Structural Growth of the Kanto Tectonic Basin

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Hisao Nakagawa

(With 1 text-figure)

INTRODUCTION AND ACKNOWLEDGEMENTS

The Kanto Tectonic Basin is a name proposed by Yabe and Aoki (1927) for the geomorphic and geologic features of the low plateau of the central Kanto Region. Aoki and Tayama (1930) put forth the view that the Kanto Tectonic Basin corresponds to the sedimentary basin and depositional surface of the Narita Group and that the basin-forming movement which has continued into Recent originated during the pre-Narita age. The descriptions on the stratigraphy and geologic structure of the Boso Peninsula given in this article and its surrounding areas is followed by a discussion of the structural development of the Kanto Tectonic Basin. The geologic map is a compilation from the works of K. Nomura (1948), S. Tokunaga et al. (1949), K. Koike (1950), Y. Naruse et al. (1951), K. Hatori (1951), S. Hayasaka (1952), J. Usui (1952), H. Mii (1953), K. Shoji (1953), J. Kataoka (1954), T. Mitsunashi (1954), T. Nagai (1955), H. Fujimoto (1955), H. Ozaki (1958) and the writer.

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STRATIGRAPHY OF THE BOSO PENINSULA

The oldest sediments in the Boso Peninsula, the Mineoka Group, with its type-locality at Mineokayama, in the southern part of the peninsula, comprises black slate, green tuff and an alternation of sandstone and shale distributed in a zone separated by faults with E-W trend and construct a horst. The total thickness is unknown because of its complicated structure and the base being not exposed. The siliceous shale has yielded molluscan fragments, foraminifers and radiolaria, all of which are insufficient for determination of the exact geologic age.

The Hota Group with its type-locality at Hota, Awa-gun, Chiba Prefecture, lies above the Mineoka with fault contact and is subdivided into the Futomi and Kamogawa Formations (Shoji, 1953). The Futomi Formation with its type-locality at Futomi, Emi-machi, Awa-gun, occurs in the area south of the Soro and Iwai Rivers and consists largely of yellowish gray siltstone with white fine tuff, tuffaceous sandstone and tuffaceous siltstone layers. The Kamogawa Formation with its type-locality along the middle course of the Kamo River, comprises an alternation of tuffaceous sandstone and siltstone. It occurs in the area north of the Futomi with fault contact. The geologic age of the Hota is Oligocene from the occurrence of *Portlandia watasei*, *Periploma besshoense* and others (Hatai and Koike, 1957), though the details of the stratigraphy remain unknown for its complicated structure with general E-W trend. The Hota and Mineoka Groups are intruded by basic and ultra-basic rocks arranged in the same direction as the tectonic lines. Among them, serpentine has the largest distribution and is closely related with anorthosite, pyroxenite, hornblendite, gabbro and plagioclase rocks. The basalt and dolerite occur

along the tectonic lines and intrude the Mineoka and Hota Groups and basic and ultrabasic rocks.

The Sakuma Group overlying the Hota with unconformity comprises the Nakahara and Amatsu Formations (Mii, 1953). The Nakahara Formation with its type-locality at Nakahara, Katsuyama-machi, Awa-gun, in the northern part of Awa, consists of bluish gray sandstone (Okuyama Sandstone Member), rounded pebbly and cobbly conglomerate with brown medium sandstones (Okuzure Sandy Conglomerate Member), an alternation of medium sandstone and siltstone (Nakaobara Alternation Member), and light grayish purple siltstone with sandstone and tuff layers (Kinone Siltstone Member). According to Mii, the Okuyama Sandstone occupies the basal part of the central part of the Nakahara Formation and, from the lower upwards, the Okuzure Sandy Conglomerate, Nakaobara Alternation and Kinone Siltstone are distributed from the center outwards in the same order, and their facies laterally interfinger with each other. The 10 meters thick basalt flow and volcanic conglomerate occur in the Okuzure Sandy Conglomerate. The Nakahara occurs in a zone with E-W trend and the thickness attains as much as 700 meters in the central part thinning westwards to 500 meters on the western coast of the peninsula, where the Nakahara overlies the Hota Group with parallel to low-angled unconformities. The Nakahara Formation has yielded *Amphistegina*, *Lepidocyclina*, *Miogypsina*, molluscs and other fossils (Mii, 1953). The Amatsu Formation with its type-locality at Amatsu, Amatsu-Kominato-machi, Awa-gun, overlies the Nakahara Formation with conformity and occurs in the northern, west central and southwestern areas of Awa. The total thickness is 600 meters. The lower part consists of massive siltstone intercalated with 10–20 meters thick tuffaceous layers, the lower-half of the upper part of an alternation of tuffaceous sandstone with tuffs, and the upper-half of the upper part of an alternation of scoria, pumice and tuffaceous sandstone which can be traced through the area of distribution of the Amatsu Formation. Outside the area of the Nakahara Formation, the Amatsu overlies with unconformity the Hota Group. The Amatsu has yielded molluscan and other fossils (Shoji, 1953; Mii, 1953).

The Sakuma Group is overlain locally with unconformity by the Toyooka Group (Otuka and Koike, 1949) as well as by the Inagozawa, Kiyosumi, Hagiu and Anno Formations in the northern area, and by the Toyofusa Formation in the southern area. The Inagozawa Formation with its type-locality at Inagozawa, Minekami-mura, Kimitsu-gun, occurring in the western half of the main watershed ranges of the peninsula and at the foot of Mt. Nokogiri, comprises an alternation of tuffaceous sandy siltstone and tuff amounting to 250–400 meters in thickness. The lower part consists largely of coarse sandstone and conglomerate which yielded molluscan and other fossils (Mii, 1953). Ripple marks and worm trails are often found in the tuffaceous siltstone of the formation. The alternation of the Inagozawa Formation laterally grades into yellowish brown medium to fine sandstone intercalated with siltstones and tuffs of the Kiyosumi Formation whose type-locality is Kiyosumiyama, Amatsu-Kominato-machi. The latter overlies with conformity the Amatsu Formation and attains 800 meters in thickness. The Kiyosumi occurs in the eastern half of the main watershed ranges. On the eastern coast, the lower part of the Kiyosumi contains sharpstone conglomerate derived from the Amatsu and the middle part intercalates an alternation of tuff, tuffaceous siltstone and sandstone attaining 30–100 meters in thickness. The Kiyosumi yielded *Ostrea* cfr. *gravitesta*, *Macoma* sp., *Ancistrolepis* sp., *Robulus* sp., *Makiyama chitanii* and others (Shoji, 1953).

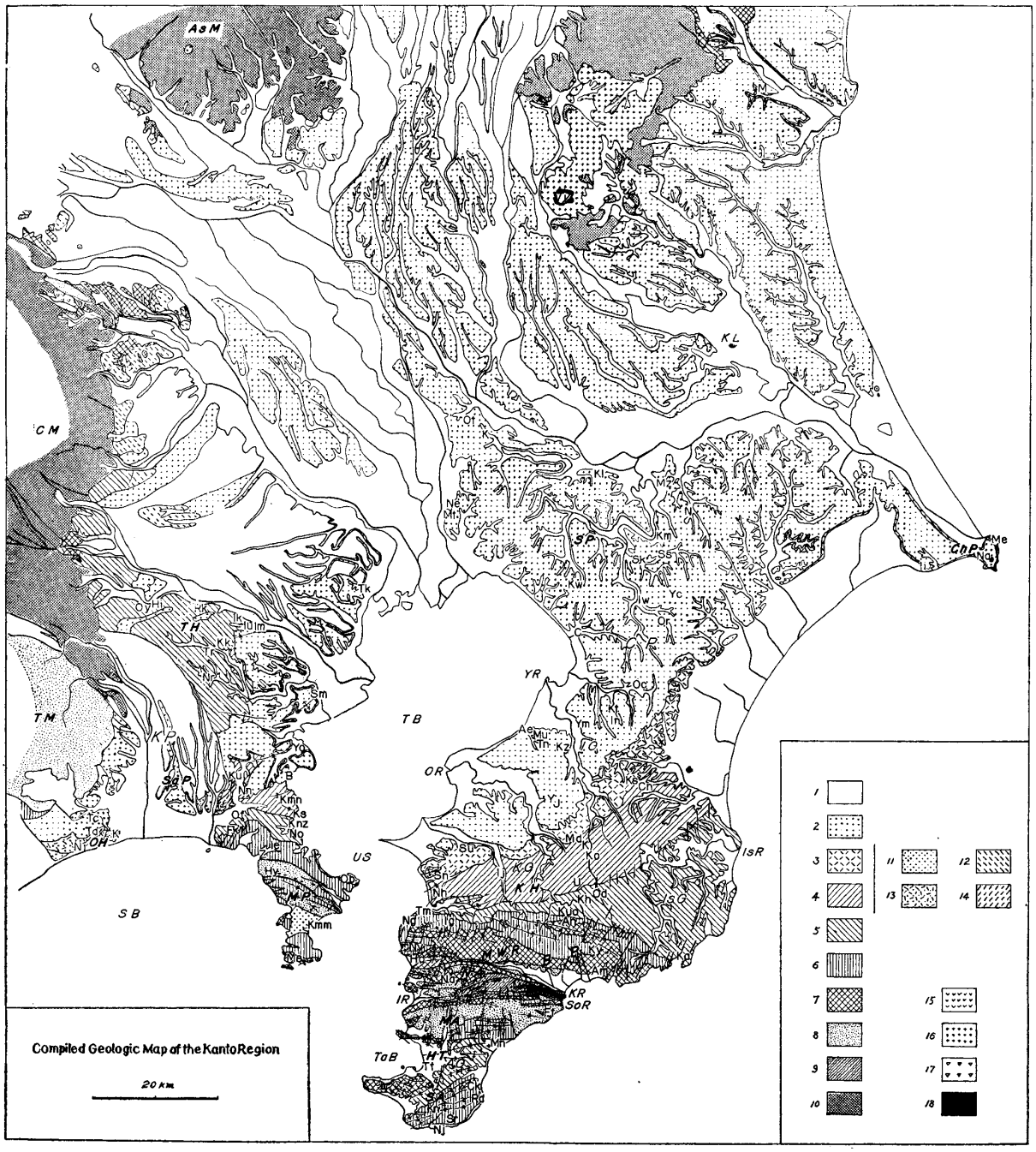
The Inagozawa Foramtion is overlain with conformity by the Hagiu Formation (Koike, 1948) of tuff breccia intercalated with tuffaceous siltstones amounting to 300 meters in thickness. The type-locality is at Hagiu, Amaha-machi, Kimitsu-gun. The Hagiu laterally grades into the alternation of tuff, tuffaceous sandstone and siltstone of the

Anno Formation (Mitsuchi, 1937) whose type-locality is in the north of Anno, Kazusa-machi, Kimitsu-gun, and distribution along the northeastern foot of the main watershed ranges of the peninsula. The 250 meters thick Anno overlies with conformity the Kiyosumi and is unconformable with the next younger Kurotaki Formation.

The 1500 meters thick Chikura Formation (Naruse et al., 1951) with its type-locality at Chikura, Chikura-machi, Awa-gun, is distributed in the southern Awa. The lower 300 meters which is distributed in Nojimazaki and Shirahama largely consists of tuffaceous sandstone with volcanic conglomerate and siltstones, the middle parts of the sandstones are intercalated with siltstones at Kanamari, Tateyama City, and of tuffaceous coarse sandstone with sharpstone conglomerate at Rendaishi, Chikura-machi. The upper part is distributed along the southern coast of Tateyama Bay and locally consists of scoria with pumice and siltstone layers which laterally grade eastwards into a siltstone-rich alternation. The Chikura yielded molluscs and foraminifers (Naruse et al., 1951) and can be correlated to the Toyooka Group of the northern areas.

The Pliocene Seki Group, unconformable with the Miocene Toyooka Group, comprises the Kurotaki, Tomiya, Katsuura, Kiwada and Otadai Formations. The Kurotaki Formation (Ueda, 1933) with its type-locality at Kurotaki, Kazusa-machi, Kimitsu-gun, is distributed in the northern slopes of the main watershed ranges and Mt. Nokogiri. The rocks are tuff breccia and tuffaceous sandstone amounting to 250 meters in thickness in the western part, conglomerate cemented by andestic tuff and tuffaceous sandstone amounting to 10–35 meters in thickness in the middle part, and tuffacous coarse sandstone with conglomerate amounting to 20–70 meters in thickness in the eastern part. The Kurotaki Formation is overlain with conformity by the Tomiya Tuff along the western coast, by the Katsuura Formation on the eastern coast, and by the Kiwada Formation in the other areas. The 300 meters thick Tomiya Tuff (Otuka and Koike, 1949) with its type-locality at Tomiya, Amaha-machi, occurs along the northwestern foot of the main watershed ranges and consists of scoria and pumice with tuffaceous siltstones thins and laterally grades eastwards into the Kurotaki Formation. The Katsuura Formation (Sawada, 1939) occurs along the coast of Katsuura-machi, Isumi-gun. The lower part consists of sandstone with conglomerate, the middle part of an alternation of tuffaceous siltstone, sandstone, fine tuff and scoria, and the upper part of sandstone with siltstones and rounded hardstone cobbles. The Katsuura yielded molluscan fossils (Nagai, 1955). The Katsuura Formation attains 250 meters in thickness at the type-locality thinning westwards and grades into a part of the Kurotaki Formation. The Kiwada Formation (Ueda, 1933) with its type-locality at Kiwadahata, Kazusa-machi, comprises compact blue siltstone intercalated with tuffs and sandstones amounting to 3000 meters in thickness along the Isumi River, thinning westwards to several hundreds meters along the Obitsu River and to several meters at the western coast of the peninsula. The Kiwada yielded molluscs and foraminifers (Hatai, 1958). The Kiwada is overlain with conformity by the Otadai Formation (Ueda, 1933) whose type-locality is at Otadai, Otaki-machi, Isumi-gun. It comprises an alternation of sandstone and siltstone amounting to 1000 meters in thickness along the Isumi River. Three sandstone lenses of 10–70 meters thick along the upstreams of the Obitsu and Yoro Rivers laterally grades into the alternation of sandstone and siltstone and dies out westwards in the siltstone of the Kiwada Formation along the Sasa River.

In the southern part of the peninsula, the Toyofusa Formation (Naruse et al., 1951) with its type-locality at Toyofusa, Tateyama City, overlies the Chikura Formation with local unconformity. The 1000 meters thick Toyofusa consists of an alternation of tuffaceous sandstone, tuffaceous siltstone and pumiceous tuff. In the southern part, the Toyofusa overlies the Chikura with conformity, in the central part, the middle and upper parts of the Toyofusa overlies the Amatsu Formation with unconformity, and in the



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1, Post-Narita sediments
2, Narita Group
3, Tsurumai Group
4, Akimoto and Sugita Groups
5, Seki and Kanazawa Groups
6, Toyooka and Kamakura Groups
7, Sakuma Group and Misaki Formation
8, Hota and Hayama Groups
9, Mineoka Group
10, Pre-Tertiary sediments
11, Miyata Formation
12, Monomiyama Formation
13, Ninomiya Formation
14, Naganuma Formation
15, Rhyolite
16, Granite
17, Quartz-diorite
18, Basic and ultra-basic rocks

Amatsu, Am
Anegasaki, Ae
Anno, An
Ashio Mts., AsM
Awa-gun, AG
Boso Peninsula, BP
Byobugaura, B
Chiba City, C
Chba Prefecture, CP
Chichibu Mts, CM
Chikura, Ck
Chonan, Cn
Choshi Peninsula, ChP
Fukazawa-yato, Fk
Futomi, Ft
Hagiu, Hg
Hayama, Hy
Hirayama, Hi
Hojo Trough, HT
Hota, Ho
Ichihara-gun, IG
Ichijuku, Ij
Iimuro, Im
Iioka, Ii
Ikego, Ie
Ikuta, Iu
Inagozawa, Ig.
Inaki, Ik
Innari, In
Isumi-gun, IsG
Isumi River, IsR
Iwai River, IR
Iwatomi, Iw
Jizodo, J
Kakinokidai, K
Kakio, Kk
Kamiiwahashi, Km
Kami-miyata, Kmm
Kami-nakazato, Kmn
Kamo River, KR
Kanagawa Prefecture, KP
Kanamari, Kn
Kanazawa, Knz
Kasamori, Ks
Kashiwa, K
Kashiwai, Kw
Lake Kasumigaura, KL
Katsuura, Ka
Kazato, Kz
Kazusa Hills, KH
Kimitsu-gun, KG
Kioroshi, Ki
Kita, Kt
Kiwadahata, Kh
Kiyosumiyama, Ky
Kokumoto, Ko
Koraizan, Kr
Koshiba, Ks
Kuratsubo, Ku
Kurotaki, Kuo
Main Watershed Ranges, MWR
Mandano, Md
Manzaki, Mz
Matsudo, Mt
Metogahana, Me
Middle Awa Hills, MAH
Minamihara, Mn
Mineokayama, My
Misaki, Ms
Mito, M
Miura Peninsula, MP
Mukaida, Mu
Naarai, Na
Nagahama, Nh
Naganuma, Nn
Nakahara, Nk
Nara, Nr
Narita, N
Nemoto, Ne
Ninomiya, Ni
Nojima, No
Nojimazaki, Nj
Nokogiriyama, Ny
North Awa Ridge and Valley, NA
Obaradai, Ob
Obitsu River, OR
Ochishimoshinden, Oc
Ofuna, Of
Oiso Hills, OH
Oshinuma, Os
Ota, Ot
Otadai, Od
Oyabe, Oy
Oyaru, Or
Rendaishi, Rd
Renkoji, Rk
Sagami Bay, SB
Sagamino Plateau, SaP
Sakura, Sk
Sanuki, Sn
Sasa River, SR
Shimosa Plateau, Sp
Shimosueyoshi, Sm
Shirahama, Sr
Shisui, Ss
Soro River, SoR
South Awa Hills, SAH
Sunami, Su
Takatoriyama, To
Takatsu, Ts
Tama Hills, TH
Tanzawa Massif, TM
Tateyama City, Tt
Tateyama Bay, TaB
Tokyo, Tk
Tokyo Bay, TB
Tomiya, Tm
Toyofusa, Tf
Toyonari, Tn
Tsuchizawa, Tc
Tsukubayama, Ty
Tsurukawa, Tr
Umegase, U
Uraga Strait, US
Yabu, Y
Yachimata, Yc
Yamakura, Ym
Yokohama, Yo
Yoro River, YR
Zushi, Z

northern part, the upper part overlies the intensely folded Chikura with clino-unconformity. The upper part of the Toyofusa consisting of sandstone-rich alternation has yielded abundant fossils and can be correlated to the lower part of the Seki Group of the northern areas.

The Seki Group is overlain by the Akimoto Group with local unconformity. The latter includes the Umegase, Kokumoto, Ichijuku, Kakinokidai and Chonan Formations. The type-locality of the Umegase Formation (Ueda, 1930) is at Umegase, Kamo-mura, Ichihara-gun. Along the Obitsu River, the lower 200 meters consists of an alternation of 1–5 meters thick sandstones and 0.2–0.5 meters thick siltstones, the lower part of the middle 100 meters of several layers of conglomerate grading into sandstone and siltstone ending upwards sharply against the base of the overlying layer, the upper middle 100 meters of

siltstone with sandstones, and the upper 200 meters of an alternation of 5–15 meters thick sandstones and 0.2–0.6 meters thick siltstones which laterally grade westwards into sandy conglomerate with siltstones. The conglomerate layers of the middle part die out eastwards before reaching the middle course of the Yoro River, and thicken westwards grading into conglomeratic sandstone. The basal part of the lower sandstone-rich alternation contains conglomerates with abundant fossils (Nomura, 1949). The lower part of the Umegase grades westwards into conglomerate with irregularly bedded siltstones and sharpstones which overlies the underlying formations with unconformity. A fossil submarine canyon is reported from the bottom of the Umegase in the western area by Sato and Koike (1957). The total thickness of the Umegase varies from 200 meters in the west, 500 meters in the middle to 600 meters in the east where it consists of a sandstone-rich alternation.

The Kokumoto Formation (Ueda, 1930) with its type-locality at Kokumoto, Kamo-mura, Ichihara-gun, superposes the Umegase with conformity and consists of massive siltstone and an alternation of sandstone and siltstone. In the middle and eastern areas, it consists of, from the bottom upwards, 60 meters thick massive siltstone with sandstones, 120 meters thick alternation of 2–6 meters thick sandstones and 0.1–3 meters thick siltstones, 100 meters thick sandy siltstone, and 100 meters thick alternation of 5–15 meters thick sandstones and 0.2–15 meters thick sandy siltstones. The lower half of the Kokumoto grades westwards into 100 meters thick sandstone, the lower sandy siltstone of the upper half dies out, and the uppermost alternation laterally grades into sandstone of the lower part of the Ichijuku Formation. The Kokumoto does not thicken eastwards. The Kokumoto Formation has yielded molluscan fossils (Nomura, 1949; Hatai, 1958).

In the middle and eastern areas, the Kokumoto is overlain with conformity by the Kakinokidai Formation (Ueda, 1930) with its type-locality at Kakinokidai, Kamo-mura, which consists of sandy siltstone with sandstones amounting to 80 meters in thickness and laterally grades westwards into the sandstone of the Ichijuku Formation. In the eastern area, the upper part of the Kakinokidai Formation intercalates two thick sandstone layers and attains 100 meters in total thickness.

The Kakinokidai is overlain with conformity by the Chonan Formation (Mitsuchi, 1933*b*) whose type-locality is at Chonan, Chonan-machi, Chosei-gun. Along the middle stream of the Yoro River, the upper and lower parts of the Chonan Formation consists of a siltstone-rich alternation and the middle part of a sandstone-rich alternation amounting to 80 meters in total thickness. The siltstone-rich alternation of the upper part grades eastwards into a sandstone-rich alternation and in the eastern area, the total thickness attains 100 meters. The alternation of the Chonan Formation along the Yoro River grades westwards into sandstone amounting to 60 meters in thickness along the Obitsu River and partly grading into the sandstone of the Ichijuku Formation.

The Ichijuku Formation (Makiyama, 1931) with its type-locality at Ichijuku, Seiwa-mura, Kimitsu-gun, is distributed in the area west of the Obitsu River and consists of laminated fine to medium sandstone and cross laminated medium to coarse sandstone attaining 250 meters in thickness. The Ichijuku interfingers with and is a lateral sedimentary facies of the upper part of the Kokumoto, Kakinokidai and lower part of the Chonan Formations, and overlies the Kokumoto with conformity.

The Akimoto Group is overlain with local unconformity by the Tsurumai Group which includes the Nagahama, Mandano, Kasamori, Sanuki and Sunami Formations. The Nagahama Formation (Fujiwara and Ogose, 1952) with its type-locality at the gravel pit of Nagahama, Osawa-machi, Kimitsu-gun, occurs in the western part of the peninsula and consists of conglomerate of rounded pebbles of igneous and Paleozoic rocks intercalated with sandstones. The thickness ranges from five to 50 meters and thickens westwards. The Nagahama Formation overlies the Kokumoto and Ichijuku with unconformity.

Eastwards the conglomerate grades into sandstone which thickens and grades again into the conglomerate of the Mandano Formation. The Nagahama yields molluscan fossils (Hatori, 1951; Hatai, 1958) and a mammalian fauna consisting of *Orca paleorca, Palaeoloxodon namadicus naumanni, Parelephas trogontherii, Sika nippon, Deperetia kazusensis* and *Giraffa nipponica* (Matsumoto, 1924; Takai, 1936).

At the type-locality, Mandano, Kamo-mura, the Mandano Formation (Mitsuchi, 1933) consists of, from the bottom upwards, pebbly conglomerate intercalated with sandstones, laminated sandstone, cross laminated pebbly to cobbly conglomerate, sandstone with pebbles, silty sandstone with lignite, and cross laminated sandstone with conglomerate and siltstone blocks, and the total thickness attains 50 meters. The uppermost sandstone yielded abundant fossils (Hatai, 1958). The 50 meters thick conglomerate and sandstone of the Mandano Formation grade eastwards into two layers of sandstone which die out in the silty sandstone of the Kasamori Formation.

The Kasamori Formation (Mitsuchi, 1933) with its type-locality at Kasamori, Nagara-machi, Chosei-gun, consists of loose sandstone and compact silty sandstone. In the area between the Obitsu and Yoro Rivers, the Kasamori consists of, from the bottom upwards, 17 meters thick alternation of sandstone and siltstone which conformably overlies the Mandano, six meters thick compact silty sandstone, 10 meters thick loose sandstone, 10 meters thick alternation of sandstone and siltstone, 15 meters thick loose sandstone, 15 meters thick alternation of sandy siltstone and cross laminated sandstone locally with lignite seams, and seven meters thick compact silty sandstone. The total thickness attains 80 meters. Along the Obitsu River, the Kasamori is 60 meters thick, where the two thick layers of loose sandstone continuing from the eastern area are intercalated in the middle part. Along the Yoro River, the two tongues of the Mandano Formation consisting of conglomerate and sandstone are intercalated with silty sandstone of the lower part of the Kasamori, which, amounting to several tens meters in thickness, is an accreted appendage from the lateral gradation of the Mandano to Kasamori attaining 200 meters in total thickness with another appendage due to its thickning in the middle and upper parts. In the eastern areas, the tongues of the Mandano die out and the Kasamori consists largely of massive sandy siltstone layers, where the total thickness attains 250 meters. The middle and upper parts of the Kasamori Formation laterally grades westwards into the Sanuki and Sunami Formations.

The Sanuki Formation (Fujiwara and Ogose, 1952) with its type-locality at Sanuki, Osawa-machi, occurs in the western area of the peninsula and overlies the Nagahama Formation with conformity and also laterally grades into the Sunami Formation in part. The Sanuki Formation consists of blue siltstone with fine sandstones amounting to 80 meters in thickness, thinning westwards to 20 meters along the western coast and grades eastwards into parts of the Mandano and Kasamori Formations.

The Sunami Formation (Fujiwara and Ogose, 1952) with its type-locality at Sunami, Osawa-machi, occurs in the south of the lower stream of the Koito River. It consists of an alternation of siltstone and sandstone amounting to 70–100 meters in thickness, grading eastwards into the silty sandstone of the upper part of the Kasamori. The Sunami is overlain with local unconformity by the Jizodo Formation.

The Narita Group includes the Jizodo, Yabu, Kamiiwahashi and Kioroshi Formations which are characterized by sedimentary cycles, and the Shimosueyoshi Volcanic Ash overlies them. The stratigraphy of the Jizodo and Yabu Formations was recently described and discussed by the present author (Nakagawa, 1960*a*).

The Yabu Formation is overlain with conformity by the Kamiiwahashi Formation (Kozima, 1959) whose type-locality is at Kamiiwahashi, Shisui-machi, Imba-gun. This is overlain with conformity by the Kioroshi Formation, and both of them are widely dis-

tributed in the northern part of the Boso Peninsula and Shimosa Plateau. The Kamiiwahashi Formation ranges from 15 to 25 meters in thickness and consists of sand and silt. Along the lower stream of the Yoro River, the middle part shows graded bedding in each layer of which coarse sand with granules forms the basal part, grading upwards into silty fine to medium sand, and sandy silt to clay form the upper part, ending upwards sharply against the base of the overlying layer. At the same time, these layers shows cross bedding, in which, the basal coarse material overlies the eroded surface of the upper fine material of the underlying layer. These features of bedding disappear away from the Yoro River. At most localities, the lower part of the Kamiiwahashi Formation consists of intensely cross laminated sand, the middle part of laminated sand, and the upper part of sandy silt and clay. Diastems are often observed at the bottom of the lower cross laminated sand. The Kamiiwahashi, particularly the lower parts, yield abundant fossils at Innari, Kita and Ochishimoshinden, Ichitsu-mura, Ichihara-gun, Kazato, Nanso-machi, Yamakura, Sanwa-machi, Ichihara-gun, Mukaida and Toyonari, Anegasaki-machi, Kimitsu-gun, Kamiiwahashi, Iwatomi, Sakura City, Oyaru, Yachimata-machi, Imba-gun, and at other localities (Yokoyama, 1922; Makiyama, 1931; Mitsuchi, 1933*a*, 1935; Suzuki and Takai, 1935; Ikebe, 1936, 1937; Oinomikado, 1937*b*; Kozima, 1959).

The Kamiiwahashi Formation is overlain with conformity by the Kioroshi Formation (Kozima, 1959) whose type-locality is at Kioroshi, Inami-machi, Imba-gun. The Kioroshi comprises sand and silt amounting to 10–15 meters in thickness. The lower part consists of intensely cross laminated sand, the middle part of laminated sand, and the upper part of sandy silt and clay. The Kioroshi yields abundant fossils at the type-locality, Manzaki, Narita City, Nemoto, Matsudo City, Ota, Kashiwa City, Kashiwai, Chiba City, and at other localities (Yokoyama, 1922; Yabe and Nomura, 1926; Makiyama, 1931; Mitsuchi, 1935; Oinimikado, 1937; Kozima, 1938*a*, *b*, 1959). Diastems are often observed at the base of the Kioroshi.

The Kioroshi Formation is overlain with conformity by the Shimosueyoshi Volcanic Ash and its marshy equivalent, the Matsudo Clay whose type-locality is at Matsudo. The Matsudo Clay occurs in the Shimosa Plateau and grades into the terrestrial Shimosueyoshi Volcanic Ash in the northern part of the Boso Peninsula, where the volcanic ash layer overlies the lower part of the Kioroshi and underlying formations with unconformity. The depositional surface of the Kioroshi Formation is well preserved and forms the plain of the Shimosa Plateau which is overlain with still younger volcanic ash layers, which are laid down as a mantle over the preexisting topography and therefore construct no distinctive topographic forms.

STRUCTURAL GEOLOGY OF THE BOSO PENINSULA

There are six distinct sections in the Boso Peninsula, each with its own characteristic geologic structure. They are, from the south northwards; (1) South Awa Hill Section consisting of the Amatsu, Chikura and Toyofusa Formations; (2) Middle Awa Hill Section comprising the Hota and Sakuma Groups; (3) North Awa Ridge and Valley Section incorporating mainly the Mineoka, Hota and Sakuma Groups; (4) Main Watershed Range Section including Hota, Sakuma, Toyooka and Seki Groups; (5) Kazusa Hill Section of the Seki, Akimoto and Tsurumai Groups; and (6) Shimosa Plateau Section largely of the Narita Group. Most of the differences in the structure of the successive sediments have geohistorical significance in the structural growth of the Boso Peninsula and the Kanto Tectonic Basin, though a part resulted from the local characteristics of the structure. The North Awa Ridge and Valley Section makes the core of the peninsula. In the eastern part of the section, the oldest sediments of the peninsula, the Mineoka Group exhibiting a complicated structure occurs as a horst separated by the faults from the other blocks on the

northern and southern sides. Many faults separating the blocks, which have folded structure, show E–W trend, and some others intersect and offset them. The ultra-basic and basic rocks which intrude the Mineoka and Hota Groups but covered by the Sakuma Group, occur along the fault-lines of E-W trend. The sedimentary basin of the Nakahara Formation, which can be restored from the lateral changes of its thickness and lithofacies, and local features of the unconformity with the underlying Hota Group, was controlled by the pre-existing structures. The Middle Awa Hill Section which is bounded by the North Awa Ridge and Valley Section with faultline is the southern wing of the core of the peninsula. The axes of the folded Hota and Sakuma Groups of this section trend generally west and east, though the Sakuma is superposed on the more intensely folded Hota with clino-unconformity. There are two types of fault. The faults with E-W trend parallel to those of the North Awa Section, and the faults with N–S trend intersect and offset them. Some of the latters continue to those of the northern and southern sections. Minor folded structures are common within each blocks, particularly in the Hota Group. The South Awa Hill Section is bounded by the Middle Awa Section with faults which extend in E-W direction with right-lateral offsetting by the N-S faults from the northern sections. The Chikura and Toyofusa Formations of the South Awa Section show an asymmetric synclinorium. The southern wing of the synclinorium consists of the Chikura and Toyofusa Formations which have a regional dip northwestwards, and with no sedimentary break in the sequence of the sediments. The upper part of the Toyofusa Formation rests upon the folded Amatsu Formation along the axis of the synclinorium as faulted blocks separated, and on the folded Chikura Formation of the northern wing. The northern wing of the synclinorium is separated from the axial zone with a fault extending across the peninsula in E-W direction, and consists of the folded Chikura Formation, which is divided into several blocks with N-S faults. Among the separated blocks of the folded Chikura Formation, the eastern ones are broader than the western, and the westernmost one is very small in width. There are some gradation in intensity of folding of the Chikura Formation viz. it is gently folded with three synclines and two anticlines in the eastern block, isoclinally folded with the same number of synclines and anticlines, though the northern anticline grades into the fault in the central block, and is so intensely folded and faulted in the western block that the structural section could not be made but the upper part of the formation is characterized by abundant pyroclastics along the synclinal axes in the eastern blocks which suggests the existence of destroyed synclines. The clino-unconformity between the Chikura and Toyofusa Formations is observed in the northwestern part of the axial zone of the synclinorium, where a part of the folded Chikura Formation is separated from the western block with E-W fault, and the upper part of the Toyofusa Formation covers the N-S fault separating the folded Chikura Formation. Yabe and Tayama (1932) named the northern part of the axial zone of the synclinorium the Hojo Trough, which extends from Tateyama Bay to the Minamihara coast, where the peninsula is constricted and the hills become lowered. The Main Watershed Range Section is a northern wing of the core of the peninsula and consists of the Hota, Sakuma, Toyooka and Seki Groups dipping regionally northwards. The section bounds the North Awa Section with fault extending across the peninsula in E-W direction. The Sakuma and Toyooka Groups are widely distributed in this section and folded with WNW-ESE axes plunging westwards and many transverse faults offset the folded structure right-laterally in the eastern part and right- and left-laterally in the western part. The Hota Group occurs in the southwestern part and along the anticlinal axes in the small blocks separated from the surrounding terrain with faults. A local unconformity between the Sakuma and Toyooka Groups is observed in the western part of the section. The Kurotaki Formation of the Seki Group overlying the older formations with unconformity occurs in the outliers along

the synclinal axes.

The Kazusa Hill Section is separated from the Main Watershed Range Section by the unconformity between the Toyooka and Seki Groups and consists of Seki, Akimoto and Tsurumai Groups. The structure is homoclinal with regional north to northwest dip of from 20 degrees of the lower part of the Seki Group in the southern part to five degrees of the upper part of the Tsurumai Group in the northern part. The sediments consist largely of sandstone and siltstone, which of the Katsuura and Kiwada Formations thicken eastwards. Coarse material of the layers intercalated in these sediments laterally grades westwards into coarser and eastwards into finer. The thickness variation, consequent shifting of the strike, and grading of the lithofacies of the sediments are mutually related with one another. The unconformities among the sediments observed in the western part of the section laterally grade into conformities. The origin of the cadena, or pervious cuesta topography of the Kazusa Hill Section formed in the alternation of sandstone and siltstone was described elsewhere (Nakagawa, 1960*a*). Many minor faults with N-S direction are observed in the Mobara Gas Field of the eastern part of the Kazusa Hill Section.

The Shimosa Plateau Section is bounded from the southern section by the up-dip escarpment made by the sandstone of the Jizodo Formation facing the dissected lowland situated in the siltstone of the Kasamori Formation. The plateau consists of the nearly horizontally bedded Narita Group and its plain and is essentially a depositional surface of the upper part of the Narita Group, which is widely distributed in the central part of the Kanto Region beyond the Shimosa Plateau. It has a structure of gentle basin or double plunging syncline whose main axis extends in NW-SE direction, parallel to those of the Kanto Tectonic Line and the Tanzawa-Mineoka Ranges. No distinct local structure is observed in the Narita Group throughout area of distribution.

STRATIGRAPHY AND STRUCTURAL GEOLOGY OUTSIDE THE BOSO PENINSULA

The oldest known sediments in the Miura Peninsula are referred to the Hayama Group (Akamine et al., 1956) whose type-locality is in Hayama-machi, Miura-gun, Kanagawa Prefecture. The group is distributed in the two areas separated by zonal distribution of the younger sediments. In the northern area, the Hayama Group consists of an alternation of sandstone, siltstone and tuff with conglomerate and attains more than 1000 meters in thickness. In the southern area, the group comprises siltstone with tuff and conglomerate amounting to more than 500 meters in thickness. The Hayama Group is folded, faulted and intruded by ultra-basic rocks, and the tectonic lines extend in WNW-ESE direction. The Hayama can be correlated to the Hota Group of the Boso Peninsula from lithologic and structural features and foraminiferal faunas (Koike, 1957; Asano et al., 1958). The Misaki Formation (Koike and Murai, 1950) with its type-locality at Misaki, Miura City, occurs in the southern part of Miura Peninsula and is not in contact with the Hayama Group. The Misaki consists of an alternation of scoriaceous siltstone, sandstone and tuff, and its upper part, particularly the western part distributed along the western coast of the peninsula, contains abundant pyroclastics. It is 700 meters in total thickness but the base is not exposed. The Misaki yielded *Chlamys miurensis*, *Dentalium yokoyamai*, *Balanus rostratus*, and corals (Usui, 1952). Usui has obtained *Trigonia* sp. from the limy shell bed of the Misaki Formation at Misaki. The specimen is fresh and complete, but is considered to have been derived from an unexposed unit. The Misaki of the southern part of the peninsula homoclinally dips northwards but with an anticlinal structure in the southeastern part, and eastward dips along the western coast. The Misaki Formation is

overlain with conformity by the Kamakura Group (Koike and Murai, 1950) which includes the Zushi and Ikego Formations. The Zushi Formation (Koike, 1951*b*) with its type-locality at Zushi, Zushi City, overlies the Hayama Group. The basal part of the Zushi Formation consists of 5–30 meters thick tuffaceous conglomerate with abundant *Chlamys miurensis* and other fossils (Usui, 1952; Akamine et al., 1956). The main part of the formation is 700 meters thick siltstone with sandstone and tuff. In the southern part of the peninsula, the Zushi consists of tuff breccia and tuffaceous sandstone. The Zushi is overlain with conformity by the Ikego Formation (Akamine et al., 1956) whose type-locality is at Ikego, Zushi City. The 200 meters thick Ikego Formation occurs in the northern part of the peninsula and consists of siltstone and pyroclastics grading and interfingering with one another. The intensely folded Kamakura Group in the southern and middle parts of the peninsula exhibits a striking contrast to that of the northern part which homoclinally dips northeast- to northwards. The Kamakura Group is overlain with conformity by the Kanazawa Group (Koike and Murai, 1950) which includes the Fukazawa, Nojima and Ofuna Formations. The 250 meters thick Fukazawa Formation with its type-locality at Fukazawayato, Kamakura City, consists of tuffaceous sandstone with conglomerate. In the eastern part, the Fukazawa has yielded *Dentalium yokoyamai*, *Glycymeris rotunda*, *Limopsis tokaiensis*, *Limopsis crenata*, *Limopsis azumana*, and *Patinopecten tokyoensis* which are common (Akamine et al., 1956). The Nojima Formation with its type locality at Nojima, Kanazawa-ku, Yokohama City consists of an alternation of tuffaceous siltstone, sandstone and tuff amounting to 200 meters in thickness. It laterally grades westwards into massive sandstone amounting to 50 meters in thickness. The Nojima yielded *Turritella nipponica*, *Dentalium yokoyamai*, *Limopsis crenata*, *Glycymeris nipponica*, *Terebratulina crossei* and others (Hayasaka, 1952; Akamine et al., 1956). The Nojima is overlain with conformity by the Ofuna Formation (Otuka, 1937) whose type-locality is at Ofuna, Kamakura City. The Ofuna consists of compact massive siltstone amounting to 150 meters in thickness and yielded *Limopsis obliqua*, *Limopsis tokaiensis*, *Lucinoma acutilineatum*, *Thyasira nipponica*, and others (Otuka, 1937; Hayasaka, 1952; Akamine et al., 1956). The Ofuna is overlain with conformity by the Sugita Group (Koike and Murai, 1950) which includes the Koshiba, Nakazato and Hama Formations. The Koshiba with its type-locality at Koshiba, Kanazawa-ku, Yokohama City, consists of tuffaceous sandstone whose lower part laterally grades eastwards into fossiliferous tuffaceous coarse sandstone. The total thickness attains 90 meters thinning out westwards. It has yielded *Limopsis crenata*, *Limopsis obliqua*, *Venericardia ferruginea*, *Japelion adelphicus*, and others (Hayasaka, 1952; Akamine et al., 1956). The Nakazato Formation with its type-locality at Kami-nakazato, Isogo-ku, Yokohama City, overlies the Koshiba and consists of siltstone with tuff and sandstone amounting to 100 meters in thickness. It has yielded *Acila* sp., *Nuculana gordonis*, *Limopsis crenata*, *Turritella ikebei*, *Yoldia naganumana*, and others (Hayasaka, 1952; Akamine et al., 1956). The Hama Formation with its type-locality on the eastern coast of Kanazawa-machi, Kanazawa-ku, Yokohama City, overlies with conformity the Nakazato Formation and consists of an alternation of sandstone and siltstone attaining 60 meters in thickness. The Kanazawa and Sugita Group occur in the northern part of the Miura Peninsula with the homoclinal structure and regional northeast to north dip ranging from 20 degrees in the southern part to almost horizontal in the northern part, where a gentle synclinal structure is observed. Many transverse faults are observed in the northwestern part of the peninsula.

Several hundreds meters thick Pliocene sediments occur in the Tama Hills (Tokunaga et al., 1949). The lowest, or 25 meters thick Oyabe Formation consisting of slitstone overlies the Mesozoic Kobotoke Formation at the southeastern foot of the Kanto Mountains, and is overlain with conformity by the 40–60 meters thick Hirayama Formation

of sandstone. The Hirayama is conformably overlain by the 50–80 meters thick Renkoji Formation of an alternation of sandstone and siltstone. It is overlain with conformity by the Inaki Formation consisting of 70–100 meters thick sandstone. The Inaki is succeeded with conformity by the 70–180 meters thick Tsurukawa Formation which consists of an alternation of sandstone and siltstone. Its upper part laterally grades northeastwards into the siltstone of the Nara Formation, the alternation of sandstone and siltstone of the Ozenji Formation, and the siltstone of the Kakio Formation. The Ikuta Formation overlies the Tsurukawa Formation and laterally grades into the Kakio and Ozenji Formation. The Ikuta consists of 200 meters thick sandstone which dies out northeastwards. The Iimuro Formation overlies the Ikuta Formation and consists of siltstone amounting to 65 meters in thickness which laterally dies out. The Iimuro Formation is overlain with conformity by the Takatsu Formation of an alternation of siltstone and sandstone which attains 60–110 meters in thickness. These sediments exhibit a syncline plunging northeastwards with axis extending from Haramachida to Mizonokuchi in SW-NE direction. In the area between the Tama Hills and Miura Peninsula, the sediments gently undulate and the Tsurukawa Formation of the Tama Hills laterally grades into the Ofuna Formation of the northern part of the Miura Peninsula.

In the northwestern peripheral area of the Miura Peninsula, the Naganuma Formation (Otuka, 1937) with its type-locality at Naganuma, Totsuka-ku, Yokohama City, overlies with unconformity the Ofuna, Koshiba and Nakazato Formations. It consists largely of bluish gray siltstone with gravels and attains 30 meters in thickness and thickens westwards. The Naganuma Formation has yielded abundant fossils (Yokoyama, 1920; Makiyama, 1931; Otuka, 1930, 1937). The Byobugaura Formation (Taya Gravel and Byobugaura Bed, Otuka, 1937) with its type-locality along the coast of Byobugaura, Isogo-ku, Yokohama City, overlies with unconformity the Naganuma and underlying formations. It comprises sand, silt and gravel amounting to 50 meters in total thickness. The sequence of the lithofacies frequently vaires laterally though in general the lower part consists of pebbly gravel and sand, the middle part of silt, and the upper part of sand. The middle part of the Byobugaura yielded abundant fossils (Makiyama, 1931; Otuka, 1937). The Byobugaura Formation is overlain with local unconformity by the Kuratsubo Formation (Kuratsubo Silt and Odoriba Sand, Otuka, 1937) whose type-locality is at Kuratsubo, Totsuka-ku, Yokohama City. The 30 meters thick Kuratsubo comprises silt, sand and pumice. The succession of these facies is variable but the 10 meters thick pumice layer always occupies the top of the formation. The lower part of the formation which consists of sand in many localities has yielded fossils (Otuka, 1937; Hayasaka, 1960).

The Shimosueyoshi Formation (Otuka, 1937) with its type-locality at Shimosueyoshi, Tsurumi-ku, Yokohama City, is distributed on the eastern side of the Tama Hills, and overlies with unconformity the Byobugaura and underlying formations. The Shimosueyoshi consists, from the bottom upwards, of gravel and sand, sandy silt, sand and pumiceous clay succeeded with conformity by the Shimosueyoshi Volcanic Ash. The total thickness ranges from five to 35 meters according to the relief of the basement. The Shimosueyoshi Formation yielded abundant fossils (Yokoyama, 1922; Makiyama, 1931; Outka 1937). The Shimosueyoshi is horizontal and its depositional surface is covered with the younger volcanic ash layers. The topographic surface of the terrace or plateau formed from them is named the Shimosueyoshi Plain. The Shimosueyoshi Formation occurs also in the suburbs of Tokyo City, where it is included in the upper part of the Tokyo Formation (Yabe 1911), and the Shimosa Plateau, where the Kioroshi Formation is its equivalent.

In the southern part of the Miura Peninsula, the Miyata Formation (Aoki, 1925) with its type-locality at Kami-miyata, Miura City, rests with unconformity on the Zushi Formation, and consists of gravel, sand and silt, yielding abundant fossils. The detailed

stratigraphy and thickness remains unknown because of the unfavorable outcrops. There are various opinions on the stratigraphic position of the Miyata Formation. From that the Miyata Formation is covered with unconformity by the volcanic ash layers which are conformable with the Shimosueyoshi Formation and the occurrence of *Palaeoloxodon namadicus*, its age and position is post-Kanazawa Group and pre-Shimosueyoshi Formation.

The Otsu Formation distributed in the environs of Obaradai, eastern part of the Miura Peninsula, consists of gravel, sands and silt and its thickness is 25 to 65 meters according to the relief of the basement, which comprises the Zushi Formation. The Otsu is overlain with conformity by volcanic ash layers and the depositional surface of the formation is well preserved. The Otsu yielded abundant fossils (Makiyama, 1931; Suzuki, 1932). At Obaradai, the lower part of the formation resting upon the irregular surface of the Zushi Formation consists of gravel and sandy silt, the middle part of sand, and the upper part of cross laminated cobbly gravel, whose succession resembles that of the Shimosueyoshi Formation.

According to Otuka (1929) and Kozima (1954) the oldest sediments of the Oiso Hills are the Koraizan Formation whose type-locality is at Koraizan, Oiso-machi, Naka-gun, Kanagawa Prefecture. It consists of siliceous siltstone, sandstone, conglomerate and tuff amounting to 800 or more meters in total thickness. The structure is complicated and the general strike is NE-SW with moderate to steep northward dip. No fossil has been recorded from the Koraizan Formation. The Takatoriyama Formation with its type-locality at Takatoriyama, Oiso-machi, lies above the Koraizan Formation with fault contact. It comprises largely conglomerate which partly grades into tuff breccia. Kozima thought that the Takatoriyama Formation grades laterally into the Oiso Formation. The Oiso Formation with its type-locality in Oiso-machi succeeds with unconformity the Koraizan Formation and consists of siltstone with sandstone and tuff, conglomerate and tuffaceous siltstone with sandstone. The Ninomiya Formation with its type-locality in the northwestern part of Ninomiya-machi, Naka-gun, occurs in the southwestern part of the Oiso Hills. It lies with unconformity upon the Oiso Formation and consists of conglomerate, sandstone and siltstone with abundant fossils (Otuka, 1929). According to Naruse and Toya (1957), Kanto Loam Research Group (1959) and Naruse (1960), who have studied the younger sediments of the Oiso Hills and Sagamino Plateau, the Ninomiya Formation occurs also in the Sagamino Plateau and is the equivalent of the Naganuma Formation of the eastern areas. The Ninomiya is overlain with local unconformity by the lacustrine Tsuchizawa and its marine equivalent the Byobugaura Formation. The 100–150 meters thick Tsuchizawa Formation with its type-locality at Tsuchizawa, Hiratsuka City, consists of gravel, sand, silt and volcanic ash in the south central part of the Sagamino Plateau (Naruse, 1960). The Tsuchizawa contains lignite layers and *Corbicula nipponensis*. It grades eastwards into the marine Byobugaura Formation.

According to Ozaki (1958) the Miocene Metogahana Formation, in the Choshi Peninsula, with its type-locality on the coast between the estuary of the Tone River and Metogahana, Chosi City, overlies the Cretaceous and Permian sediments with unconformity. It consists of 50 meters thick tuffaceous siltstone intercalated with enstatite andesite. Radiolaria and diatom have been reported from it by Yamane (1924). The Metogahana Formation is succeeded with unconformity by the Naarai Formation, whose type-locality is at Naarai Choshi City. The Naarai consists of tuffaceous sandstone with conglomerate in the lower and of siltstone in the upper amounting to 150 meters in total thickness. It has yielded *Chlamys miurensis*, *Limopsis tokaiensis*, *Glycymeris yessoensis*, *Glycymeris convexa*, *Diodora yokoyamai*, *Diodora* cfr. *quadriradiata*, *Gryphus angularis*, *Laqueus quadratus*, *Laqueus rubellus*, *Terebratalia gouldii*, and others (Ozaki, 1958). The Naarai is overlain with unconformity by the Iioka Formation whose type-locality is at Iioka,

Iioka-machi, Kaijo-gun. It consists largely of siltstone which attains 900 meters in thickness. The Iioka yielded *Limopsis obliqua*, *Limopsis tokaiensis*, *Lucinoma actilineatum*, *Uberella yokoyamai*, *Ancistrolepis trochoideus*, *Laqueus rubellus* and others (Ozaki, 1958). The upper part of the Narita Group in the Choshi Peninsula is called the Katori Formation (Mitsuchi, 1933*a*). It superposes with unconformity the gently folded Metogahana Formation and homoclinal Iioka Formation dipping west to northwestwards. The depositional surface of the Narita Group underlying the younger volcanic ash layers is well preserved and the topographic surface of the plateau is the northeastern extension of the Shimosueyoshi Plain.

The Shimosueyoshi Plain is extensive in the central part of the Kanto Region, and occupies a large portion of the Kanto Plainland. The altitude of the plain is between 20 and 50 meters. The Shimosueyoshi Plain is underlain by younger volcanic ash layers and the upper part of the Narita Group of sand, clay and volcanic ash. The Tokyo Formation, which is the upper part of the Narita Group in Tokyo includes the Kioroshi and the upper part of the Kamiiwahashi. Abundant fossils have been reported from it (Yabe, 1911; Makiyama, 1931; Oinomikado, 1936*a*). The upper part of the Narita Group yields fossils also in the environs of Mito City (Saito, 1959) and the vicinity of the Kasumigaura (Sato, 1927; Oinomikado, 1936*b*).

OUTLINE OF THE GEOLOGY AND GEOMORPHOLOGY OF THE NORTHERN AND WESTERN PARTS OF THE KANTO REGION

In the southeastern part of the Tohoku Region, north of the Kanto Region, the Abukuma Massif forms a distinct geologic and geomorphic unit. The massif consists largely of granitic rocks with local development of Paleozoic, Mesozoic and Tertiary sediments and metamorphics. On the eastern border of the massif, Pleistocene sediments accompanied with terraces are well developed. The important tectonic lines within the massif are the Futaba Faults, Hatagawa Crushed Zone, Central Sheared Zone and Tanakura Sheared Zone which extend parallel with one another with NWN-SES trend, and transverse faults as the Nakamura Fault, Futatsuya Fault and Yunokuchi Fault with WNW-ESE trend. The southern blocks separated by the Tanakura Sheared Zone extend southwards into the northeastern part of the Kanto Region. The Ashio-Joetsu Mountains are the southern extension of the Backbone Ranges of the Tohoku Region (Kitamura, 1959) and comprise largely marine early and middle Miocene, terrestrial late Miocene and early Pliocene sediments all of which superpose with unconformity the Paleozoic sediments and granitic rocks and are overlain with unconformity by the Quaternary volcanics. The stratigraphy and structure of the ranges show a zone of Tertiary orogeny. The Chichibu Mountains consists of dissected blocks largely of Paleozoic and Mesozoic rocks. The geologic structure has a striking effect upon the arrangement of ridges and valleys and the drainage system comprises the segments consequent to the summit level and subsequent to the tectonic lines extending in NW-SE direction. The main ridges of the Tanzawa Massif of quartz-diorite and metamorphic rocks rise about 1500–1700 meters above sea-level. Oligocene and Miocene sediments are distributed widely in the Tanzawa Massif. The Tanzawa Massif, Oiso Hills, the southern part of the Miura Peninsula, and the southern part of the Boso Peninsula, where Oligocene and Miocene rocks are distributed with complicated structure, align themselves and form a range, which may be called the Tanzawa-Mineoka Ranges.

DEVELOPMENT OF THE KANTO TECTONIC BASIN

Koike (1957) recognized three periods in the post-Early Mesozoic history of the

southern Kanto Region, namely, an early Mesozoic — early Oligocene phase, a late Oligocene — early Miocene phase, and a middle Miocene — Recent phase. The first is the geosynclinal phase of the outer zone of southwestern Japan preceded by the late Paleozoic — early Mesozoic orogeny, the second is the volcanism succeeded by the Tanzawa Orogeny, and the third is the Tanzawa Orogeny phase. Tectonism occurred leading to the development of the Kanto Tectonic Basin during the early phase or Koike's Tanzawa Orogeny. The thick sediments of the Misaka Formation of the Tanzawa Massif, the Koraizan Formation of the Oiso Hills, the Hayama Formation of the Miura Peninsula, and the Hota Group of the Boso Peninsula were intensely disturbed and uplifted during the early phase of the Tanzawa Orogeny. Basic and ultra-basic intrusion was accompanied with this phase. The uplift commenced in the northwestern part of the Tanzawa-Mineoka Ranges and progressed southeastwards bringing the anticlinal zone above sea-level; its axial part was above sea-level during the late Oligocene time. The Miocene transgression was preceded by the early phase of the Tanzawa Orogeny. The Nishikatsura Group of the Tanzawa Massif, probably the lower part of the Oiso Formation of the Oiso Hills, the Misaki Formation in the southern part of the Miura Peninsula, and the Nakahara Formation of the Boso Peninsula rest upon the older rocks with unconformity. In the southern part of the Boso Peninsula, the transgression started in a trough in the anticlinal zone, in which the Nakahara Formation, with *Amphistegina*, *Lepidocylina*, *Miogypsina* and *Operculina* and basalt flow in its lower part was deposited. The Amatsu Formation with wide distribution increases its thickness away from the axial part of the anticlinal zone. These sediments, particularly the upper parts include abundant pyroclastics.

The later phase of the Tanzawa Orogeny is characterized by the uplifting of its axial zone accompanied with block movements, through which the sedimentary basin was separated into the southern and northern basins. The Chikura Formation of the Boso Peninsula and the Zushi Formation in the southern part of the Miura Peninsula were deposited in the southern basin and the upper part of the Oiso Formation of the Oiso Hills, the Kamakura Group of the Miura Peninsula, the Toyooka Group of the Boso Peninsula, and the Metogahana Formation of the Choshi Peninsula were deposited in the northern basin. The relation between the sediments within these basins to the older ones is a local unconformity which can be observed on the flank of the uplifted zone. This grades into a conformity. The late Miocene sediments, particularly the Chikura Formation, were folded with the progress of the block movements of the uplifted zone. In spite of E-W trend of the main tectonic lines of each block in the uplifted zone characterized by numerous faults and folds, which has almost become completed in the latest Miocene age, the uplifted zone extends in NW-SE direction by the effects of the transverse faults. The Miocene-Pliocene break in the southern part of the Kanto Region is associated with the latest phase of the Tanzawa Orogeny. The upper Miocene sediments deposited in the marginal zone of the basins, comprising abundant pyroclastics, were jointed in the zone of uplift. These sediments have suffered folding with the axes subparallel to the main trend of the uplifted zone and the Pliocene sedimentary basins. As the result of the shifting of the main trend of the uplifting zone accompanied with the offsetting of the anticlinal axis and the differential uplifting, the Miocene sediments suffered considerable erosion and subsequently rapidly submerged in the area as the eastern part of the northern flank of the uplifted zone, and those preserved from denudation continued downsinking in the other areas. The unconformity between the Toyooka and Seki Groups extends across the Boso Peninsula, the Kamakura Group in the northern part of the Miura Peninsula with abundant pyroclastics in its upper part is overlain with conformity by the Kanazawa Group, the Chikura Formation of the southern flank of the zone of uplift is overlain with unconformity by the Toyofusa Formation which grades upwards from the former at several kilometers away.

The Pliocene sediments of the Oiso and Tama Hills cover with unconformity the Miocene and pre-Miocene formations.

A sedimentary basin thus produced in the north of the uplifted zone in which the Pliocene and Pleistocene marine sediments were deposited successively is called the Kazusa Sedimentary Basin and the pre-Pliocene uplift the Tanzawa-Mineoka Uplift, in this paper. The Kazusa Geosyncline of Hanzawa (1950) was not described in details. From the process of development of the Kazusa Sendimentary Basin and of its two distinct phases, all of which diverge from the general concept of geosyncline, the writer judges it better to adhere to the more clear-cut term. The northern margin of the Kazusa Sedimentary Basin coincides with the boundary between the southern and northern parts of the Kanto Region each with its own distinctive characteristics. The Tsukuba block of the southern part of the Abukuma Massif and the Ashio Mountains largely of Paleozoic sediments and granitic rocks abruptly rise above the Shimosueyoshi Plain which is the depositional surface of the youngest sediments within the Kazusa Sedimentary Basin. The upper parts of the Narita Group rest with unconformity on the Miocene sediments in the vicinity of Mito City, and on the Permian, Cretaceous and Miocene sediments in the Choshi Peninsula from where southwards to the Tanzawa-Mineoka Uplift along the Pacific coast no pre-Pliocene sediments occur.

Three sedimentary cycles are recognized in the stratigraphy of the Pliocene and Pleistocene formations of the Kazusa Sedimentary Basin. In the Boso Peninsula, the first comprises the Seki Group, the second the Akimoto Group and the third the Tsurumai and Narita Groups. The lower part of the Seki Group consists of the Katsuura Formation of an alternation containing abundant pyroclastics as well as the upper part of the Toyooka Group, the middle part the massive siltstone of the Kiwada Formation, and the upper part the thin alternation of the Otadai Formation. Down sinking of the Kazusa Sedimentary Basin is indicated by the rapid eastward thickening of the Katsuura and Kiwada Formations. Interformational disturbances are frequent in the lower and upper parts of the Seki Group (Koike, 1955; Hatai et al., 1956). The lower part of the second cycle consists of the sandstone-rich alternation of the Umegase Formation, locally with unconformity with the Seki Group in the western part of the peninsula. The lower part of the Umegase Formation is intercalated with conglomerate layers and graded beds alternating with sandstone and siltstone. Interformational disturbances are frequent in this part. The middle part of the second cycle consists of thick siltstones and sandstones of the Kokumoto and Kakinokidai Formations and the upper part of a sandstone-rich thin alternation of the Chonan Formation. The Umegase Formation thickens eastwards perceptibly and the others imperceptibly. The layers of coarse sediments intercalated in the Akimoto Group become conspicuous on the approach of the flank of the Tanzawa-Mineoka Uplift, and the group comprises thick conglomerate and sandstone in the western part of the peninsula. The third cycle begins with the conglomerates of the Mandano Formation which grade upwards into sandstones and siltstones with lignite seams and laterally thinning out eastwards into the sandy siltstone of the Kasamori Formation which thickens eastwards. The lower part of the Mandano Formation grades laterally westwards into the Nagahama Formation which consists of conglomerate and rests with unconformity upon the Akimoto Group. The begining of the thrid cycle is somewhat obscure in the eastern part of the peninsula in the transition from the thin alternation of the sediments of the Chonan Formation to the sandy siltstone-rich alternation of the lower part of the Kasamori Formation. The middle part of the third cycle comprises sandy siltstone and sandstone of the Kasamori, Sanuki and Sunami Formations which differ from those of the middle part of the second cycle in the poor sorting of fine grained materials. The upper part of the third cycle comprises four formations each with their own cycle of sedimentation. The lower two, or the

Jizodo and Yabu Formations change in their thickness in accordance with the main trend of the Kazusa Sedimentary Basin which was established in the early Pliocene and to which the distribution and thickness of the upper two, or the Kamiiwahashi and Kioroshi Formations bear no relations. In the Miura Peninsula, the first cycle comprises the Kanazawa Group, the second the Sugita Group and the third intermittently the Naganuma, Byobugaura, Kuratsubo and Shimosueyoshi Formations.

A successive shallowing of the Kazusa Sedimentary Basin which is indicated by paleontological studies (Sakakura, 1935; Hatai, 1958; Naruse, 1959) was accompanied with the northwestward tilting. The changes in lithofacies and thickness of the layers are controlled by the distribution of the Tanzawa-Mineoka Uplift and the layers overlapping one another converge westwards and homoclinally dip northwestwards. The NE-SW strike of the portions without change in thickness and lithofacies of the layers indicates the NW-SE trend of the axis of the Kazusa Sedimentary Basin along which the depositional center has successively migrated northwestwards with the southeastward uplifting of the area. Most of the Pliocene and Pleistocene sediments of the Tama Hills were deposited in the northwestern part of the Kazusa Sedimentary Basin, where the cycles of sedimentation are obscure and incomplete but the last cycle intermittently comprises the Byobugaura, Oshinuma and Shimosueyoshi Formations. The Oshinuma Formation (Kanto Loam Research Group, 1960) with its type-locality at Oshinuma, Kawasaki City, is overlain with conformity by a volcanic ash layer which grades downwards into the Kuratsubo Formation and is an equivalent of the latter. These sediments, except for those of the third cycle, have a regional southeast dip on which the undulations with NE-SW to E-W trends are found in the eastern part of the hills. The undulations with the same trends are found also in the western part of the Boso Peninsula and northern part of the Miura Peninsula. These undulations may have been formed as a consequence of the uplifting of the northwestern and southeastern parts of the Kazusa Sedimentary Basin, which resulted in its transformation to the double synclinal structure from the initial synclinal one. The sediments comprised in the third cycle have a double synclinal structure regardless of the undulations in the south central part of the basin and their intermittent succession in the northern part of the Miura Peninsula and Tama Hills, where parts of the sediments of the third cycle extend southwestwards through the Tanzawa-Mineoka Uplift in passes or straits, exhibits a striking contrast to the continuous succession in the Boso Peninsula. The Shimosueyoshi Plain which is an ultimate surface of the Kazusa Sedimentary Basin exhibits an elongated basin topography with its center in the vicinity of Kukimachi, Minami-Saitama-gun, Saitama Prefecture. Its major axis trends NW-SE and the minor one NE-SW both which parallel the main trends of the Tanzawa-Mineoka Uplift and Kanto Tectonic Line, and the secondary axes of the Kazusa Sedimentary Basin, respectively. The topographic basin is asymmetrical because the areas on the southwest side are broader than those on the northeast side and the major axis is rather in the northeastern part of the plain as the upper parts of the Narita Group underlying the Shimosueyoshi Plain are distributed rather in the northern part of the Kazusa Sedimentary Basin. The basements of the Kazusa Sedimentary Basin on its northern border consist of the pre-Pliocene rocks on which abut the upper parts of the Narita Group. This exhibits a striking contrast to those on the southern border consisting of Miocene sediments which are overlain by the thick sequence of sediments including the lower Pliocene. The asymmetrical feature of the Kazusa Sedimentary Baisn seems to have developed throughout its whole phases.

The Kanto Tectonic Basin evolved from the synclinal Kazusa Sedimentary Basin through its double-synclinal transformation during its later phases and this thought to be responsible for the breaks along the Tanzawa-Mineoka Uplift as the Uraga Strait and

Sagami Bay.

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