29. *Tectonic Classification of the Japanese Islands as referred to their Cainozoic History. (1).*

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Introduction.

Taturo MATUMOTO[1] has called our attention to what he considers the present stagnative attitude of Japanese tectonic geologists, in which Japanese geology has been nothing but a classified collection of results of geologic phenomena during successive geologic ages, and has proposed that Japanese geologists study tectonic geology in order to ascertain the processes of geologic phenomena. In many respects, the writer is inclined to agree with him, but MATUMOTO does not seem to have considered whether tectonic classification has been thoroughly and completely studied or not. It seemes to the writer that, in Japan, even the units of tectonic classification have not yet been established. The writer having met with numerous problems in the tectonic classification of Cainozoic geology in the course of his studies in Tertiary geologic structure, will discuss tectonic classification itself and the tectonic classification of the Japanese islands from the standpoint of Cainozoic history.

On the smallest unit used in tectonic classification.

Although the method of classifying a region according to its geologic or its tectonic characteristics has been suggested in E. HAUG's book,[2] it was in STILLE's "Die vergleichenden Tektonik, 1924",[3] that the idea of tectonic classification was fully discussed. V. BUBNOFF,[4] who divided Europe into a number of tectonic provinces, has even used in his paper the paragraph title "die geologische Systematik". The definition of the smallest unit used in tectonic classification is not so clear

1) T. MATUMOTO, *Jour. Geol. Soc. Japan*, **46** (1939).
2) E. HAUG, *Traité de Géologie I*, 1921, pp. 157—171.
3) H. STILLE, *Grundfragen der vergleichenden Tektonik*, 1924.
4) S. v. BUBNOFF, "*Grundprobleme der Geologie*", (1931), p. 146.

as that used in systematic biology. For instance, there is no objection to regarding the Japanese archipelago as a part of the Cainozoic tectogenetic zone of the whole world, when universal tectonics is considered. But, when the island of Honsyû is tectonically considered, it must be classified into a number of smaller tectonic provinces instead of as part of the Cainozoic tectogenetic zone. Although there are occasions in which the tectonic geologists must bring into use his knowledge of mineralogy and atomic physics, there is no sense in using the smallest unit of tectonic classification with every rock forming mineral or mineral forming atom. For these reasons, the writer, at first, regarded a bed, and an igneous body comparable to a bed, to be the smallest unit of tectonic classification, although, as will be explained later, he has found that a bed is too small a unit in the Tertiary tectonic classification of the Japanese islands.

The results of the operation of various geologic processes are shown on the land surface by means of outcrops and exposures. The outcrops and exposures of any rock and strata are clearly shown in geological maps, in which they are classified lithologically and stratigraphically with reference to the materials that compose them, the fossils contained in them, and their stratigraphic relations.

For tectonic classification, with these geologic facts classified in geologic maps, it is necessary to take into consideration the history of the strata and rocks since the time those came to be useful as tecto nic data. But, if, as MATUMOTO has said, the tectonic province of a certain geologic age acquires a different tectonic character in the succeeding geologic age, then in an extreme case of MATUMOTO's, the tectonic characteristics of a certain geologic age must change every instant. We are then confronted with the question, in studying tectonic classification, what is the smallest necessary tectonic unit and the smallest necessary geologic time unit for the purpose. Absolute time scale, such as the second, minute, hour, day, and year, are useless for tectonic unit time. In this case, what must be used for the unit of tectonic time ?

The writer,[5] when previously discussing the possibility of contemporaneity of the Japanese Cainozoic formation, expressed the opinion that the smallest correlatable stratigraphic unit may be, under ideal conditions, one-third the time range of any series (or epoch) of the Tertiary system (or period). Consequently, excepting in the most ideal of conditions, it may be impossible to correlate any seperated strata in terms of the smallest unit, "bed". There is no sense in classifying the

5) Y. OTUKA, *Jour. Geol. Soc. Japan*, **45** (1938), 302~315.

tectonic characteristics with a unit so small as to render correlation of strata impossible. The writer has already stated that a bed, and an igneous body comparable to a bed, may be regarded as the tectonic unit, although the time unit for a **bed** is much smaller than the time scale of a **stage.**

In view of the foregoing discussion, the writer will use as the smallest tectonic unit, the **stage,** which consists of many **beds,** and which is the subdivision of a **series.** However, it is at present impossible to classify the geologic formation of the world into several subdivisions of a geologic age of the same position. Consequently, it follows that it is impossible to classify the world into small tectonic provinces with the same smallest unit.

Fortunately, whole series and stages of the Japanese Tertiary are exposed in the archipelago, so that it is possible to correlate the strata according to the degree of that "stage" by merely using the fossils and lithologic characters alone, without any tectonic evidences, whence it follows that it is possible for the writer to classify the Japanese archipelago into certain tectonic provinces by using the tectonic units proposed in the preceding paragraph.

The Tertiary stable land mass.

The region, which, during a certain geologic epoch or period, was not overlain by deposits of a certain epoch or period, but kept on upheaving, and which remained unaffected by any tectogenetic crustal deformation, is called a **stable land mass** of that particular geologic epoch or period.

The Kitakami Tertiary stable land mass.

The Kitakami and the Abukuma mountainlands, both of which lie

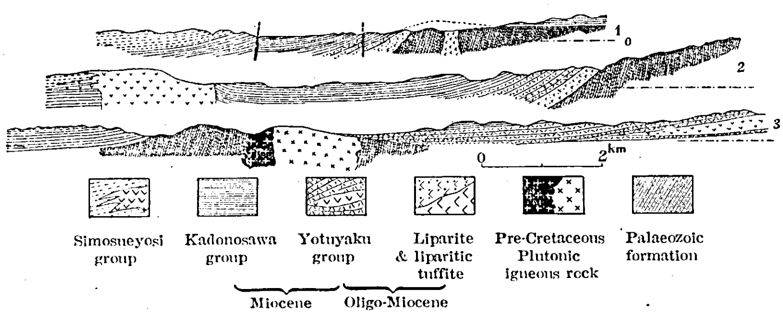

Fig. 1. Geologic sections of the Itinohe district, Iwate prefecture.

on the eastern half of northeastern Japan, consist of intensely folded and faulted strata that were deposited in pre-Cretaceous time.

The Palaeozoic formation, the Triassic, and the Jurassic systems are intensely folded, and are sometimes cut by complicated fault systems. This folded structure was intruded by plutonic and hypabyssal igneous rocks, which intensified the complexity of the structure. This plutonic structure, which is now exposed on the land surface, is clino-unconformably overlain by the younger Cretaceous and Tertiary groups that developed around these two mountains. Some of these Cretaceous and Tertiary groups have accumulated in the depressed parts of the dissected reliefs in the erosional surface of this plutonic structure. The igneous rocks in these Cretaceous and Tertiary groups are extrusive or eruptive, but not plutonic or intrusive. Since these groups were not deformed by folding, the Kitakami basal structure must have been stable since the Cretaceous period.

The writer will now describe in detail the tectonic characteristics of these Cretaceous and Tertiary systems that are exposed around the Kitakami mountainland, from its northern margin to the southern.

1) Northern end of the Kitakami mountainland.

In the Kokonohe and Ninohe districts in Iwate prefecture (A in Fig. 5) the writer's Kadonosawa group (marine Middle Miocene)[6] is exposed with the latter group of which bears many land plant leaves. These groups are either almost horizontal or dip slightly northwestward, with the exception of local drags along minor faults, the dip angle not exceeding 10°. Fig. 1 shows the geologic sections of the Ninohe district. (1, 2, 3 in Fig. 5.)

S. NAKAMURA,[7] who studied these districts, similarly described the structure of these Tertiary groups, in which the writer found about 50 species of marine and land fossils. The Yotuyaku group often merges into pyroclastic rocks, and sometimes alternates with lava flows of andesite and liparite. In the Hiranuka basin, the southern part of the Ninohe district, only the Yotuyaku group is found, which is an alternation of sand and mud bearing fossil plant leaves. This alternation is underlain by a complicated basal complex with clino-unconformity. These Early Neogene deposits and igneous rocks are not intruded by the plutonic and hypabyssal igneous rocks, but are underlain by these igneous rocks with clino-unconformity. For example, N. KONDÔ[8] and

6) Y. OTUKA, *Bull. Earthq. Res. Inst., Tokyo Imp. Univ.*, **12** (1934), 566~638.

7) S. NAKAMURA, *Expl. Text. Geol. Map, Japan, "Ichinohe" sheet*, 1 : 200,000, (1911).

the writer found a marked clino-unconformity between the Torigoe gabbro and the granite mass that intrudes the Palaeozoic formation, and the Miocene groups mentioned above, that is to say, this plutonic structure was formed by the intrusion and consolidation of these igneous rocks during pre-Miocene times, and that this plutonic structure was exposed by subaerial denudation on account of the upheaval movement of the Kitakami area before the deposition of these Miocene formation.

The Kuzi district (B in Fig. 5). Upper Cretaceous and Palaeogene deposits are exposed near the town of Kuzi in the northeastern part of the Kitakami mountainland. The Palaeogene group exposed here, which is a continental deposit, bearing many fossil plants; is underlain by a marine Upper Cretaceous group with parallel unconformity.

These two groups, which undulate gently more or less, are underlain by intensely folded Palaeozoic formation and granite with clino-unconformity. As shown in the geologic section in the explanatory text to the geologic map of this region, surveyed by S. NAKAMURA,[9] slightly undulated Palaeogene (and Upper Cretaceous)* groups overlie the basal

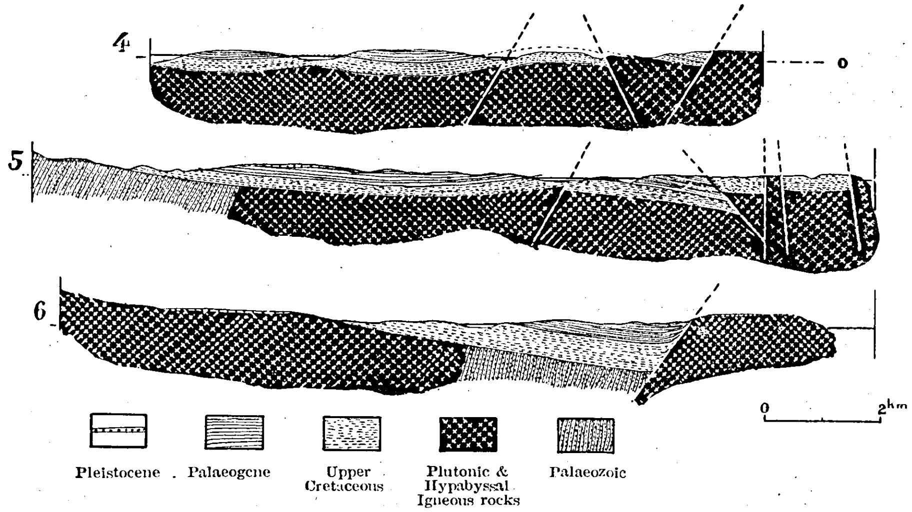

Fig. 2. Geologic sections of the Kuzi district, Iwate Prefecture.

8) N. KONDÔ, *Jour. Geol. Soc., Tokyo (now Japan)*, **37** (1930), 433~458; 467~490.

9) S. NAKAMURA, *op. cit.*, (1911).

* Existence of the Upper Cretaceous was pointed out by S. SAHEKI in 1928 [*Jour. Geol. Soc. Tokyo (now Japan)*, **35** (1928), 560~562.]

complex with clino-unconformity. Y. SASA,[10] who studied the geology of this district in detail, reached conclusions similar to NAKAMURA's regarding its geologic structure. Sections 4, 5, and 6 in Fig. 2 show the geologic section along the lines 4, 5, and 6 in Fig. 5 after Y. SASA.

As already shown in Fig. 2, since the basal complex overlain by these two groups may be regarded as the continuation of the Kitakami basal complex, the complexity of the Palaeozoic strata and the intrusion of plutonic igneous rocks in the Kitakami basal complex must have antedated the deposition of the Upper Cretaceous. The age of the Kitakami basal structure in the Ninohe districts must be quite old. But this inference on the geologic age of the Kitakami basal structure may have to be revised owing to the unconformable stratigraphic relation between the Miyako Cretaceous group[11] and the basal complex. According to the recent studies of A. NAKAMOTO[12] and H. IMAI,[13] the completion of the Kitakami basal complex must have been pre-Early Cretaceous, because some hypabyssal igneous rocks that are exposed near the Miyako region, east of the Kitakami mountainland, although older than the Miyako Cretaceous, are younger than the age of the Omoto plant bearing group,[14] which is a transitional formation between Jurassic and Cretaceous, whence it follows that the Kitakami basal structure was intruded by igneous rocks in the deep part of the earth's crust until the end of the Jurassic age, when it was gradually exposed by subaerial denudation with its upheaval. When this plutonic structure was exposed on the land surface, its marginal parts were repeatedly invaded by the Early Cretaceous and other younger seas.

2) The northern part of the Kitakami mountainland.

It will be seen from the geological map of the Kitakami mountain-

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10) Y. SASA, *Jour. Geol. Soc. Tokyo (now Japan)*, **39** (1932), 401~430; 480~501; 552~586.

11) H. YABE and S. YEHARA, *Sci. Rep. Tôhoku Imp. Univ.*, [ii] (Geol.), **1** (1913) 9~23; T. NAGAO, *Jour. Fac. Sci. Hokkaido Imp. Univ.*, [iv] **2** (1934), 177~277.

12) A. NAKAMOTO, *Grad. Thesis, Geol. Inst. Fac. Sci. Tokyo Imp. Univ.* (1930).

13) H. IMAI, *Grad. Thesis, Geol. Inst. Fac. Sci. Tokyo Imp. Univ.* (1939).

14) H. YABE, *Sci Rep. Tôhoku Imp. Univ.*, [ii] (Geol.), **1** (1913), 57~64; H. YABE, *Sci. Rep. Tôhoku Imp. Univ.*, [ii] (Geol.), **11** (1927), 46~52. In the latter paper, H. YABE wrote as follows: "It is noteworthy that the Cretaceous deposits have not yet been found to extend into the interior of the Kitakami Mountainland. Furthermore, the marine Cretaceous rocks incline gently eastwards, and in this behaviour, as well as in their less consolidated aspect, they appear quite different from the plant bed of Omoto. By all these geological conditions, one is impressed with the notion of the Omoto plant beds being involved in the basement complex of the mountainland and of the younger marine Cretaceous strata being, on the contrary, simply a superjacent formation."

land (Fig. 5) that some Tertiary formations are exposed here and there in the mountainland. Some of these Tertiary formations were studied by S. YAMANE[15] and F. SAITÔ,[16] according to whom, the Tertiary exposed east of the town of Kawaguti is almost horizontally stratified in the depressed surface of relief, which consists of intensely folded Palaeozoic formation, intruded by granitic rocks with clino-unconformity. It mainly consists of conglomerate, sandstone, marl, and tuffite, and is regarded as either a lacustrine or fluviatile deposit. Although its exact geologic age is unknown, owing to lack of fossils, its lithic characters are closely allied to those of the Hanamaki Neogene, to be described later. The Kawaguti region, therefore, was stable, at any rate, during Neogene. (C in Fig. 5.)

The Tertiary formation exposed near Iwaizumi, Simohei-gôri, which was studied by F. SAITÔ,[17] is divided into two, the upper and the lower. The lower group consists of *Ostrea* bearing marine sand and gravels; the upper consists of coal bearing beds, the uppermost being gravel or subconsolidated conglomerate. (D in Fig. 5.)

As SAITÔ has described, since the *Ostrea* bearing lower part and the coal-bearing upper part are closely allied to the Upper Cretaceous and Palaeogene groups of Kuzi, the former two may be respectively contemporaneous with the latter two groups, which are clino-unconformably underlain by the basal complex. These groups are exposed in narrowly elongated distributions, striking from N 60°W to NE, and gently dipping northward, as shown in Fig. 5, loc. D. These groups are bounded by a steep normal fault on its north and by a plane of clino-unconformity on its south, hence they are exposed in a narrowly elongated fault angle structure.

According to the geological map of Morioka, as surveyed by YAMANE, the basement structure is not greatly displaced by this narrowly elongated fault angle structure; in other words, the distribution of the Palaeozoic limestone and other plutonic and hypabyssal igneous rocks is not disturbed by this fault angle structure, from all of which the writer infers that the northern part of the Kitakami basal plutonic structure, which was exposed on the land surface before the deposition of the Upper Cretaceous (or Lower Cretaceous), was invaded by the shallow sea of the Late Cretaceous, although it soon emerged above the sea with the dawn of the Tertiary. During Early Tertiary, simple

15) S. YAMANE, *Expl. Text. Geol. Map, Japan, "Morioka" sheet*, 1 : 200,000, (1913).

16) F. SAITÔ, *Jour. Geogr. (Tokyo)*, **40** (1928), 1~6.

17) F. SAITÔ, *Jour. Geogr. (Tokyo)*, **39** (1927), 694~704.

faulting was active, and by it the Iwaizumi fault angle basin structure was formed. The marine Upper Cretaceous and the coal-bearing Palaeogene were preserved in this basin from subaerial denudation. It may be said that no tectogenetic differentiation was found in the northern Kitakami mountainland since Late Cretaceous.

3) The central and southern part of the Kitakami mountainland.

Since the Tertiary formation in the central and southern Kitakami mountainland is limited to its wetsern margin, the Tertiary history of the central part of this mountainland cannot be reconstructed, but, from the distribution of older formations and plutonic and hypabyssal igneous rocks, it is seen that the same basement complex extends to these parts as is found in the northern. But in these parts, Triassic and Jurassic rocks form one of the basal structures.

The Tertiary formation of Hanamaki, Hinuki-gôri, Iwate prefecture, which contains many fossil plants, is underlain by the Kitakami basement complex with clino-unconformity. The fossil flora of this group consists of some characteristic species of the Japanese Pliocene. According to SAITÔ,[18] the Tertiary system, which is almost horizontal, consists of agglomerate at its base, and tuffaceous sandstone beds, brown coal beds, mudstone beds, and sandy mudstone beds, in ascending order. These characteristics of the structure, therefore, do not impugn the Tertiary stability of the Kitakami mountainland. Fig. 3 is a geologic

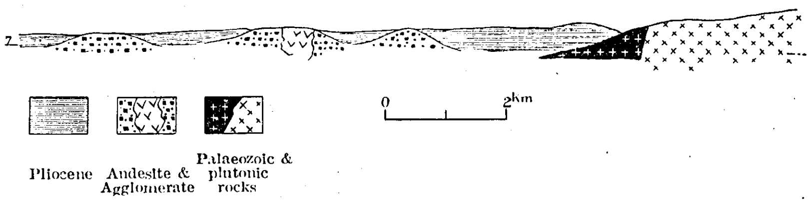

Fig. 3. Geologic section of the Hanamaki district, Iwate Prefecture.

section of the Hanamaki Pliocene according to SAITÔ's scheme of the structural contrast between the horizontal stratification of the Pliocene and the complicated basal structure. (Section line 7 in Fig. 5.)

The Neogene, developed in the Iwayadô,[19] east of the region between the towns of Kurosawaziri and Mizusawa, consists of various rocks: e. g. andesite, agglomerate, tuffite, gravel, sand, and mud beds. It is underlain by an intensely folded Palaeozoic formation, which is intruded by plutonic and hypabyssal rocks. In this Neogene, some

18) F. SAITÔ, *Jour. Geogr. (Tokyo)*, **40** (1928), 250~258; 323~328.
19) F. SAITÔ, *Jour. Geogr. (Tokyo)*, **39** (1927), 444~452; 513~516.

marine mollusca and fossil plant leaves were found. Fig. 4 is a geologic section of this Tertiary, from which a marked structural contrast is also seen between the horizontal Neogene stratification and the complicated basal complex.

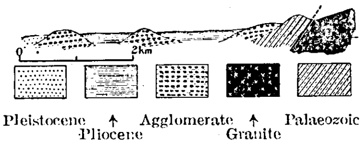

Fig. 4. Geologic section of the Iwayadô district, along line 8 in Fig. 5 (after F. Saitô.)

There is exposed a Tertiary group near the city of Itinoseki, which is closely allied to that of Hanamaki and Iwayadô, consisting of marine sediments and some brown coal seams, with a total thickness of about 50 m with almost horizontal stratification. It is underlain by Kitakami basal rocks with marked clino-unconformity. (G in Fig. 5.)

Y. KIKUCHI[20] has described the same structural characteristics of this Tertiary formation, in this district, as just remarked.

The Neogene in the southern Kitakami mountainland, which is clino-unconformably underlain by intensely folded pre-Cretaceous, is almost horizontally stratified, without any evidence of tectogenetic movement either during or post-Neogene.

According to S. NOMURA's description,[21] the Neogene formation that is exposed at Matusima and its vicinity is as follow: "A complex of tuff and tuffaceous rocks in alternation that is developed around, and in, the Bay of Matusima, including Siogama, has a thickness of several hundred meters. This complex, which is here named the Siogama formation, is about N 10°E, and dips 5°~10°E, but often 20°~30°E at places disturbed by several small faults". That is, the stratification of this Neogene is gently tilted, less than 10°, with the exception of steep local inclinations along small faults. The same author, who collected 44 species of molluscan shells from the Siogama formation, found that more than 50% of it are species common to the Kadonosawa group exposed in the Ninohe district, from which he concluded that the Siogama may be contemporaneous with the latter. He also states that this Siogama formation is overlain by the Umoregi group that is exposed in Sendai with unconformity. This Umoregi group, namely, the brown coal bearing group; may be contemporaneous with the Neogene exposed near Hanamaki and Itinoseki. Consequently, the southwestern margin of the Kitakami mountainland was not disturbed by any tectogenetic crustal deformation, not at any rate since the Miocene. (H in Fig. 5.)

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20) Y. KIKUCHI, *Expl. Text Geol. Map, Japan, "Ichinoseki" sheet,* 1 : 200,000, (1892).

21) S. NOMURA, *Saitô Mus. Res. Bull.*, 6 (1935), 193~5.

As the writer has already pointed out, the basal complex of the Kitakami mountainland, which consists of complicated structure, was exposed on the land surface by denudation as the Kitakami basal complex upheaved, until the Cretaceous age began. This complicated plutonic structure may have been completed and exposed by, at latest, the earlier half of the Cretaceous. Since then, its northeastern part was invaded by the Cretaceous shallow sea, from which, however, it emerged with the beginning of the Tertiary. Although the Miocene sea partly invaded the northwestern and southwestern margins of the Kitakami mountainland, it does not seem that this sea invaded the whole of the Kitakami, seeing that these Miocene seas contain shallow or estuarial sea mollusca, suggesting the presence of dry land not far away. During late Miocene and Early Pliocene, the sea regressed from there, but the late Pliocene shallow sea partly invaded the southwestern margin from the southeast to the north and deposited some brown coal-seams. But this sea occupied only a narrow elongated area along the southwestern margin of the Kitakami mountainland, not the whole of it. Besides, the main part of the Kitakami mountainland maintained land conditions during Tertiary without any tectogenetic crustal movement, particularly as these Upper Cretaceous, Palaeogene, Miocene, and Upper Pliocene strata show no evidences of tectogenetic crustal movement since late Cretaceous.

The foregoing geologic characteristics are closely allied to that of the Canada and Baltic shield, which consist of pre-Cambrian formations and igneous rocks, with its plutonic structure exposed on the land surface on account of its upheaved nature by subaerial denudation.

As the formation that rests on a part of these shields is not deformed by any tectogenetic movement, these shield were stable since the Cambrian era. The post-Pre-Cambrian strata are only the epidermis that cover the margin of these Pre-Cambrian plutonic structures.

The Kitakami was not stable throughout the whole of the post Pre-Cambrian era, but only during the Cretaceous and Cainozoic. It is, however, interesting that such Cainozoic stable land mass exists in the so-called Tertiary tectogenetic zone of the world.

To recapitulate, a region which, during a certain geologic epoch or period, has maintained its upheaved character, and which has not been affected by any tectogenetic crustal deformation, is called the **stable land mass** of this particular geologic period or epoch. The Kitakami mountainland, for example, may at least, be called a **Cainozoic** or **Tertiary stable land mass.**

Postscript.

In the course of this study, the writer came upon a number of tectonic problems. One of them is the determination of the tectonic boundary between the Uetu-Fossa Magna fractured zone[22] and the Kitakami Tertiary stable land mass. Heretofore, this boundary was supposed to be the one that runs along the Mabeti, the Kitakami, and the Abukuma main valleys,[23] although its exact locality is not yet known. It is a problem that will have to be attacked before very long.

The exact position of the boundary line between the Mizuho-Fossa Magna folded zone[24] and the Kitakami stable land mass is also a problem in connexion with the tectonics of Japan.

These two boundary lines are certainly not situated in the eastern margin of the Neogene that is exposed west of the Kitakami Cainozoic stable land mass. This stable land mass extends westward under the Neogene strata exposed there, since the structure of this Neogene shows the characteristics of the "Stable Shelf".[25] From these considerations the writer is convinced that these two tectonic boundary lines must be looked for in that region of Tertiary west of the Kitakami mountainland.

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22) Y. OTUKA, *Bull. Earthq. Res. Inst.*, **15** (1937), 4, 1041~1046.
23) F. VON, RICHTHOFEN, *Gebirgskettungen im japanischen Bogen*, (1903), p. 32.
24) Y. OTUKA, *op. cit.* (1937), 4, 1041~1046.
25) S. V. BUBNOFF, *op. cit.*, (1931), 153~162.

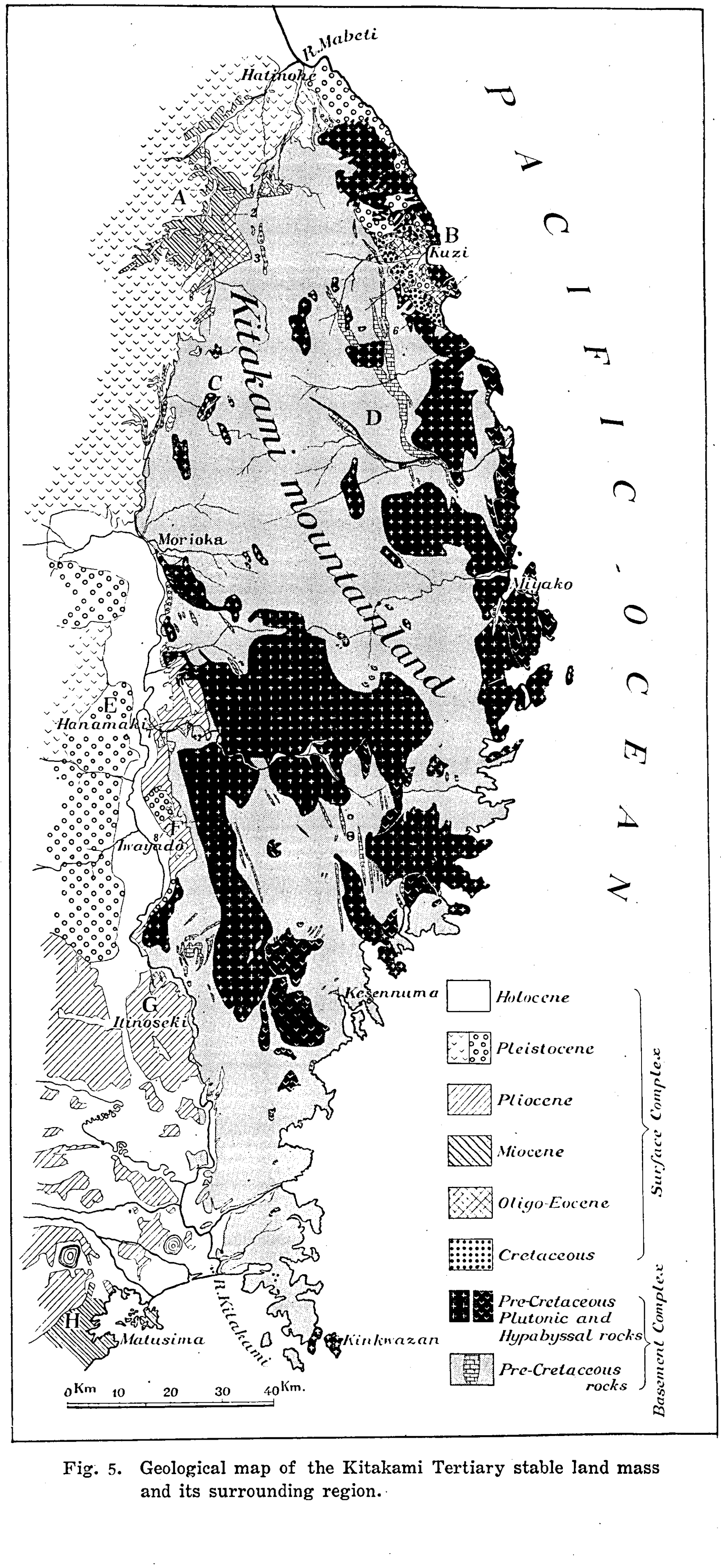
29. 新生代地史に依る日本群島の構造地質學的分類 (1)

地震研究所 大塚彌之助

著者は日本群島の構造地質學的分類が未だ完成されてゐないことに氣付き，その完成のために新生代の地史を參照して日本群島の構造地質學的分類を試みてゐる．

本論文では，著者は日本群島の構造地質學的分類が如何なる地質學的特長に依つて行はれなければならぬかに就いて述べ，分類基準の最小單位は"階"及びそれに該當する火成岩體であると論じた．次に構造地質學的分類の一例として北上山地の新生代に於ける地史學的特長を記し，北上山地が新生代を通じて安定陸塊の特長を示すことを論じ，北上山地を新生代又は第三紀安定陸塊であると結論してゐる．

附記として，上の結論を出した結果生ずる二三の構造地質學的問題が記載されてある．特に北上山地安定陸塊と羽越ーフォッサ・マグナ拆裂帶との境界線の位置，及び，北上山地安定陸塊と瑞穗ーフォッサ・マグナ皺曲帶との境界線の位置に關する著者の意向が述べられてある．



(震研彙報 第十七號 圖版 大塚)

Fig. 5. Geological map of the Kitakami Tertiary stable land mass and its surrounding region.