

24. *Early Pliocene Crustal Movement in the Outer Zone of Southwest Japan and in the Naumann's Fossa Magna.*

By Yanosuke ÔTUKA,

Earthquake Research Institute.

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The object of this communication is to describe an interesting structural feature of the lower Pliocene strata in the Outer Zone of Southwest Japan¹⁾ and in the Naumann's Fossa Magna.²⁾

The areas dealt with are plotted on the accompanying index map (Fig. 1); these are:—

1. The northeastern part of Miyazaki prefecture, along the southeastern coast of Kyûsyû.

2. The eastern part of Kôti prefecture along the Tosa bay.

3. The Kakegawa district, west of Siduoka.

4. The Asigara district, adjoining to the north of the volcano Hakone.

5. The Nagano prefecture.

The first three districts of the above list are sited in the Outer Zone of Southwest Japan and the latter two are in the Fossa Magna.

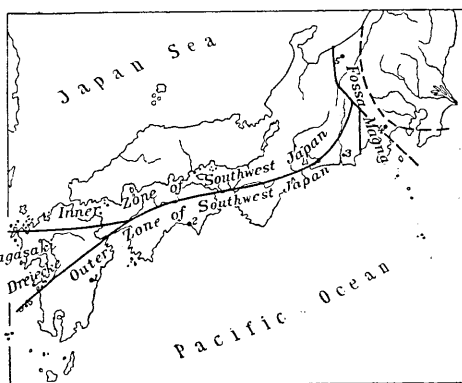


Fig. 1.

1) Dr. H. Yabe divided the southwest Japan into two parts, the inner or northern side and the outer or southern side, with his median dislocation line, which is the boundary line between the Izumi sandstone and gneiss on one side and the crystalline schists and the lower Chichibu series on the other.

2) The term "Fossa Magna" was proposed originally by E. Naumann to the transverse divisional zone between the southwest Japan and the northeast Japan. Western border of the Fossa Magna is the Itoigawa-Siduoka line of Dr. H. Yabe.

1. The northeastern part of Miyazaki prefecture, along the south-eastern coast of Kyûsyû.

The northeastern part of Miyazaki prefecture is built up of Mesozoic deposits, of which the precise geological age is still unknown, porphyrite, older and younger Tertiary and Quaternary in ascending order.

Dr. T. Iki³⁾ who first studied the geology of this district gave some accounts of the younger Tertiary in his explanatory text to the geological map of Japan, 1 : 200,000, the Sadowara sheet, 1896, published from the Imperial Geological Survey. Later Dr. H. Yabe⁴⁾ made a reference to an *Operculina*-rocks in Japan, and Dr. M. Yokoyama⁵⁾ published in 1928 the result of his thorough study of fossils collected by Mr. T. Kobayashi from the formation, thereby describing 119 species. The following accounts of the younger Tertiary formation of this district is an outcome of my field work carried on late in the spring of 1930.⁶⁾

The area occupied by Neogene strata is a dissected raised coastal plain, called the Hyûga coastal plain, drained by the rivers Omaru and Hitotuse ; it is triangular in outline, bounded by the Hyûga-nada (Hyûga sea) coast on the east and Osuzu mountainland and Higasimorogata mountainland on the other two sides.

The general sequence of the younger Tertiary deposits as observed between the Omaru and Hitotuse is as follows, in descending order :

Takanabe group	{	Heki beds Kôonzi beds Sadowara beds
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Tuma group

The Takanabe group which occupies the eastern portion of the area (Fig. 2) is divisible into Heki beds, Kôonzi beds and Sadowara beds. The upper member, Heki beds, is essentially gray sandy mud, intercalating two pumiceous zones and sometimes enclosing calcareous nodules : there are many fossiliferous zones in this complex. The Kôonzi beds consist of mud and silt in thin-bedded alternation and have fossiliferous zones. The Sadowara beds consist of barren sand and mud in the northern part of the area, which gradually pass into brown fine grained

3) T. IKI, *Expl. Text Geol. Map Japan*, "Sadowara" Sheet, 1 : 200,000, (1904).

4) H. YABE, "Notes on *Operculina*-Rocks from Japan, with Remarks on *Nummulites cumingi* Carpenter", *Sci. Rep. Tôhoku Imp. Univ.*, II ser., 5, 1 (1918).

5) M. YOKOYAMA, "Pliocene Shells from Hyûga", *Jour. Fac. Sci. Imp. Univ.*, Tôkyô, Sect. II, 2 (1928), 331-350.

6) Y. ÔTUKA, "Some Geologic Problems in the Southwestern Coast of Kyûsyû", *Georg. Rev.*, Japan, 6, 7 (1930), (in Japanese).

conglomerates in the southern part of the area ; an archætypal *Stegodon* reported by Dr. Yokoyama⁷⁾ is from the latter.

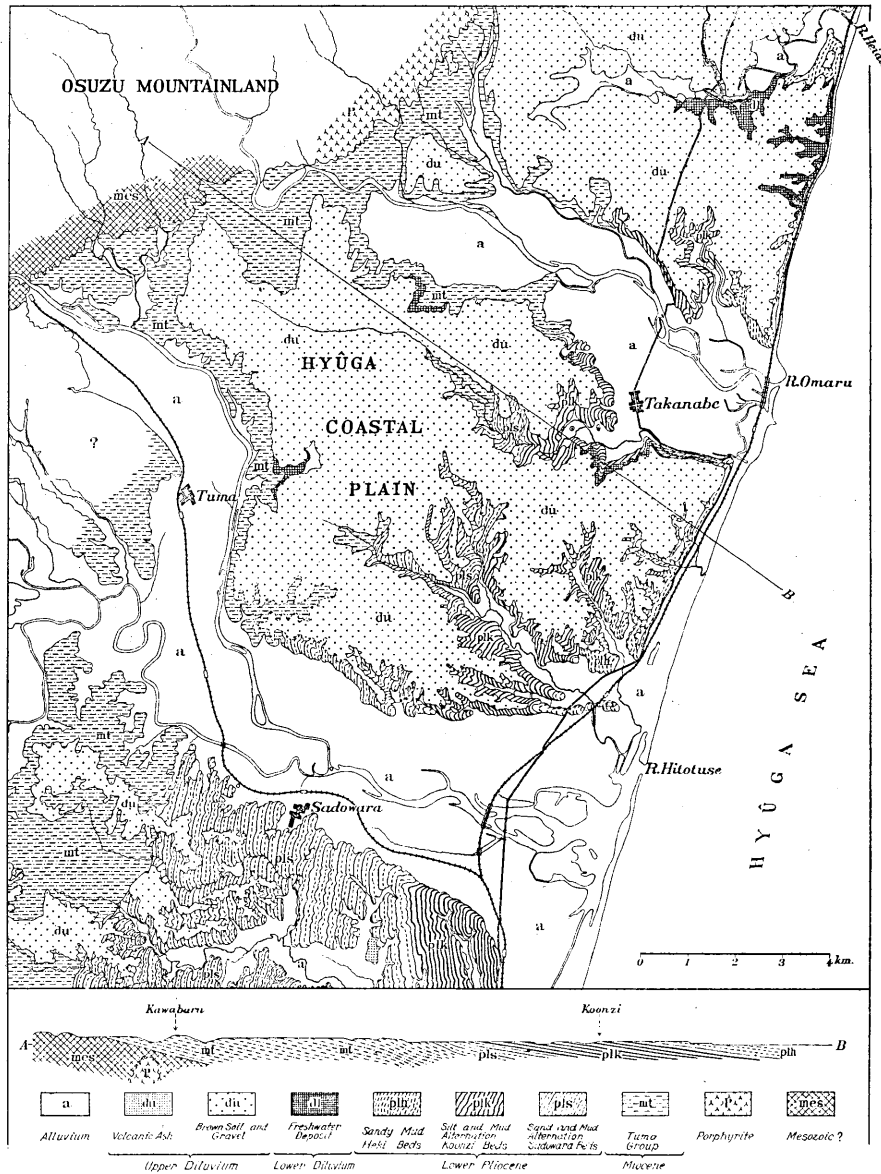


Fig. 2. Geological Map of Hyûga Coast by Yanosuke Ôtuka.

7) M. YOKOYAMA, "Stegodon from Uryûno, Miyazaki Prefecture", *Jour. Geol. Soc.*, Tôkyô, 20 (1913), 236, (in Japanese).

Of numerous species of the fossil shells found in the Takanabe group, *Anadara satowi castellata* (Yokoyama), *Glycymeris nakamurai* Makiyama, *Pecten (Amussiopecten) praesignis* Yokoyama, *Venericardia panda* (Yokoyama), *Umbonium suchiense* Yokoyama, *Umbonium suchiense subsuchiense* Makiyama, *Umbonium mysticum* Yokoyama, *Clavatula dainichiensis* Yokoyama, *Latrunculus eratus* (Yokoyama) etc., are specially worthy of note, because of their being also common and characteristic species of the lower part of the Kakegawa series of Dr. J. Makiyama,⁹⁾ to be mentioned later on.

The older, Tuma Group, which occupies the western part, consists of unstratified thick dark gray muds in its upper part and stratified sands in the lower. It covers the older basement complex in clinounconformity with its base on the west almost coinciding with the topographic boundary between Osuzu mountainland and the Hyûga coastal plain.

The structural arrangements of these younger Tertiary complexes are regular, having the strike varying from N 20° E to N-S and hence generally parallel to the shoreline of the plain and the dip about 10° NE or E: the general strike and dip, however, are sometimes affected by local foldings or other disturbances. Freshwater deposits, presumably of the lower Pleistocene age, rest horizontally upon these groups in a few isolated patches. Fig. 2 is a map showing the geologic structure of this district and a profile on the line AB, which is normal to the general trend of the younger Tertiary.

2. The eastern part of Kôti prefecture along the Tosa bay.

The first geological survey of this district was prosecuted by Dr. T. Ogawa⁹⁾ and the late Y. Ôtsuki,¹⁰⁾ the author of the explanatory text to the geological map of Japan, 1:200,000, the Kôchi (Kôti) and Muroto sheet respectively, which contain many instructive geological accounts worthy of special attention.

In the explanatory texts to the geological map of Japan, 1:75,000, the Muroto¹¹⁾ and Kôchi¹²⁾ (Kôti) sheet, Mr. T. Suzuki ascribed middle Pliocene age¹³⁾ to the upper Tertiary deposits of this field which rest

8) J. MAKIYAMA, "Molluscan Fauna of the Lower Part of the KAKEGAWA Series in the Province of Tôdômi, Japan", *Mem. Coll. Sci. Kyôto Imp. Univ.*, Ser. B. 3, 1 (1927).

9) T. OGAWA, *Expl. Text Geol. Map Japan*, "Kôchi" sheet, 1:200,000, (1905).

10) Y. ÔTSUKI, *Expl. Text Geol. Map Japan*, "Muroto" sheet, 1:200,000, (1902).

11) T. SUZUKI, *Expl. Text Geol. Map Japan*, "Muroto" sheet, 1:75,000, (1930).

12) T. SUZUKI, *Expl. Text Geol. Map Japan*, "Kôchi" sheet, 1:75,000, (1931).

13) M. YOKOYAMA, "Pliocene Shells from Tônohama, Tosa", *Imp. Geol. Surv.*, Japan, Rep. 104 (1929).

unconformably upon the formation of Mesozoic ? rocks and consist of marine conglomerate and sand. Prior to this, Dr. J. Makiyama¹⁴⁾ found *Umbonium mysticum* Yokoyama, a characteristic fossil of his lower part of the lower Kakegawa series, and suggested the contemporaneity of one part of the fossiliferous deposits and the lower part of the lower Kakegawa series. According to Mr. T. Suzuki, the middle Pliocene beds occupy small isolated patches along the coast of Aki-gun, Kôti prefecture, with a slight seaward dip; the strike turns from NE in the southern part to N 60° W or even to E-W in the northwestern. The younger Tertiary deposits are covered by horizontal gravel beds presumably of the Pleistocene age. Fig. 3 is a geological map, after T. Suzuki, showing the distribution of the Pliocene and Pleistocene deposits in this area.

3. The Kakegawa district, west of Siduoka.

It was in the explanatory text to the geological map of Japan, 1: 200,000, Shidzuoka (Siduoka) sheet (1886), that the late Dr. K. Nakajima¹⁵⁾ divided the Tertiary deposits of the area covered by the sheet into the upper and the lower Ôigawa. For a long time since, stratigraphical details and faunal nature of the Tertiaries had been studied by nobody. First several years ago, Mr. Y. Chitani¹⁶⁾ and Dr. J. Makiyama¹⁷⁾ independently begun their researches on the Tertiaries in the Kakegawa district, west of Siduoka, and the recent rapid progress of our

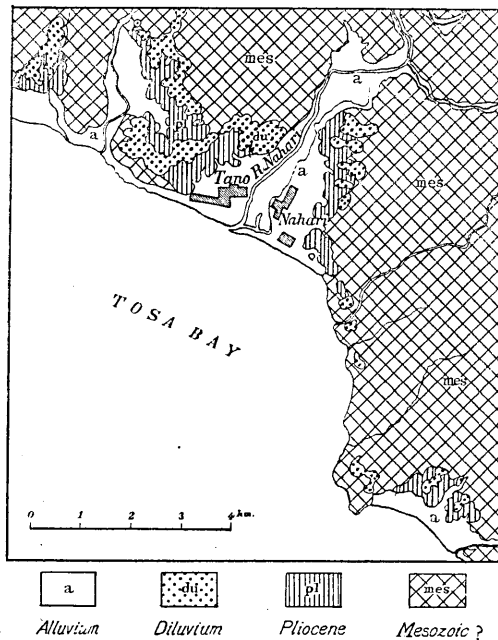


Fig. 3 Geological Map of the Eastern Part of Kôti Prefecture along the Tosa Bay. (After T. Suzuki).

14) J. MAKIYAMA, *op. cit.*, (1927), 21.

15) K. NAKAJIMA, *Expl Text Geol. Map Japan*, "Shidzuoka" sheet, 1:200,000, (1886)

16) Y. CHITANI, "The Tertiary in the Vicinity of Kakegawa and Sagara, Tôdômi", *Journ. Geogr.*, 38 (1926), 84-89, (in Japanese).

17) J. MAKIYAMA, "On the Geology near Kakegawa, Shidzuoka Prefecture", *Chikyû*, 9, 1-2 (1928), (in Japanese).

knowledge on the subjects is essentially due to the works of the two authors.

According to Dr. J. Makiyama,¹⁸⁾ the Mesozoic and Cainozoic formations developed in the eastern part of Tôtômi are divisible into eight groups of Mikura (Cretaceous or Palaeogene), Ôigawa (lower Miocene or older), Sagara (upper Miocene), Horinouchi (Horinouti) (transition), Kakegawa (lower Pliocene), Soga (upper Pliocene), Ogasa conglomerate (upper Pliocene), and Pleistocene gravel deposits.

The Kakegawa series is a formation about 640 m. thick in its type locality treated by Dr. Makiyama, where it represents a complete cycle of sedimentation. Its stratigraphical relation to the underlying Soga is marked unconformity. The averaged dips of these strata are 10°–15° and the strike is usually about N 50° W. There are small dip- and strike-faults, and also very slight folding of strata.

The area covered by the geological map of Japan in 1 : 75,000, Sagara sheet (1927) by Mr. Y. Chitani¹⁹⁾ includes the southern part of Makiyama's field, and in the southern part of this sheet, the younger Tertiary strata have the dips 10°–30° SW and the strikes ranging from N 10° W to N–S. EF in Fig. 5 is a geologic profile, after Y. Chitani, at right angles to the main strikes of the younger Tertiary.

4. The Asigara district adjoining to the north of volcano Hakone.

A thick complex of sandstone and conglomerate occupies the area immediate north of volcano Hakone and between the Yamakita and Suruga station on the Tôkaidô railway line. Dr. T. Hirabayashi²⁰⁾ who studied this formation in 1896 in connection of his geological research of the volcano Hakone, called it the Ashigara Tertiary (Asigara Tertiary) and some more detailed accounts of it was subsequently given by the late Tetsunosuke Katô²¹⁾ in his paper "Report of the geology of the vicinity of Yamakita" (in Japanese) published in the Bulletin of Imperial Geological Survey of Japan, No. 18, 1910. In 1926, Dr. M. Yokoyama²²⁾ examined the fossil shells from this formation and expressed that the

18) J. MAKIYAMA, *op. cit.*, (1927), 5.

19) Y. CHITANI, *Expl. Text Geol. Map Japan*, "Sagara" sheet, 1:75,000, (1927).

20) T. HIRABAYASHI, "Geologic Report of Hakone and Atami", *Shûnsai Yobô Chôsakai Hôkoku Report of the Imperial Earthquake Investigation Committee in Japanese Language*, 16 (1896).

21) TE. KATO, "The Geologic Report near Yamakita, Sagami Province", *Bull. Imp. Geol., Surv.*, Japan, 18 (1910).

22) M. YOKOYAMA, "Neogene Shells from Kôzuke and Other Provinces," *Jour. Fac. Sci. Imp. Univ., Tôkyô*, Sect. II, 1, 7 (1926).

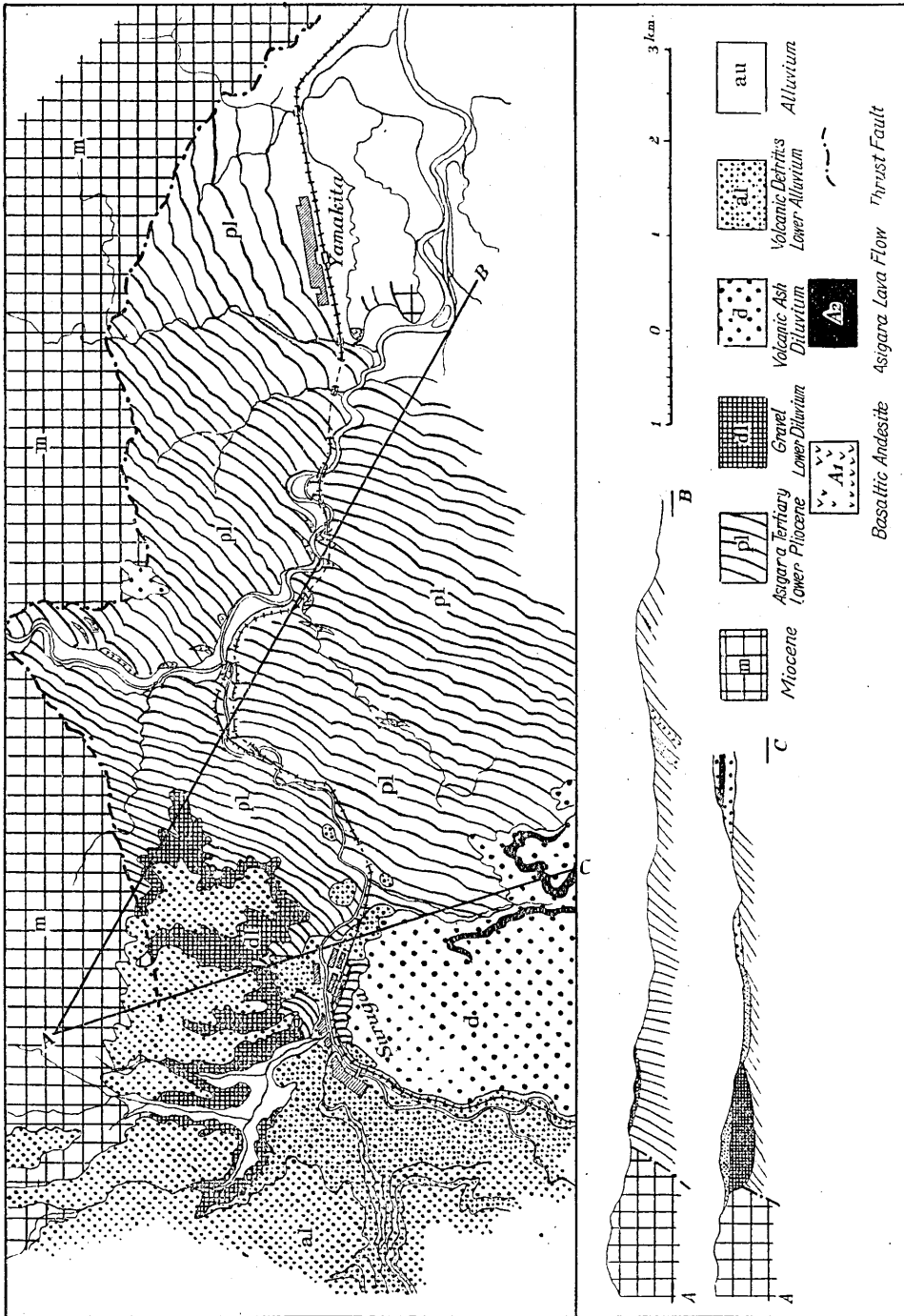


Fig. 4. Geological Map and Profiles of the Asigara District by Yanosuke Ôtuka.

fauna, which is by no means rich in species, is certainly Pliocene in age. The "Asigara Tertiary" or better Asigara beds turn the strike from E-W in the northeastern part of the field to N 10° E-10° W in the southeastern part, the dip being almost always northwestern. Previous authors ascribed this deformation of strata to a tectonic disturbances of the late Pliocene. On the north this formation lies beneath the Miocene

Table I.

List of Fossils from the Asigara beds	{ a. Yōzawa b. Yagurazawa c. Yaga		
	a	b	c
1. <i>Acila mirabilis</i> Adams et Reeve	a	b	c
2. <i>Yoldia lischkei</i> ? Smith			c
3. <i>Yoldia</i> sp.	a		
4. <i>Glycymeris yessoensis</i> (Sowerby)		b	
5. <i>Ostrea gigas</i> Thunberg	a		
6. <i>Pecten</i> sp.		b	
7. <i>Thracia</i> sp.		b	
8. <i>Millia (Lucinoma) annulata</i> (Reeve)	a	b	
9. <i>Diplodonta japonica</i> ? Pilsbry			c
10. <i>Cardium braunsi</i> Tokunaga		b	
11. <i>Cardium (Fulvia)</i> sp.			
12. <i>Paphia</i> ? sp.		b	
13. <i>Macrocallista pacifica</i> (Dillwyn)	a		c
14. <i>Chamaeformis meretrix</i> Linné		b	
15. <i>Dosinia japonica troscheli</i> Lischke	a	b	c
16. <i>Macoma nasuta</i> (Conrad)	a		
17. <i>Tellina</i> aff. <i>gratiosa</i> (Römer)	a		
18. <i>Tellina nitidula</i> Dunker	a		
19. <i>Solen krusensternii</i> Schrenck	a		
20. <i>Mactra sulcataria</i> Reeve	a		
21. <i>Mya</i> aff. <i>japonica</i> A. Adams	a		
22. <i>Panope japonica</i> A. Adams	a		
23. <i>Turritella</i> sp.		b	
24. <i>Neritaeformis didyma</i> (Bolten)	a		
25. <i>Terebra bifrons</i> Smith	a		
26. <i>Umbonium suchiense</i> Yokoyama	a		
27. <i>Cancellaria spengleriana</i> Dunker	a		
28. <i>Lingula hians</i> Swainson	a		
29. <i>Carpinus yedoensis</i> ? Maximoviczi	a		
30. <i>Salix</i> sp.	a		
31. <i>Phyllites</i> sp.	a		

Misaka series overthrust from the north upon it. Simultaneous with and also after these movements basaltic andesites intruded into it as dykes or intrusive sheets. The area of the Asigara beds is bordered by Pleistocene volcanic deposits elsewhere than north.

Fig. 4 is a geological map of the field now in question showing the structural relations of the Asigara beds to the other formations.

In the last winter I had an opportunity to collect fossils in the Asigara beds and obtained the species listed above (Table I) some of which are additional to Dr. M. Yokoyama's²³⁾ list.

One of these species, *Umbonium suchiense* Yokoyama, is a characteristic fossil of the lower part of the Lower Kakegawa series and is a lower Pliocene form in the evolutionary series of its phylum after Dr. J. Makiyama's scheme.²⁴⁾

Now in the Ôiso block northeast of the volcano Hakone, the Takatori-yama conglomerates,²⁵⁾ which are the eastern extension of the Asigara beds, are covered by the middle Pliocene Nisikoiso²⁶⁾ beds and the upper Pliocene Ninomiya beds in clinounconformity. Consequently the process which disturbed the Asigara beds must be accepted as having been active in the latest stage of the lower Pliocene, and this is in strong contrast with what we find in the Neogene strata of the Outer Zone of Southwest Japan.

5. The Nagano prefecture.

Tertiary deposits in the northern part of the Fossa Magna in the Nagano prefecture have recently been studied by Mr. F. Homma²⁷⁾ in some details; his Sigarami and Ogawa beds too are regarded by Dr. M. Yokoyama²⁸⁾ to be lower Pliocene in age on the molluscan fauna they contain, and Dr. S. Tokunaga²⁹⁾ described once a *Cervus* remain of an upper Miocene type derived from either of them, whereas Dr. J. Makiyama³⁰⁾ holds an eclectic

23) M. YOKOYAMA, *op. cit.*, (1926), 230.

24) J. MAKIYAMA, "The Evolution of *Umbonium*", *Jap. Jour. Geol. Geog.*, 3-4 (1924).

25) Y. ÔTUKA, "A Stratigraphical Study of the Ôiso Blocks and Its Adjacent Area," *Jour. Geol. Soc.*, Tôkyô, 36, 434 (1929).

26) Y. ÔTUKA, "On the Ôiso Bed," *Jour. Geol. Soc.*, Tôkyô, 33, 451 (1931), (in Japanese).

27) F. HOMMA, "Shinano Chûbu Chishitsushi (Geology of the Middle Part of Shinano Province)," (1931), (in Japanese).

28) M. YOKOYAMA, "Tertiary Mollusca from Shinano and Echigo." *Jour. Fac. Soc. Imp. Univ.*, Tôkyô, Sect. II, 1, 1 (1925).

29) S. TOKUNAGA, "A New Form of *Cervus* from the Tertiary of Shinano," *Jour. Geol. Soc.*, Tôkyô, 33 (1926), 397-402, (in Japanese).

30) J. MAKIYAMA, "Preliminary Report of Tertiary Fossils from Minauchi-gôri, Shinano Province," *Chûkyû*, 8 (1927), 181-188, (in Japanese).

view slightly diverging from those of the two authors, referring one complex to the upper Miocene and the other to the lower Pliocene.

According to Mr. Homma, these two complexes form an anticlinorium, which is intruded by the pyroxene andesites, and the main folds are parallel to the trend of the Fossa Magna, which runs in $N 30^{\circ} W$ across the Honsyû. These folds are arranged in échelon along the eastern side of the Itoigawa-Siduoka line of Dr. H. Yabe,³¹⁾ by which the southern ends of each fold are separated from the pre-Tertiary formation on the west of the tectonic line. In this part the Itoigawa-Siduoka line is a series of thrust faults. Fig. 5 CD is a geological profile, after Homma, of this district normal to the main trend.

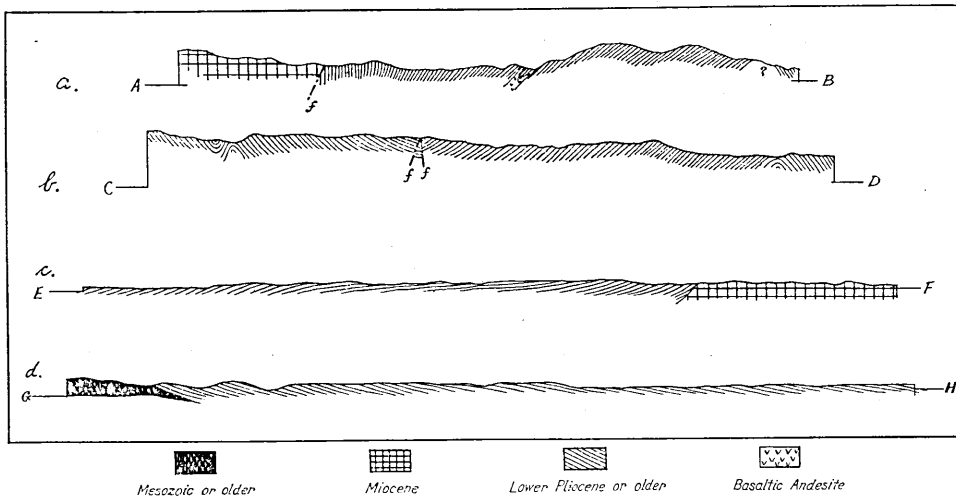


Fig. 5. Geological Profiles at Right Angles to the Strikes of the Lower Pliocene Strata. *a*, through the Asigara beds ($AB = N 40^{\circ} W$); *b*, through the Sigarami and Ogawa beds (after F. Homma) ($CD = N 75^{\circ} E$); *c*, through the lower Kakegawa series (after Chitani and Makiyama) ($EF = N 65^{\circ} W$); *d*, through the Takanabe group ($GH = N 70^{\circ} W$). *f* = faults.

The results of the previous descriptions of the Pliocene deposits of the five districts may be summarized as follows:—

1. Stratigraphically the Pliocene deposits of the five districts cited above are to be correlated as follows (Table II).

2. In the latest stage of lower Pliocene, crustal movements took place in Japan. In the Outer Zone of Southwest Japan, the lower Pliocene or

31) H. YABE, "Itoigawa-Siduoka Geotectonic Line", *Gendai no Kagaku*, 6, 3 (1918), (in Japanese)

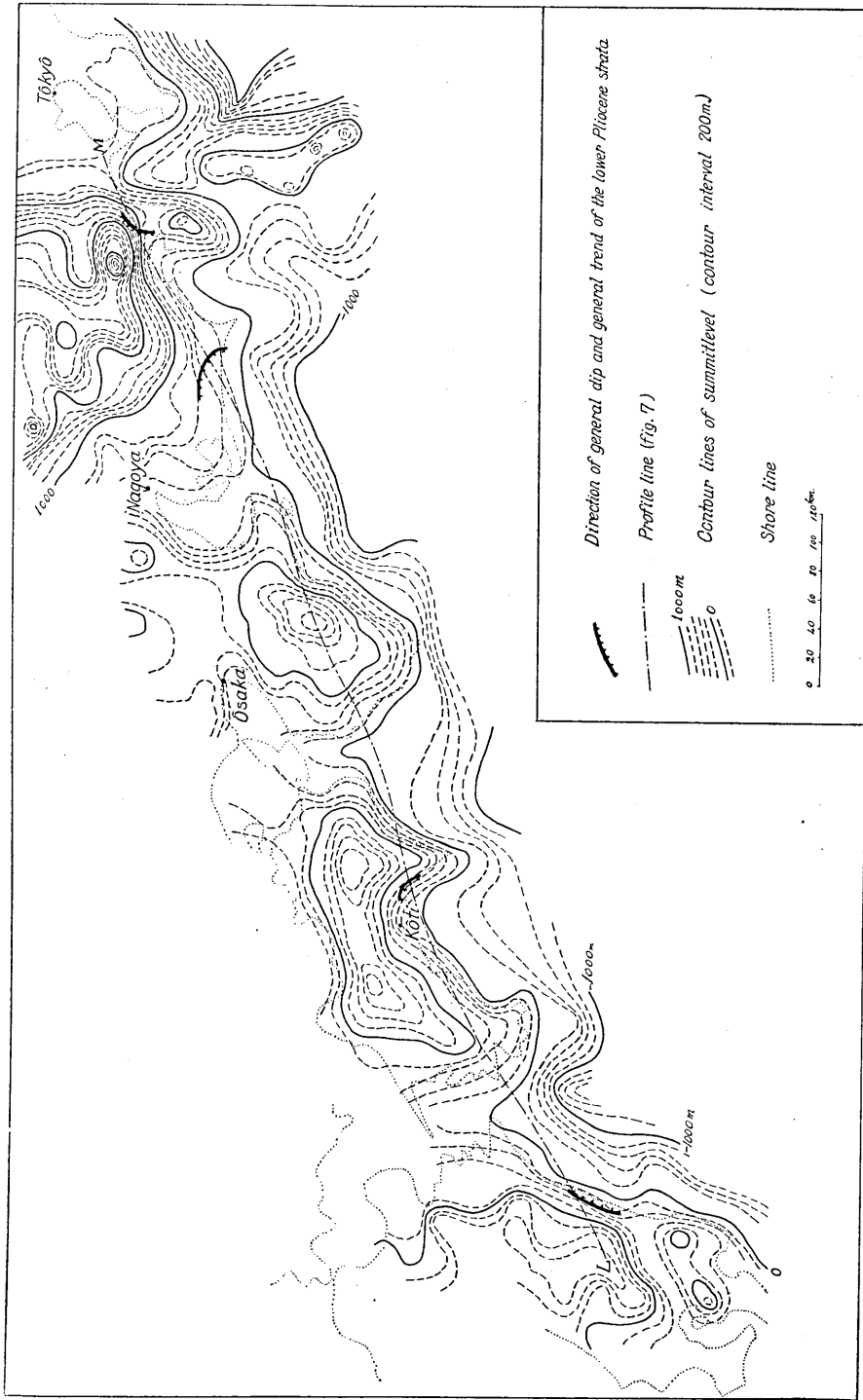


Fig. 6. Summit-level of Southwest Japan.

Table II.

Geologic Age \ Locality	(1) Miyazaki	(2) Kôti	(3) Kakegawa	(4) Asigara	(5) Nagano
Upper Diluvium	Gravel beds	Gravel beds	Gravel beds	Volcanic lava and ash	
Lower Diluvium	Freshwater deposits		Ogasa conglomerate	Gravel beds	
Upper Pliocene			Soga beds	(Ninomiya beds) Nisikoiso beds	
Lower Pliocene	Takanabe group { Heki beds Kôonzi beds Sadowara beds	Suzuki's Pliocene	Kakegawa series	Asigara beds	Sigarami beds
		<i>Umbonium mysticum</i> Zone	Horinouti series		Ogawa beds
Miocene	Tuma group		Sagara beds	Misaka beds	

Pliocene strata are usually monoclinical in low angles either to southwest, or to south with a few exception of other small displacements, while the contemporaneous deposits in the Fossa Magna form a complex anticlinorium, each pericline with the trend parallel to that of the Fossa Magna. There are many thrust- and normal-faults in association of these folds, and volcanism was often active.

3. The structural lines of the lower Pliocene deposits do not conform with the general trend of the Honsyû arc or with the main structural lines of the Outer Zone of Southwest Japan, but with the trend of contour lines of a summit level in the Outer Zone of Southwest Japan. Fig. 6 is a map showing the conformity of the structural lines of the lower Pliocene strata and the trend of contour lines of the summit-level.

4. Fig. 7 is a schematic profile from Siduoka through the Tosa bay to Miyazaki along the line LM in fig. 6. That is parallel to the main structural trend of the Outer Zone of Southwest Japan. It shows us that the inclination of the bedding plane of the Pliocene strata is steeper than that of the surface of the summit-level dipping to the same direction; and suggests that an extensive crustal movement in the form of broad swells took place in the Outer Zone of Southwest Japan along the lines rather parallel to the Ryûkyû arc than to the Honsyû arc

5. Comparing the thickness and rock facies of these lower Pliocene strata, the Fossa Magna may be regarded as a geosynclinal trough of the geological period.

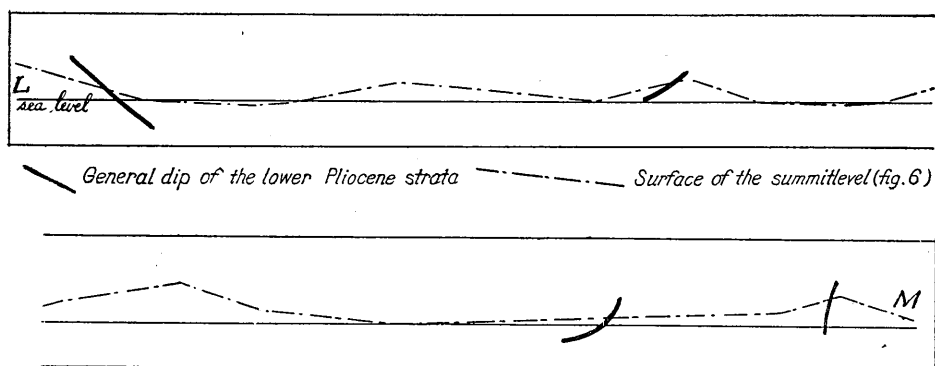


Fig. 7. Profile along L in Fig. 6. Vertical scale $\times 5$

24. 西南日本外帯とフォッサ・マグナとに於ける 鮮新时期末の地殻運動

地震研究所 大塚彌之助

西南日本外帯とフォッサ・マグナとの下部鮮新統の發達地域五ヶ處(宮崎縣日向海岸平野、高知縣東部土佐灣沿岸、静岡縣掛川地方、静岡縣奈川兩縣下足柄地方、長野縣北部)の地質を略記し、それらの地質構造の一般的特徴を述べ互に比較した。

その結果次のやうなことが知られた。

鮮新时期末に著しい地殻運動が日本に起つた。その擾亂の程度はフォッサ・マグナに於て極めて著しく、褶曲、正逆斷層、火山活動等が生じた。外帯ではその程度が極めて弱く展張性を帯びてゐた。陸地測量部の五萬分ノ一地形圖一枚の面積を一單位として作つた切峯面と下部鮮新統の構造とを比べてみると、下部鮮新統の層向の走向とその地域の切峯面の等高線の走向とはかなり一致し、その地層の傾斜の度は、その地域の切峯面の傾斜の度より急であるが、その方向は一致してゐる、又地層の厚さはフォッサ・マグナの地域の鮮新統の方が厚い。

上記の事實から鮮新时期末に起つた地殻運動は極めて激しかつたやうだが、西南日本外帯では展張性な廣い「うねり」があつたやうにも見える。そしてその「うねり」の峯の延び方は琉球弧に平行なものの方が、本州弧に平行なものに比べて著しく目について見える。尙フォッサ・マグナはデオンクラインであつたらしい。