27. *Geology of Imaichi District with Special Reference to the Earthquakes of Dec. 26th., 1949. (I)*

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I. Introduction.

Dec. 26th., 1949, the area around Town Imaichi, 7 km to the east of Nikkō, Kamitsuga-gun, Pref. Tochigi, and about 110 km to the north of Tokyo, was attacked by severe earthquakes that took place successively at 8:18, and 8:26 a. m. (Fig. 1). The wrier reached the town at the scene of the earthquake when the most severe aftershock of 5:54 p. m., Dec. 27th., rocked this area. Not only the focus of this most conspicuous aftershock, but also the focusses of the quakes that occurred in quick succession after the heaviest, are situated exclusively in depth within 10 km from the surface, the aftershocks with focusses estimated at about 5 km or less in their depth being the most common.[1] In spite of the small magnitude of the present earthquakes, the change of surface took place remarkably in the meizoseismic area, especially where the thick aeolian pumice deposits such as "Kanuma-zuchi" and "Imaichi-zuchi" are distributed. The epicentres of the two principal quakes are situated near Imaichi, the town built on the alluvial fan of the River Daiya which, in this area, runs eastwards through the valley between Ashio mountain land and Nikkō volcanic region.[2] And the focusses of the many aftershocks which

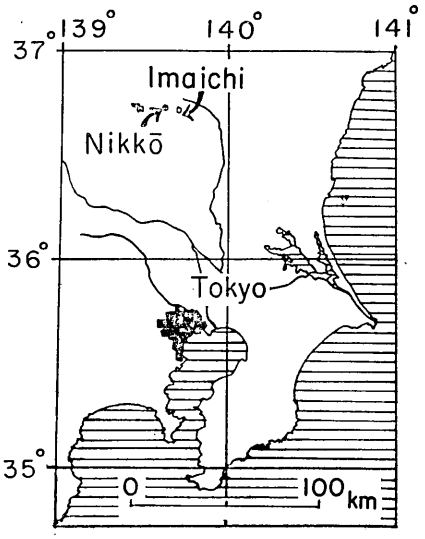

Fig. 1. Index map showing the locality of Imaichi district.

1) T. HAGIWARA, etc., *Bull. Earthq. Res. Inst.*, 28 (1950), 393 400.
2) Y. KOSHIKAWA, *Bull. Earthq. Res. Inst.*, 28 (1950), 369-377.

took place successively for about three months are distributed in an area of about 100 km^2 including the town of Imaichi as its northernmost margin, the valley of Ogurugawa as its westernmost, the village of Itaga as its southernmost, and the lower reach of the River Namegawa as its easternmost.[3] The geology of this area is mainly composed of hard compact Palaeozoic formations intruded by biotite granite or granite-porphyry, and the earthquake vibration through these strata sounds like an explosion of dynamite in mines. These sounds could be heard during the writer's field work whenever the aftershocks were felt, and the inhabitants said that such mountain rumblings conld be heard ever since the beginning of last August or about 5 months before the present earthquakes.[4]

The area has long been neglected without any further geological investigation being made except that carried out by Nasa long years ago.[5] While on the other hand, the Nikkō and Shiobara volcanic regions belonging to the socalled Nasu volcanic zone, northeast of this area, have been investigated repeatedly or in detail.[6] The writer investigated the general geology of this area with special reference of the change of surface that had been brought about by the present earthquake, and in this paper, brief notes on the results of these field works are given.

Most of the expense necessitated for the investigation was defrayed from the funds for the Scientific Research of the Educational Ministry. In his field work, the writer is indebted to the Tochigi Prefectural Government, and he owes much to Drs. F. Tada and G. Imamura for their kind instruction and criticism during this study, and also to Y. Fukuda's of Itaga who gave him full facilities with regard to the field station during his stay there.

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3) T. HAGIWARA and etc, *op. cit.*,

4) Oral communication from S. Fukuda, a mail deliverer of Miyanoshita, Ogurugawa. Another inhabitant of Yamanaka, the outskirts of Ogurugawa-village, said that he also had heard such sounds for 10 days or more before the quakes. And a villager of Oohara, Itaga also testified to 20 days or more. But it must be noted here that they without exception thought that these sounds were the explosion of dynamite in the working mines distributed in the southern vicinity.

5) T. NASA, *Explanatory Text of the Geological Map of Japan*, Scale 1:200,000. "Nikkō" (1899).

6) S. TSUBOI and K. SUGI, "Geological guide to the Nikkō district", *Guide Book of the excursions, Pan-Pacific Science Congress, Japan*, (1926).

S. IWAO, *Bull. Geol. Survey of Japan*, 3 (1913), 4–14 (in Japanese).

M. YAMAZAKI, *Jour. Geol. Soc. Japan*, 56 (1950), 38 (in Japanese).

H. NIINO, *Jour. Geol. Soc. Japan*, 40 (1930), 517–532 (in Japanese). etc.....

II. Geology of Imaich District.

Topography and general outline of geology.

The area consists of two topographic units: one is the alluvial fan of the River Daiya, and the other is an isolated topographic unit surrounded by the comparatively higher Palaeozoic mountain ridge passing through Mts. Keimei (961 m), Sasamekura (799 m), and Sekison (594 m), (Fig. 2). The former is diverging and is gently sloping eastwards, and combined with the fan of the River Kinu and her tributaries, it adjoins the great Kwanto plain. The latter is divided from the Ashio mountain land by the above-mentioned circularly arranged mountain ridge and is bounded by the River Namegawa from the flood plain developing in the east of the area. In short, the topography of the area is closely related with the geology of this district, and its present relief may be ascribed mainly not to the results of the denudation of the ground but to the results of differential erosion. Silicified Palaeozoic conglomerate or shale gives sharp slope to the higher mountain ridge while the rocks exposed at the valley or at the lower lands in this area are exclusively granite, especially monzonitic biotite-granite containing remarkable porphyritic potash felspar. Non-porphyritic biotite-granite, as well as the Palaeozoic rocks, however, resisting the exogenous agencies, forms the mountain such as Nakayama in the central portion of this area. Quartz-porphyry or granite-porphyry which forms the ridge running from NNW to SSE along the right side of the River Namegawa is also often capped by the quite silicified Palaeozoic rock. Some destructive land slides of large scale occurred along this ridge.

On the pediment developing at the foot of these mountains, uniform aeolian deposits of pumice are distributed. It covers extensively the northeastern part of this area, especially the Diluvial gravel of the River Daiya and sometimes amounts to several metres in thickness. As will be mentioned in the succeeding chapter (Chapter III), these pumice beds play an important rôle in bringing about the remarkable land slips of various scale that did the most conspicuous damage to civil engineering, forestry, and agriculture.

Tertiary formation developing in the north and northeast of the area is almost lacking in this area except at Itagabata where scanty outcrops of the formation composed mainly of pyroclasts are found. But the accurate geological relation to the associating rocks could not be ascertained during this investigation. Description about each rock and their geological relations will be given briefly as follows:

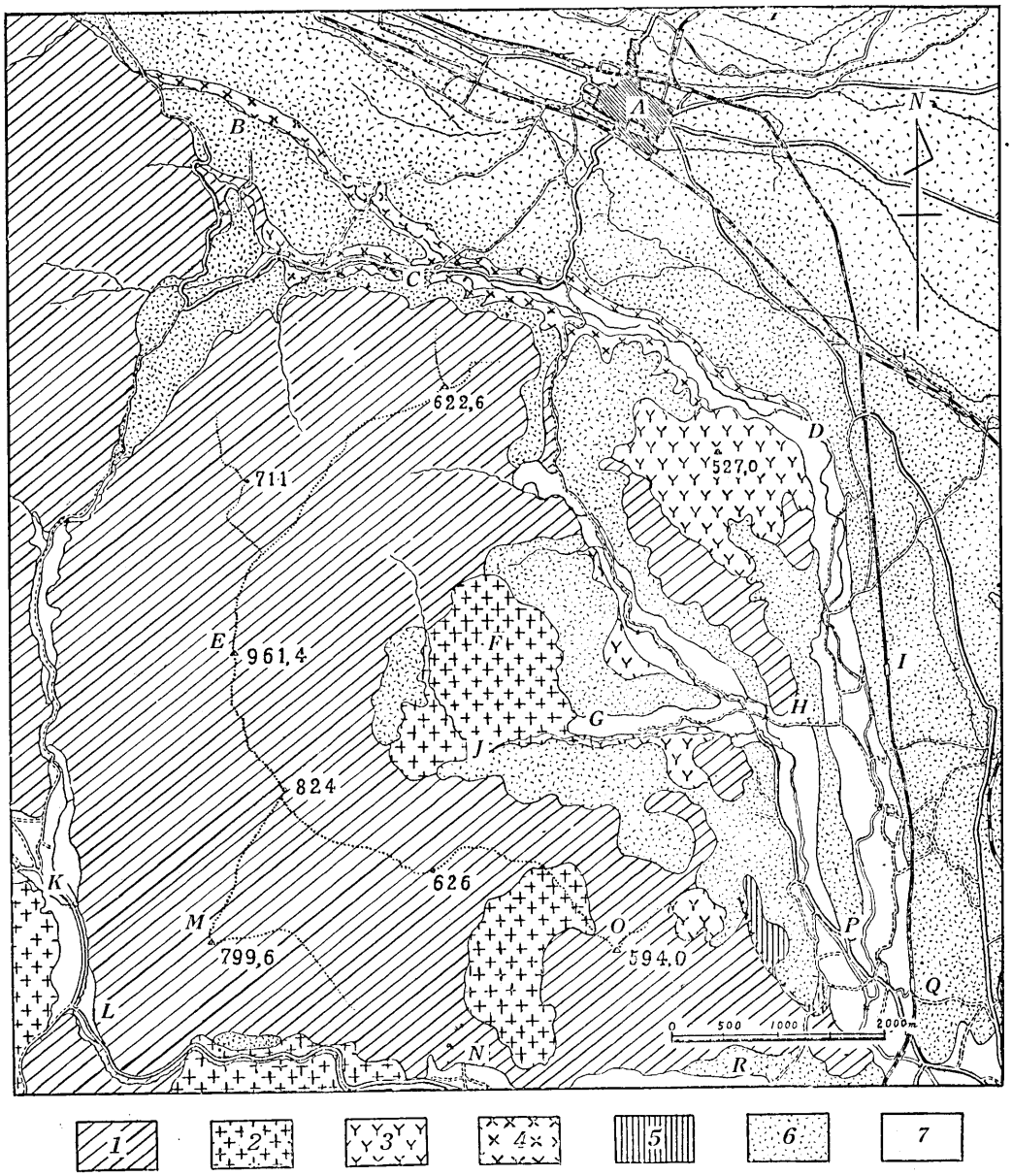

Fig. 2. Geologic map of Imaichi district.

A...Town of Imaichi, B...Numauchi, C...Matsunokiuchi, D...Murose-namegawa, E...Mt. Keimei, F...Mt. Nakayama, G...Nagahata-nakai, H...Ushiroyama, I...Myōjin station (Tōbu line), J...Keimei mine, K.. Ogurugawa, L...Yamaguchi, M...Mt. Sasamekura, N...Oohara, O...Mt. Sekison, P...Itagabata, Q...Shimokojiro station of Tōbu line, R...Itaga, 1...Chichibu system, 2...Granite, 3...Granite-porphyry or quartz-porphyry, 4 . Andesite flow, 5...Liparitic rock associated with pyroclastics, 6...Diluvium, 7...Alluvium.

(1) Chichibu System.

The Chichibu System, the oldest formation in this district, occupies a large area of the southwestern portion of the present macroseimic region. It continues to the Palaeozoic strata forming Ashio mountain land which shows an uniform valley system. The formation consists mainly of sandstone (composed of angular fragments of quartz, plagioclase, orthoclase, and shaly patches) and slate, and is more or less metamorphosed into compact hornfels owing to the intrusion of granitic rocks. Contact portion of the cherty hornfels and the porphyritic biotite-granite was found at the river bed, in the western outskirts of Oohara, where remarkable quartz veins were observed in both rocks (Fig. 3). The structure of the formation is not clear owing to its conspicuous silicification and shattering. But judging from the general trend of the distribution of each rock facies, it takes generally the NE–SW direction, dipping in most cases northwestwards.

Highty silicified rocks are often found as remnants of the roof pendants in or around the outcrops of the granitic rocks mentioned in the following sections. Reddish brown biotite frakes are commonly contained in the slate or in the cementing portion of the sandstone, while no other contact minerals are found.

(2) Granitic rocks.

Coarse-grained biotite-granite shows sometimes porphyritic appearance owing to the remarkable perthite crystals amounting up to 1 cm or more. The monzonitic facies of the granite is apt to be decomposed. Thus the granite occupies the valley or the rounded hill, while the highly silicified Palaeozoic strata form a sharp slope or ridge. Contact-effect on the Palaeozoic strata of this granite is not so remarkable as to bring about complete recrystallization of the surrounding rock. The only metamorphic mineral to be found is biotite. The strata were hardened along the contact zone by conspicuous silicification. According to these metamorphic feature shown by the Palaeozoic strata in this area, it may be considered that the boundary between the sedimentary rocks and the igneous body is not deep, being less than several hundred metres from the surface even where the Palaeozoic formation is distributed extensively. The granite exposed at the southwestern side of Mt. Sekison (Fig. 2), seems to change its facies gradually into granite-porphyry or quartz-porphyry. Near the contact with the hornfels showing quartz spots, it becomes aplitic, and contains dark greenish biotite. On the contrary, in the granite-porphyry exposed at the northeastern side of the same mountain, coarse grained granite-like facies are observable. These granitic rocks such

as granite, granite-porphyry, and quartz-porphyry seem to be mutually transitional though such outcrops that would clearly show the mutual transition among each rock facies could not be found. At the river bed, south of the tribe of Nagahatanakai, however, the quartz-porphyry comes into sharp contact with granite, and the blocks of the granite are included in the former (Fig. 5). And this quartz-porphyry gradually changes into granite-porphyry in its rock facies. The latter biotite-granite continues to the country rock of Keimei mine where the tiltmeter and extensometer were equipped after the earthquakes and also to the biotite-granite forming Mt. Nakayama. No conspicuous porphyritic crystals of perthite are recognizable in the granite, being compared with the granite exposed near Kusakyū, Nishi-ōashi. Topography indicated by the granite was discussed in the foregoing chapter. At the mine, fractures in the country rock, impregnation veinlets of quartz or aplite, in which minute frakes of molybdenite are often observable, are conspicuous. Besides the molybdenite, other minerals have been reported from this mine by K. Sakurai.[7] Such a pneumatolytic deposit of molybdenite or wolframite is not rare in the southern vicinity of this district.

As shown in an annexed geologic map (Fig. 2), quartz-porphyry forms a ridge represented by a triangulation point 527 m. On the northern and southern sides of the spot, destructive collapse of the rock took place at the time of the earthquake of 8:26 a. m. At the foot of the ridge, along the river side or at the bed of the River Namegawa, the quartz-porphyry is exposed. Above the quartz-porphyry, the highly silicified rocks which seem to have been derived from the slate or shale belonging to the Chichibu system, forms rocky cliffs. Rock fall occurred at several points along these cliffs. Granite-porphyry with regular columnar jointing is observable along the road, 1 km to the south of Numauchi, near the elementary school of Yamakubo. And this porphyry is overlained by the agglomeratic andesite flow at the joint of the road with the River Namegawa. Quartz-porphyry, liparitic rock and its pyroclastsics are recognizable at the bed of the River Namegawa near Shimokojiro and Itagabata. White tuffaceous rock including glassy breccias of liparite covered by Diluvial loam and other pumice beds is found at the western slope of Mt. Sekison, near the tribe of Itagabata. These rocks with such rock facies may be of the Tertiary age, though there are no palaeontological data. In this narrow area less than 1 km^2 near Itagabata, the rocks of various facies such as quartz-porphyry, liparite, white tuff breccia, etc., are associated and intermingled with each other. And the boundary between the Palaeozoic hornfels of Mt. Sekison and this acid igneous complex may be supposed as a fault, judging from the geographical

7) K. SAKURAI, *Our minerals* 9 (1940), 374-375. (in Japanese)

distribution of these rocks in this narrow area. From the above-mentioned observations, it may be allowed to say that these igneous rocks may be consangunious and that no remarkable chronological gap is to be supposed among them, though the mode of intrusion, eruption, and of deposition is quite complicated and must be cleared up by further study.

(3) Diluvium.

The essential member of the Diluvium distributed extensively in this district are, arranged from the older to the younger, the gravel of the flood plain of the ancient river of Daiya, the so-called loam, the reddish brown pumice bed called "Imaichi-zuchi", and the yellow pumice bed, called "Kanuma-zuchi." (Fig. 5). The gravel may be correlated to of that of the River Watarase and further to that of Musashino. And the loam continues to that of "Narita bed" distributed widely at the northern Kwantō Plain. Blocky partially auto-brecciated lava flow is continuously observable along the River Namegawa. The two pyroxene-andesite varies in its appearance; porphyritic or non-porphyritic, dark grey or purplish, compact or slaggish, rich or poor in mafic phenocrysts, etc. The lava covers directly the Palaeozoic sandstone, granite-porphyry or quarth-porphyry at the southern margin of the Diluvial flood plain of the ancient River Daiya, but it is underlain as a whole by the Diluvial gravel of the same river. The lava is overlain by the successive beds of loam, Imaichi-zuchi, and Kanuma-zuchi, and the flow terminates at the cliff of Murose-namegawa. The present river Namegawa cuts down this lava, making it form the cliff of the valley along the river. It may be said, therefore, that the present shape of the valley indicates the topography due to erosion, not of the structural valley, even though the ancient river Daiya might had run through the valley formed by Tertiary or pre-Tertiary faulting. In the present stage of our knowledge, it may be said and may be denied at the same time that the great tectonic line passes through this valley. Waving and inclination of the beds of Kanuma and Imaichi soil, aeolian pumice deposits, show the olden relief of the surface in most cases, and never suggests crustal deformation. The slipping of these bed in the Pleistocene age are commonly observable along the scarp of the river terrace (Fig. 6). Of the changes of surface brought about remarkably on these Diluvial beds, the writer will make mention in the comming chapter (Chapter III).

(To be continued.)

27. 栃木縣今市町附近の地質 (その一)

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昭和24年12月26日の今市地震に際して調べた同地方の地質の概要を述べた．地變の重要な原因の一つとなつた同地方に特有な洪積期浮石質堆積物の性質と地變の記述は第2報にゆづる．

Fig. 3. Contact portion between porphyritic biotite-granite and Palaeozoic cherty hornfels. Oohara, Itaga village.

Fig. 4. Intrusion contact of quartz-porphyry into biotite-granite, Nagahata-nakai, Ochiai village.

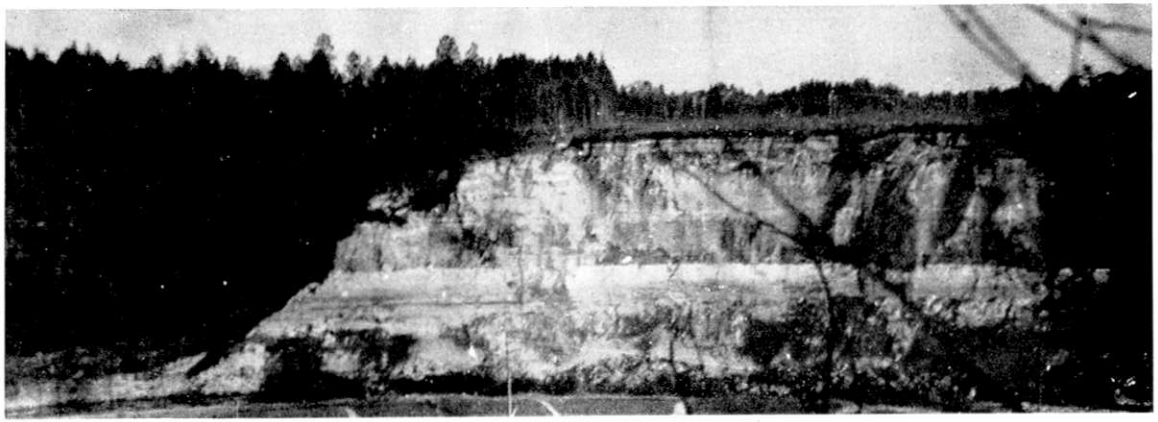

Fig. 5. Cliff showing the representative succession of the Diluvial beds. Collapsed cliff at Tashirouchi, east of Myojin, Ochiai village.

Fig. 6. Succession of the horizontal beds (right, facing the cliff) is clearly cut by the another succession of same order with a curved boundary line. Collapsed cliff at the east side of the River Namegawa, Murose-namegawa, Town of Imaichi (Cf. p. 385).