oligocene the Neogene would commence with the Burdigalian and vice versa. Another problem may be the last phase of the Neogene in Europe, which is now placed at the boundary between the Plaisancian-Astian and Calabrian-Villafranchian according to the recommendation of the committee on the Pliocene-Pleistocene boundary on the occasion of the Eighteenth International Geological Congress. With concern to the subdivision of the Neogene and the respective boundaries in it, there appears to be no current problems at issue.

Should the recommendation of the committee be applied to the sequence of strata develope in the Boso Peninsula, Chiba Prefecture, the results would be as stated by Hatai (1958), and if the supposition be extended to other parts of the Japanese Islands, the results may be as already given in this article. Thus, accepting the above view between the Neogene and Pleistocene, the upper limits of the Mizuho Period (=Japanese Neogene are now recognized upon good evidence. However, there still remain doubt as to its lower limit in the Japanese Islands and as to whether it can be regarded as correlative with the Neogene of the standard European chronology. Another question may be the selected usage of the Neogene or Mizuho in the classification of the younger Tertiary System in the Japanese Islands, even though the position of the Burdigalian stage is defined upon the occurrence of the genus *Nephrolepidina* and mammals as well as probably also by other marine invertebrate fossils. Many methods for subdivision of the younger Tertiary System of Japan have been proposed to date, although without general acceptance. May this suggest that each of them have their own defects by which their general acceptance among the geologists and paleontologists of Japan was not met with ?.

In the Japanese Islands as already mentioned, the Mizuho Period commences in all except two known places with marine transgression over an eroded land surface associated with local to rather widespread volcanism and a subtropical to tropical marine fauna. The corresponding terrestrial deposits yield not only a rich mammalian fauna but also a warm mild climate indicating flora in good agreement with the thermal gradient of the tranquil seas then already starting to flood the Japanese Islands. Where the contact between Mizuho and pre-Mizuho deposits is a conformity, there are indications of uplift of the latter without rising above sea-level then a rapid downsinking, and this movement corresponds to the unconformity aforementioned. Thus it is evident that the lower limit of the Mizuho Period is well established stratigraphically, geostructurally, paleontologically, climatologically and also from the view of volcanism.

Just to mention some examples of the boundary between early Mizuho and pre-Mizuho formation are the Natori goup in the Sendai Area which lies upon with unconformity the Mesozoic granite or granodiorites and pre-Tertiary Wariyama formation in the southern

part and the Triassic Rifu formation in the northern. In the Joban coal-fields in Fukushima and Ibaragi Prefectures the Mizuho formations as Goyasu and Kunugidaira are superjacent with unconformity to the Cretaceous Futaba group and Takachiho Uchigo group in the northern part, both Takachiho Uchigo group and Paleozoic metamorphics in the southern part. In the Boso Peninsula of Chiba Prefecture the Mizuho formations lie and come into contact with the Takachiho Hota group with fault or unconformity, and in the Miura Peninsula in Kanagawa Prefecture they overlie with unconformity the Takachiho Hayama group (pars). In northern Iwate Prefecture, the Yotsuyaku formation of early Mizuho age lies upon the Paleozoic formations with unconformity as in the case in the southwestern part of Aomori Prefecture, and in Akita and Yamagata Prefectures the early Mizuho formations lie upon granodiorites, quartz-porphyry or older rocks also with unconformity, and the same relation may also be observed in Niigata and Nagano Prefectures. However, in the Chichibu Basin in Saitama Prefecture the Mizuho-Takachiho contact is a conformity. In western and southwestern Honshu including Shikoku the early Mizuho formations where distributed are always superposed on the older rocks with unconformity.

The above mentioned few examples point to that there is an extensive unconformity separating the Mizuho formations from pre-Mizuho age, and that this represents an important land stage with the continent and favored the migration of different kinds of mammals from the continent as can well be understood from their occurrences in formations of early Mizuho age. In general early Mizuho fossil mammals occur not far above major unconformities, especially those which suggest land connection with the continent.

Concerning the upper limit of the Mizuho Period it was already stated by Hatai (1958) that crustal movements, faunal evidences and their indications of cold water above a moderate water one, stratigraphic relationships and alternate eustatic changes all serve to draw a reasonable boundary. It may be added that the paleogeographical features of the late Mizuho differ from that of early Shikishima as to the distributions of the formations ascribed to those ages. From the evidence it seems quite appropriate to draw the Mizuho-Shikishima boundary as already mentioned in the early pages of this article.

As explained, the upper and lower boundaries of the Mizuho Period are well established contrary to the Neogene of Europe whose lower limit is subjected to change according to the position of the Aquitaniam stage. And a Period whose lower limit remains in doubt and changes according to authors should be defined at the time of its usage to enable the readers knowledge of the original authors intentions. Such cumbersome usage of definition each time the chronological name is used favors the view that the name be subjected to reconsideration, as by recommendation to the International Geological Congress for some solution. Accordingly, it appears better to use the Mizuho Period in the Japanese Islands as a subdivision of the Tertiary System with the reservation that the Burdigalian and not the Aquitanian may be its lowest division. By such procedure the Japanese Neogene or Mizuho Period commences with the Burdigalian and ends with the Plaisancian-Astian should the European standard chronology be used for the sake of brevity. However, that classification of the stages in the Tertiary is by no means simple is well shown by Durham (1961), according to whom the Tongrian is generally accepted as the basal part of the Oligocene, whereas the upper may include Chattian, Aquitanian and even only the Tongrian. The lower part of the Miocene may be Aquitanian, Burdigalian, or there may be an Oligo-Miocene unit comprising the Rupelian up to and inclusive of the Aquitanian. The upper part of the Miocene may range up to and include the Pontian, be limited with the Tortonian, and there may be Mio-Pliocene unit comprising Sarmatian and Pontian. The Pliocene may include Plaisancian, Astian and Calabrian, or even extend downwards to incorporate the Pontian and Sarmatian, and in extreme cases the Pliocene includes only the Plaisancian but the Plio-Pleistocene may be used to include the

Astian and Calabrian, whereas the Pleistocene may be used to incorporate the Calabrian.

Because classification is difficult and previous views quite divergent, there should be found some means for recognition of a favorable classification whether local or regional before attempting remote correlation with the type sections. For this purpose it is felt that the cycle phase which is recognizable over wide areas in the Japanese Islands is favorable for the solution. And, it may be that acceptance of the revised name of Mizuho Period for the Japanese Neogene which can be limited stratigraphically and paleontologically as well structurally and paleogeographically, there still remain problems as to its subdivision because at present there is no concrete evidence for employment of the standard European stages to the formations within the Mizuho Period although suggestions for their usage are not altogether lacking.

Well known from the works of Hanzawa *et al.* (1923), Kitamura (1959) and others is the stratigraphic sequence developed in the Sendai area and the relationship with the geologic column of oil-field region of northwest Japan. It seems not to early to propose a time rock classification independent of the standard to avoid confusion and ministerpretation in correlation with the type section. For this reason it is found adequate to subdivide Yabe's Mizuho Period into Epochs and further into smaller units which are recognizable over wide areas within the Japanese Islands. To replace the Miocene and Pliocene standard terms of Europe for native ones the names of Oidean is proposed for the former and Miyagian for the latter, both type localities being in the Sendai area where the deposits of those ages are well developed and quite fossiliferous. The latter is covered upwards with Shikishima deposits allocated to the Aobayama formation (inclusive of its correlatives). The Oide, the lower half of the Mizuho is separated from the older deposits with significant unconformity, succeeded upwards with unconformity by the Miyagi, which in turn is covered with the Aobayama with stratigraphic break.

The stated procedure removes doubt as to the lower limit of the European Neogene term should it be used in Japan and does not involve the problem of Aquitanian position, although the yield of lepidoclines and miogypsines from its basal part may suggest or point to its age in European terminology. Additionally should the above procedure be accepted there would be a continuous downward sequence from Takachiho rocks into Akitsu Period, a marked significant break from the Mizuho, and that major geological phenomenon delimit larger categories, but not the smaller ones, favors such classification. Usage of the classification proposed may aid in clarifying problems in correlation previously complicated by involving terms for strata belonging or more preferable assignable to other units as proposed above.

Recommendations presented indicates it is clear that the Mizuho Period is more favorable for usage in the Japanese Islands than the European Neogene, particularly for that its base and boundaries, stratigraphically and paleontologically is well defined, the succession in both fauna and flora are understood, impressive, distinct and clearly distinguishable from those of both earlier and younger ages, and the revival of the name is justified. Aside from the just mentioned features, diastrophism, volcanism, marine transgressions and regressions, lithology and terrestrial facies and their relation with marine sediments are likewise known. It may be added that the stratigraphic levels of the important fossils are also well known according to respective sedimentation basins.

As outlined that the formations included into the Mizuho hitherto have been variously classified chronologically without general acceptance suggests some defect in those proposed methods. That some means for classification of the Mizuho in necessary is recognized by persons concerned therewith. The previously proposed classifications of the Tertiary System of the Japanese Islands was outlined elsewhere (Hatai, 1960) and repetition is here omitted. That local stage, zone, subzone or some other means of sub-

division is necessary is well known because age considerations based on remote areas and vague paleontological evidence yet adherence to European terminology may be the cause of confusion. Whether a new classification should be proposed and the previous unaccepted ones included into its synonymy where possible, or some previously proposed one be revised according to present levels in both stratigraphy and paleontology, may be subjected to debate because to avoid confusion is better than to increase it.

Difficulty arises in choice of type localities for the classifications of the subdivisions of the formations of the Tertiary System of the Japanese Islands because of several important reasons among which first, there is no sedimentation basin in the Japanese Islands in which fossiliferous strata form a continuous sequence, second, the geosynclinal facies in which late Oide marine formations are distributed (being unknown from formations of epicontinental seas) are not fossiliferous throughout and only in its certain parts can there be found abundant organisms, third, the epicontinental formations do not have late Oide marine deposits but terrestrial facies are outstanding, fourth, significant unconformities in the stratigraphic sequences as of the Boso Peninsula (Takachiho to and including Shikishima) and with interbedded pyroclastic deposits handicap that area for establishment of a standard classification, and, fifth, there seems to be no ideal locality within the Japanese Islands where the strata are continuous and fossiliferous and therefore enabling the establishment of a standard classification. However, upper Mizuho to Shikishima marine formations are well and best developed in the Boso Peninsula than elsewhere in the Japanese Islands. Oide or lower Mizuho formations are also rather well developed though not fossiliferous throughout, and the lower part of early Mizuho Period is well developed and quite fossiliferous in the Sendai Area.

Because the Natori group in the Sendai Area comprises strata both continuous in upward sequence and fossiliferous, classified into from the lower, Takadate andesite (interfingering with Tsukinoki formation of terrestrial facies on one hand and with the marine Moniwa member of the Hatadate formation on the other), Moniwa member of the Hatadate formation, the major part of the Hatadate formation and the Tsunaki formation, and further has eruptives in both lower and upper parts, commences with marine transgression, closes with marine regression, and its uplift is associated with crustal disturbances, it can be said to be both characteristic and typical of early to middle Oide time formations extensively distributed in the Japanese Islands. For the said reasons, the Natori group may be given choice as a standard for establishment of subdivisions of the early to middle Oide as used by the writer. Should the mentioned features be considered it will be found that such are common throughout the Japanese Islands in formations of similar geological age.

The fossil fauna and flora known from the Natori group have been listed by Hanzawa *et al.* (1953) according to the respective stratigraphic units. Since the stratigraphic relationship of the formations distributed in the Sendai Area, Nanakita Area and Shiogama Area are well known and their interrelationship worked out stratigraphically and paleontologically, it may be worthy to include all of the fossils known from the respective formations distributed in those areas into a single large unit of which name of Natori group may be used for the sake of convenience. From this procedure there can be interpreted the relation between faunal sequence, lithology and distribution within a rather short span of the early part of the Mizuho Period, previously called early to middle Miocene. Also since the correlatives of the Natori group can be recognized nearly throughout the Japanese Islands based upon the distributions of the fossils (marine, mammals, flora), it is thought worthy to first determine whether that group can be subdivided by organisms into units recognizable over wide areas.

Before attempting stratigraphic classification of the marine invertebrate fossils

known from the Sendai area, it should be added that the interrelation of the stratigraphic units distinguished in the area of Sendai Proper, the Nanakita Area north of Sendai and the Shiogama-Matsushima Areas are well known, although their respective lithological characteristics are different and not the same in thickness. However, from the known stratigraphical relationships, levels of the fossils yielded from the respective formations, and other relationships such as of the fossils to the sediments in which they were enclosed, it is judged that the remarks on their sequence in the Sendai Area (sensu lato) given in the following may be important in distinguishing certain units within the Natori group.

Although a total of 148 species of molluscs are known from the Natori group, only four species are distributed throughout, namely, *Venericardia ferruginea* (A. Adams) *Dosinia nomurai* Otuka, *Panope* (s. s.) *japonica* (A. Adams), and, *Panomya simotomensis* Otuka, and among them, the first and third extend upwards to Recent. Sixty-two species are restricted to the Moniwa member, 33 to the Hatadate formation, and 25 are confined to the Tsunaki formation. Only five species are in common between the Moniwa and Hatadate, six between the Hatadate and Tsunaki, whereas 13 are common between the Moniwa and Tsunaki. Among the 62 species known from the Moniwa only 14 extend up to Recent and 24 are doubtful as to specific position. Among the 33 species restricted to the Hatadate formation seven extend up to Recent and six are doubtful as to specific position. Among the 25 species restricted to the Tsunaki formation, only five species extend to Recent, and two are doubtful as to specific position. Noteworthy is that only about two species have hitherto been recorded from formations referable to the Takachiho Period. And, among the many extinct species recorded from the Natori group only three are known to extend their range up into the upper half of the Mizuho Period.

The above statistics clearly show that the Natori group is characterized with a molluscan fauna comprising many extinct species, the majority which do not date back to Takachiho Period nor extend upwards into the late Oide. The species known from the Natori group inclusive of the Otsusumi-, Aoso-, and Nanakita formations and other units which can be incorporated by correlation into that group are found in the works of Nomura (1938, 1940), Nomura and Hatai (1937), Masuda (1952–1960), Nomura and Onisi (1940). From those species it is evident that some extend throughout whereas others are restricted to certain units, some are mutual with one or more formations and for discussions all indetermined species are omitted.

From the species recorded from the Natori group and its correlatives it is clear that the molluscan faunas from the respective stratigraphical units are varied and this is due to the differences in lithofacies of their sedimentary environments with which they can be correlated. Also it is evident that each stratigraphic unit has its own particular fauna and that the fauna brought into the area by the transgression was also partly carried away by the regressing seas and thereafter became extinct in the Japanese Islands. The fauna of the Hatadate exclusive of its Moniwa member is also characteristic in possessing its own peculiar fauna the components of which are partly determined by lithofacies control of the original sedimentary basin, and compared with superjacent and subjacent units it may be recognized that the number in common although about the same is greater with the younger or Tsunaki formation.

For example *Anadara ninohensis* occurs in the Moniwa and Tasunaki, *Glycymeris matsumoriensis* in the Hatadate and Tsunaki, *Patinopecten kimurai* in the Hatadate and Tsunaki, *Placopecten akihoensis* in the Moniwa and Tsunaki, *Lyropecten kagamianus* only in the Moniwa, *Nanaochlamys notoensis* only in the Moniwa and Hatadate, *Trachycardium shiobarense* only in the Moniwa and Hatadate, *Kaneharaia kaneharai* in the Moniwa and Tsunaki, *Chlamys arakawai* is restricted to the Moniwa, *Myrtea k-hataii* is confined to the Hatadate, *Laevicardium angustum* to the Tsunaki, and others having different ranges

can be mentioned. This clearly shows that there is overlapping, offlapping and restriction in the respective ranges of the different species.

Because of page restrictions the details of the molluscan, brachiopod, echinoid or other kinds of fossils occurring from each of the stratigraphic units will not be given, but as easily noticed from the paleontological works given in the References, there can be recognized clear distinction of the respective fauna of the different units, some of which have intimate bearing or relationship with sediment control and others such as swimming forms which do not.

Thus it is an established feature that there can be recognized three distinct faunal assemblages or populations, one in each of the three stratigraphic units. Since these components characterize a certain thickness of strata even though their stratigraphical ranges are not the same, may indicate that zonules or zones are worthy of recognition. If such time stratigraphical units can be established upon that a certain thickness of strata are characterized by a certain population of organisms, then it may be pointed out that the Natori group contains three molluscan populations, each of which is typical to the unit in which it was found. However, the next problem is whether these three faunal units can be recognized elsewhere in the Japanese Islands. If they can, then such units may be well founded upon the data known of those areas in which deposits of similar age are distributed.

To find the validity of the just mentioned proposal it seems necessary to incorporate several other areas where fossiliferous marine sequences comparable with the Natori group are distributed. For this purpose the areas mentioned in the following lines were chosen, not for the sake of establishing the proposal, but because they are well known as to both stratigraphy and paleontology.

The Mizuho Period in the Joban coal-fields distributed in Fukushima and Ibaragi Prefectures have been studied as to the stratigraphy and paleontology by many workers, and from the previous views it seems well established that the Mizuho Period includes the Yunagaya-, Shirado-, and Taga groups in upward sequence. From each of these groups which are further divided into formations there occur fossils of molluscs and foraminifers, the former of which show intimate relationship with one another in their upward sequence even though replacement is recognized among them according to local differences in paleoenvironment, biological as well as physical. The three mentioned groups are separated by physical events with almost negligible time breaks as evidenced from the stratigraphic succession and interrelationships of the fossils occurring from them. Taken together, these three groups are correlative with the Natori group in the Sendai area, and the late Oide Shirasawa formation (Okutsu, 1955) is missing in the coal-fields being represented by a period of subaerial denudation.

The Mizuho Period in the Joban coal-fields is distinguished from the older Uchigo group (Hatai and Kamada, 1950) with a significant unconformity which corresponds to the one between the Natori group and the older rocks in the Sendai area and to one which is most extensive in the Japanese Islands, being known from all areas in which early Mizuho rocks are distributed. Everywhere as known, the significance of the unconformity just mentioned shows mutual characters in its indicating a land stage (land connection with the Asiatic continent, eastward migration of Asiatic mammals, wearing down of the once uplifted land areas), succeeded with marine transgression associated with volcanism and at places invasion over land areas of contemporaneous age as evident from paleobotanical data.

Similar to areas in which epicontinental sediments are distributed is the non-development of late Oide strata of marine origin, whereas those of lacustrine or terrestrial origin are sometimes found, and this is the case observed and proved paleontologically in the Joban coal-field area. It may again be repeated that marine late Oide rocks are

distributed only in areas of geosynclinal deposition as in the Sagara-, Kazusa-, and Japan Sea geosynclines described by Hanzawa (1950).

Comparing the Yunagaya-, Shirado-, and Taga groups with the Natori group in the Sendai areas, it is found that the molluscan fauna of the former three occur in the latter one, but none of the important species are known to extend up into higher or late Miocene formations of the Japan Sea geosynclinal deposits, of the Kazusa geosynclinal deposits or of the Sagara geosynclinal deposits. Thus it seems evident that the upper range of the mollucan fossils (extinct species) of the above mentioned three groups become extinct before late Oide tune, and they also range downwards as far as the base of the Yunagaya and Natori groups. But, because of the differences in the sedimentary environment, lithofacies control, the fauna of the early Mizuho Period in the two areas show considerable differences, being partly brackish in the Joban and purely marine in the Sendai areas.

The species (Yokoyama, 1924, 1925a, 1925b ; Kamada, 1952, 1955 ; Hatai and Nisiyama, 1949 ; Hirayama, 1955 ; etc. see References) mutual between the three units of the Natori group and those of the Joban area are evidence for their intimate faunal relationship. The more important extinct species being in common, points to that the two areas, although handicapped by sedimentary environment, lithological control and nature of the different sedimentation basins, are mutually related and inseparable so far as reliance in faunal correlation, paleontologically as well as geologically, can be applied. In other words, the three groups of the Joban area are nothing but equivalents of the Natori group even though the former has many stratigraphic units and unconformities within them whereas the latter is continuous throughout. Should a megagroup name (Swann and Willman, 1961) be proposed for the equivalents of the Natori group in the Joban coal-field, the name of Joban may be favorable because it covers the area in which the fossiliferous deposits are distributed. Such mentioned features are easily explained by the differences in the natures of the sedimentary basins, the former being deposited in an area less stable than that of the latter, giving rise, therefore, to different physical events within a short duration of time of early to middle Oide in the sense employed in this article.

The comparison of the Natori group with the stratigraphic units in the Gifu area is rendered more difficult, not from the view of paleontology but from the reason that strata younger than the Hatadate or equivalent with the Tsunaki are missing in that area. This feature seems to be a general tendency almost throughout southwest Japan (Chugoku District) where early Oide sediments are rather extensive in distribution and fossiliferous. This shows that the geological histories of the different areas were not the same throughout Oide time.

Should the interrelationships of the stratigraphic units of different areas and their marine fauna (inclusive of terrestrial fauna and flora) be accepted, if follows that the Natori group and its correlatives represent a fairly clear cut stratigraphic as well as paleontologic unit of extensive distribution within the Japanese Islands. This suggests that the name of Natorian with the Natori group as its type be proposed as a time rock unit, whereas its smaller stratigraphic units be named for similar reasons the Moniwan, Hatadatean and Tsunakian in upward sequence as subdivisions of the Natorian. The characteristic features of the stratigraphy, stratigraphical relationship and paleontology have already been mentioned in earlier pages and remarks concerning their geological histories briefly touched and repetition is here refrained from. Since the Natorian incorporates only stratigraphic units older than the Kitaura formation and its equivalents in the Japan Sea geosyncline and younger than the Mizuho sediments subjacent to it, and even though corresponding to the terrestrial Shirasawa formation (and equivalents), it may be worthwhile to recommend a type locality and time rock name for the particular unit which is older than Miyagian and younger than Natorian. Should such procedure and proposal of a name

favor coverage of sediments of marine and terrestrial (or lacustrine) facies of the same position in the geologic column at least in northeast Japan, or independent terms for the marine and terrestrial facies be better, recommendation (Hatai, 1961) of the name of Kitauran and Shirasawaian for the and latter respectively may not be altogether out of question.

The stated recommendation would lead to that geosynclinal areas show good development of the Natorian and Kitauran whereas epicontinental regions those of the Natorian and Shirasawaian without the development of the Kitauran, at least within northeast Japan and other areas in which geosynclinal facies are distributed, such as the Sagara geosyncline. Usage of the subdivisions aforegiven shows that in the majority of places in southwestern Japan only the Moniwan and Hatadatean of the Natorian are in good development and distribution whereas its youngest Tsunakian is generally missing, and the Shirasawaian seems to be represented by a break in the geologic column. Since the Moniwan interfingers with terrestrial sediments designated as Kaneyama (coal-bearing) formation, the Tsukinoki (pyroclastic) formation and Takadate andesite, the former two of which have been given no time rock names, and this relation is analogous with the Nakamura, Hiramaki- (=Takai's, 1939, Hiramakian), and marine formations (=Takai's, 1939, Togarian in part) related therewith in the Mizunami area refered to in earlier pages of this article, it is clear that land conditions had already existed at the time of marine transgression at the commencement of Natorian or early Mizuho time.

The Miyagi is separated from the Oide with unconformity, but where the stratigraphic sequence is continuous as in some parts of the Japan geosyncline (Hanzawa, 1950), there is evidence for a positive movement nearing the end of the Oide and a negative one with commencement of the Miyagi, both frequently accompanied with volcanism. The volcanism is frequent during the last phase of the Oide accompanying marine regression and uplift and again during the early phase of the Miyagi associated with transgression and subsidence. The mentioned break is significant in the Boso Peninsula, Chiba Prefecture between the Kurotaki of Miyagi age and the Anno of Oide age. In the Sendai area it is also noteworthy between the Sendai group of Miyagi age and the Shirasawa Formation and Natori group of Oide time. In some parts of northwest Japan where the break is insignificant there is evidence of shallowing of the seas, general uplift not to above sea-level and subsequent gradual and continued subsidence. Areas of epicontinental and geosynclinal deposition are contrasting in that the former is terrestrial in some or its larger part (Sendai area) with intercalated marine sediments in the lower and upper parts, whereas in the latter the sediments may be marine throughout although sometimes brackish in part. Being areas of different sedimentation and separated by a land barrier (paleo Sekiryo Range), the characteristic features in lithology, paleontology and stratigraphical sequence are not altogether in agreement even though mutual features can be recognized, particularly from historical geology.

Miyagi is distributed usually along the borderland of the Japanese Islands and its marine facies do not penetrate far inland as in the case of the sediments of the Oide, suggesting that the general frame of the Japanese Islands was already established at this time.

Stratigraphic units of Miyagi age have been briefly mentioned in a previous paper (Hatai, 1941), but the progress since then makes revision necessary to abide with our present knowledge. However, that the Yagiyama formation in the Sendai area, the Naganuma formation in the Miura Peninsula area, the Shibikawa formation in the Akita area and their equivalents can be assigned to upper Miyagi and the Tatsunokuchi formation, the Koshiba to Kanazawa formations, the Wakimoto formation in the respective areas aforementioned to the lower Miyagi appears to be accepted. The correlation once attempted by Yabe and Hatai (1941) for Mizuho deposits is still valid except for minor changes.

Marine facies of lower Miyagi are extensively distributed fringing the Japanese Islands and extend from Hokkaido in the north south and southwestwards to Kyushu. Throughout this distribution the marine fossil fauna shows considerable change in its elements and the more remote the localities for comparison are situated the less the number of mutual species becomes. Such is just what is to be expected considering even from present day conditions, differences in latitude, influences of the oceanic currents and others. However, there still exist features mutual between the extremes above mentioned as in faunal assemblages, intermixing in intermediate areas and gradual change therefrom towards both extremes, relationship with superjacent and subjacent stratigraphic units and their contained fauna.

The Miyagi is separated both below and above with significant unconformities from the Oide in the former case and from the emended Shikishima in the latter. The Miyagi is characteristic in its paleontological features in comprising elements different from that of the Oide and also in involving two contrasting provinces of northern and southern, the boundary falling within the region of the Izu Peninsula or thereabouts. The northern province north of the Izu Peninsula differs from the southern one south of the Izu Peninsula or thereabouts in the latter being decidedly warmer than that of the former, and the area of the Boso Peninsula southwards to the northern part of the Izu Peninsula may have been a mixing area of the two provinces faunistically and oceanographically, analgous with the oceanographical and faunal features off the present day Boso Peninsula where the currents vary in their distribution with season. For example the Miyagi deposits in the Kakegawa area in Shizuoka Prefecture differ widely from those of the geosynclinal areas of northwest Japan although a sea-way between them existed (Noda, 1961) as well as from those of the epicontinental facies of eastern Japan due not only to the pre-existing barriers but also to variations in the oceanographic conditions clearly reflected in the marine fossil fauna of those areas.

Whether the Miyagi should or can be subjected to faunal differentiation analogous with the early part of the Oide as already described is questionable at least throughout the whole Japanese Islands where deposits of that age are distributed because of the increased number of forms extending their ranges to the existing seas, remarkable differences in comparing northern and southern types, few number of significant types mutual to both areas, rather limited distribution and thickness of the sediments and other reasons. But it may be added that a twofold division of the Miyagi is rendered rather simple, whereas its further subdivision should be reserved for future investigation. In northeast Honshu, the lower part of the two-fold division just mentioned is outstanding in distribution, development and faunal yield and has been well studied (Nomura, 1938 ; Nomura and Hatai, 1935; Yokoyama, 1926 ; Hatai and Nisiyama, 1938, 1950 ; Otuka, 1934). The upper part, however, is not so well known as to its paleontology, for which reason further comments are here reserved for another opportunity.

It should be mentioned again at this place that Shikishima sediments are always superjacent to the Miyagi deposits with significant unconformity, contrasting faunal elements and different distribution of its wide variety of lithological characters. This latter feature is more or less analogous with the ones near the boundaries of the Miyagi-Oide and Mizuho-Takachiho as already described in earlier pages.

With regard to the Shikishima Period which is superjacent to the Mizuho and the Takachiho and Akitsu which are subjacent to it, the writer expects to submit another article.

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