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On the Landslide Appeared in Mimido, Nakaguroiwa, and Kassen Areas, Ehime Prefecture, Japan.

By

Kenji MIYAHARA

with 1 Table and 15 Text-figures

ABSTRACT: Some factors taking part in the landslide observed in three areas have been researched. It has resulted in that scrutiny for microgeologic environs as well as for average permeability or any other mechanical properties represented by the superficial deposits including the clayey matters is much more significant than that for general geology composing the related region, though not to be neglected because of emergence of the landslides in considerably restricted zones, for the grain-size proportion in the deposits, and for the species of clay minerals in relation to difference in their characteristics yielded rather secondarily by absorption of, or exchange with the foreign ions or others.

CONTENTS

I. INTRODUCTION

Remarkable fact so far confirmed in Ehime Prefecture is that the areas composing mainly of the Sambagawa metamorphics were accustomed to evolve the landslide with the highest frequency while those consisting of the Chichibu Paleozoic formations were of the second class and those of the Mesozoic formations together with granitic rocks were the remainder revealing extremely low frequency. For the purpose of scrutinizing these relations and of finding out the factors effective for land-sliding, geological research as well as several kinds of geophysical prospecting and of measurements concerning the related locations, for instance, Mimido, Nakaguroiwa, and Kassen areas, have been carried into effect. On the other hand, the core-samples obtained through boring or the specimens collected at undisturbed state from certain localities have also been materially and mineralogically inspected to a certain extent to clarify the relation of microgeology in the depth to the superficial movement. Levelling along certain routes and measurements regarding the lateral and vertical variation of the areas concerned, the inclination of sliding plane, the variation of water-table, the pressure of pore water, the anual variation in quantity of precipitation and evaporation, and that of temperature in the air have been put into operation, some of which have been proven considerably valid in connection with the subject.

Acknowledgement: The writer is grateful for valuable materials and convenience given by all members of the Research- and Planning Section of the Matsuyama Construction Office and Mr. Fumiichi SHIGEMATSU of the Kuma Branch Office, the Shikoku Provincial Branch of the Construction Department, for the reports of geophysical prospecting published by the Applied-geological Survey K. K., and for the data of electrical prospecting, given by Professors Sōichirō NAKAMURA and Sakae NISHIOKA, Ehime University. Much thanks must be dedicated to Professor Yoshiharu UMEGAKI, Hiroshima University, who gave the writer effective guidance and revised the manuscript, as well as to Mr. Toshiyuki HABARA, the main staff of Geological Section, Chūgoku and Shikoku Reconstruction Office K. K., for his hearty advices afforded throughout the work.

II. BRIEF NOTES ON THE LOCATIONS

Locations connecting closely with emergence of landslide in Ehime Prefecture are illustrated in Fig. 1. Inspection of the figure reveals their zonal distribution either along the region of the Sambagawa metamorphics from Yawatahama on the western side, across the Hiji and Omogo Rivers, and to the Dôzan River on the eastern side (79% in number of frequency) or along the region of the Chichibu Paleozoic formation (15%), and sporadic evolutions with rare frequency in granite and in the Mesozoic formation. Of all, three representative areas such as Mimido, Nakaguroiwa and Kassen will hereunder be outlined in relation of landslide to geology.

(1) Mimido area

Topographically, the area concerned discloses a gentle slope toward the Kuma River respectively with an inclination of ca. 18° at the boring point No. 2 and with that of ca. 12° at the boring point No. 1 revealing the most active sliding, culminating in a fan-like shape with an inclination of ca. 20° in the vicinity of the Mimido Bridge (see Figs. 2 and 5a, b). Superficial part of the talus constructing the related slope composes of bluish-colored clayey materials at the point No. 1 and of sandy clay comprising comparatively small gravels of quartz-schist, black-colored schist and green-colored schist in the part without sliding, while a part of the Sambagawa metamorphics consisting of black- and green-colored schists with strike N 50° W and dip 50° N is inferred to come into contact with the green-colored rocks of the Mikabu formation in relation to fault on the point situating higher than No. 2.

(2) Nakaguroiwa area

The area with the highest frequency of landslide is principally composed of green-colored rocks pertaining to the Mikabu metamorphics, its northern margin

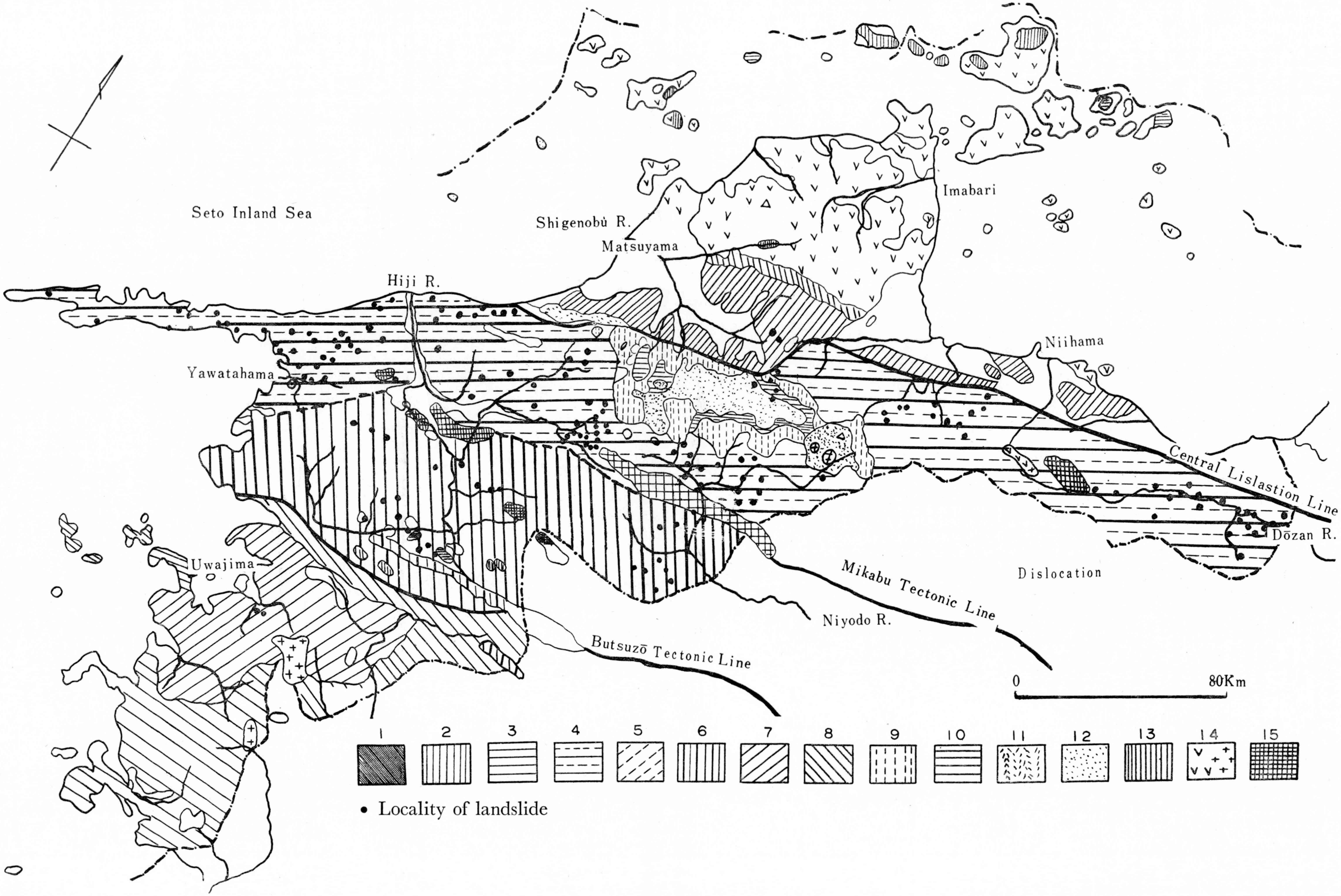

FIG. 1. Geological map with localities of landslide (compiled by Ehime Prefecture)

1. Gotlandian f. 2. Upper Paleozoic f. 3. Ryuke metamorphics. 4. Crystalline schist. 5. Sanpozan f. 6. Trias and Jurrasic fs. 7. Cretaceous f. 8. Shimanto f. 9. Paleocene f. 10. Neocene f. 11. Cretaceous volcanics. 12. Tertiary volcanics. 13. Mitaki intrusives. 14. Granite. 15. Basic intrusives.

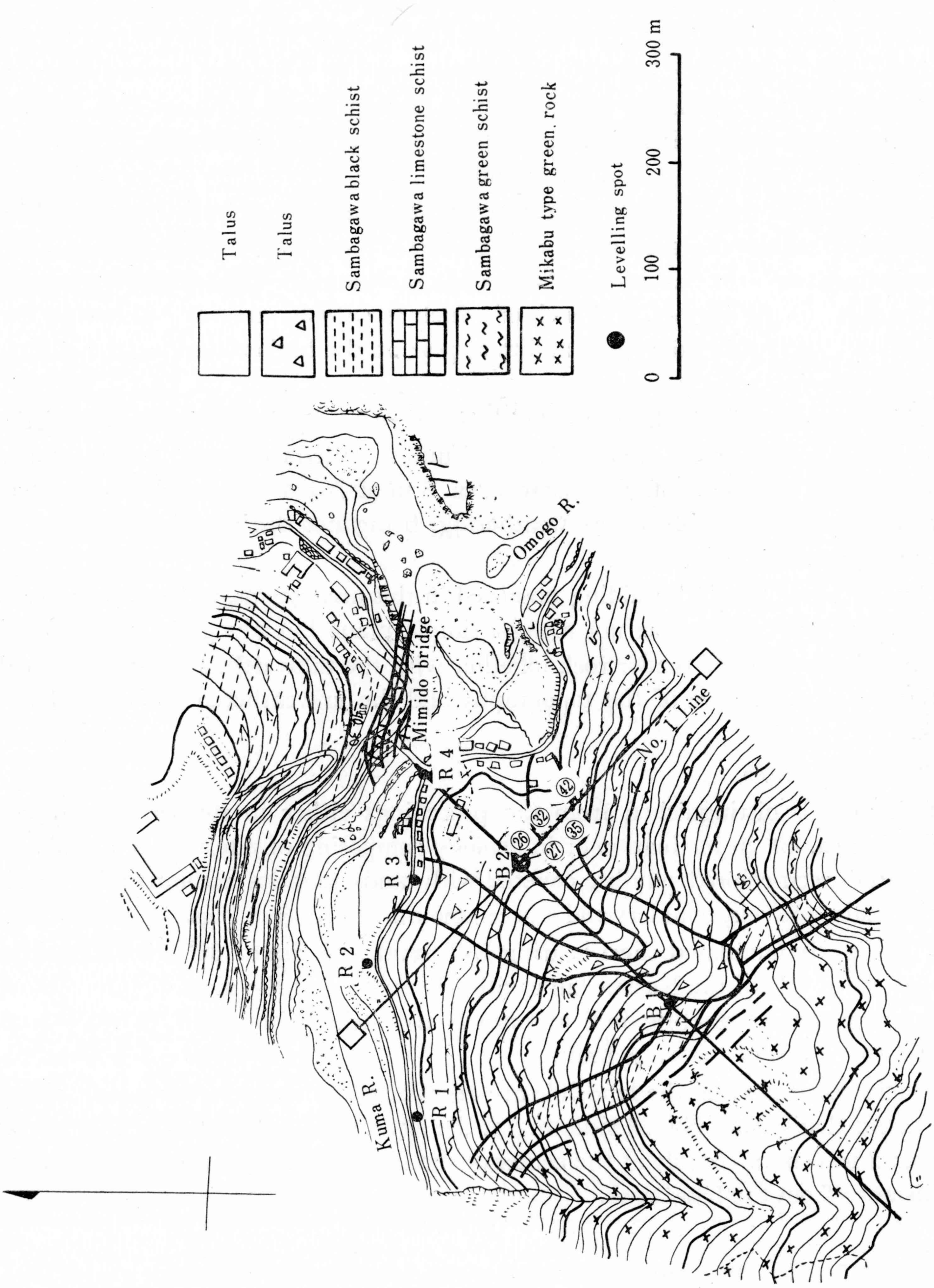

FIG. 2. Geological and location map of the Mimido area.

being in concord with the southern boundary of the Sambagawa metamorphics consisting of black-colored, and quartz-schists (see Figs. 3, 6, and 7a, b, c).

It seems significant that a reservoir collecting several streams is situated on the higher limit of the area in question, and assumed to yield the hidden water in shallower depth, accelerating the sliding to a certain extent. As for this regard, gushing of water as well as presence of bluish clay are observable in the part between No. 3 and No. 4 of the boring holes.

In addition to this, a remarkable fact is that the green-colored metamorphics distributing within the area are found traversed broadly by the fractured zone accompanied with the Sawatari-Nakaguroiwa fault and by some minor ones running parallel to the former, a branch of which is considered to be splitted in the vicinity of the boring hole No. 4 and to appear on the higher limit of the sliding in Mimido area.

As is recognized in the boring hole, the basal rocks are brittle in characteristic, and their superficial parts are found altered into so-called weathered rock of tender property with thickness of, for instance, ca. 6 m at No. 4 or into clayey matters as a result of considerably severe weathering, being not distinguishable from the overlying talus deposits.

On the other hand, the sliding observed in this area seems, as be also the case with other areas, to appear not along a simple plane but along the complicated partings in the part of tender rock together with the talus debris because of local difference in inclination of the topography and the unweathered surface of basal rock.

(3) Kassen area

This area is distinguished from the precedings either in steeper topography indicating ca. 40° in inclination or in geology composing of alternation of diabase, chert and green-colored phyllite covered with sandy mantles accompanying sand, in the main, gravels, boulders and scarce amount of clay (see Figs. 4 and 8a, b).

The slightly laminated chert bearing EW trend with dip of 30° S is exposed on the northern side of the Kassen fault with EW strike and the diabase, intercalated with green-colored phyllite, indicates nearly EW strike with dip of 10°~20° S on the southern side of the same fault.

Cracks resulted from the landslide are recognized on the protecting wall along the national highway No. 33 situating at the lowermost peripheries of the moved area and less conspicuously at the center of the same part, revealing the difference in distance from the basal rock.

III. RELATION TO GEOLOGY AND GEOLOGIC STRUCTURE

As the significant factor regarding the landslide geology composing the related terrain and its structures are to be considered in more detail.

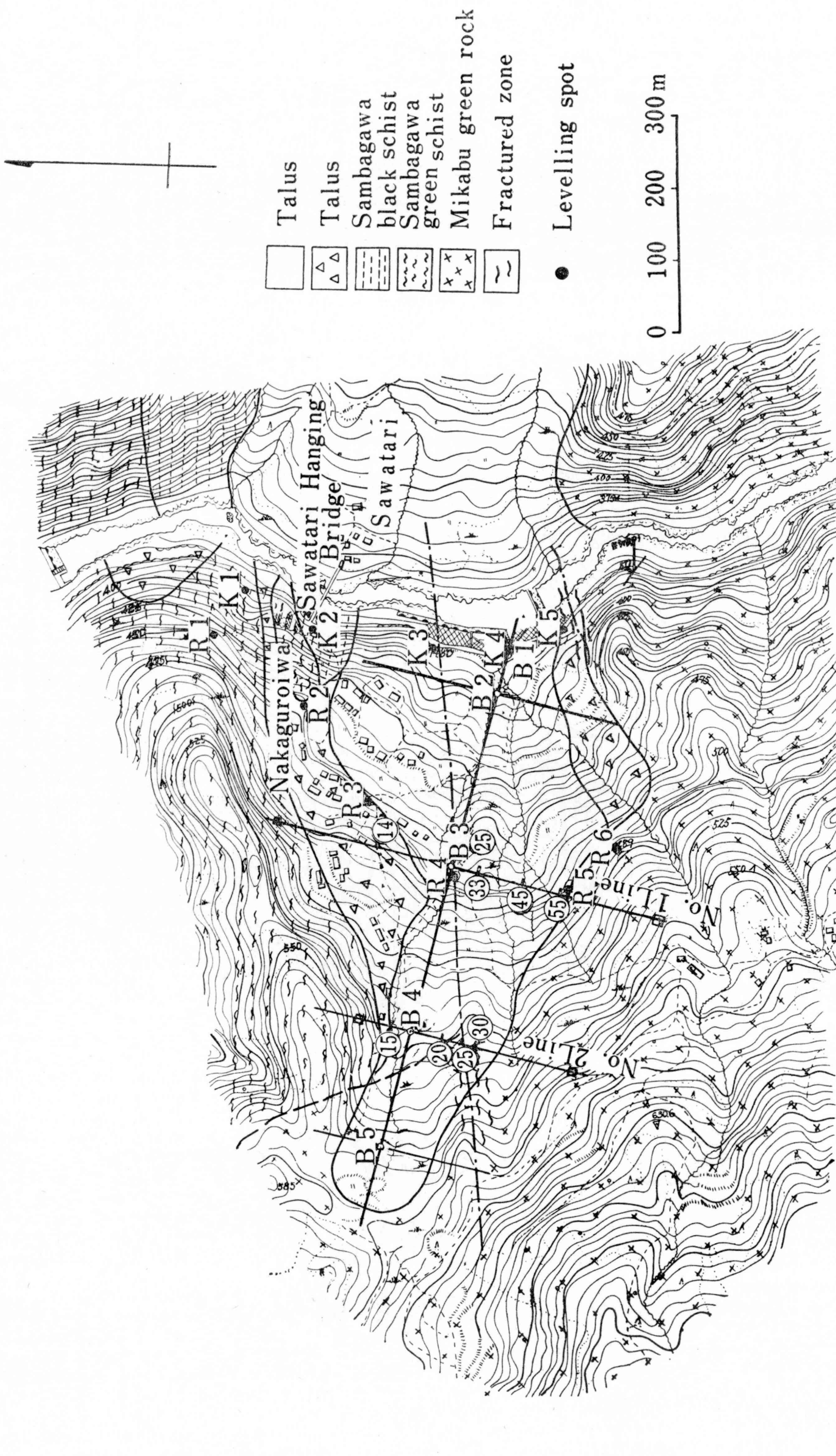

FIG. 3. Geological and location map of the Nakaguroiwa area.

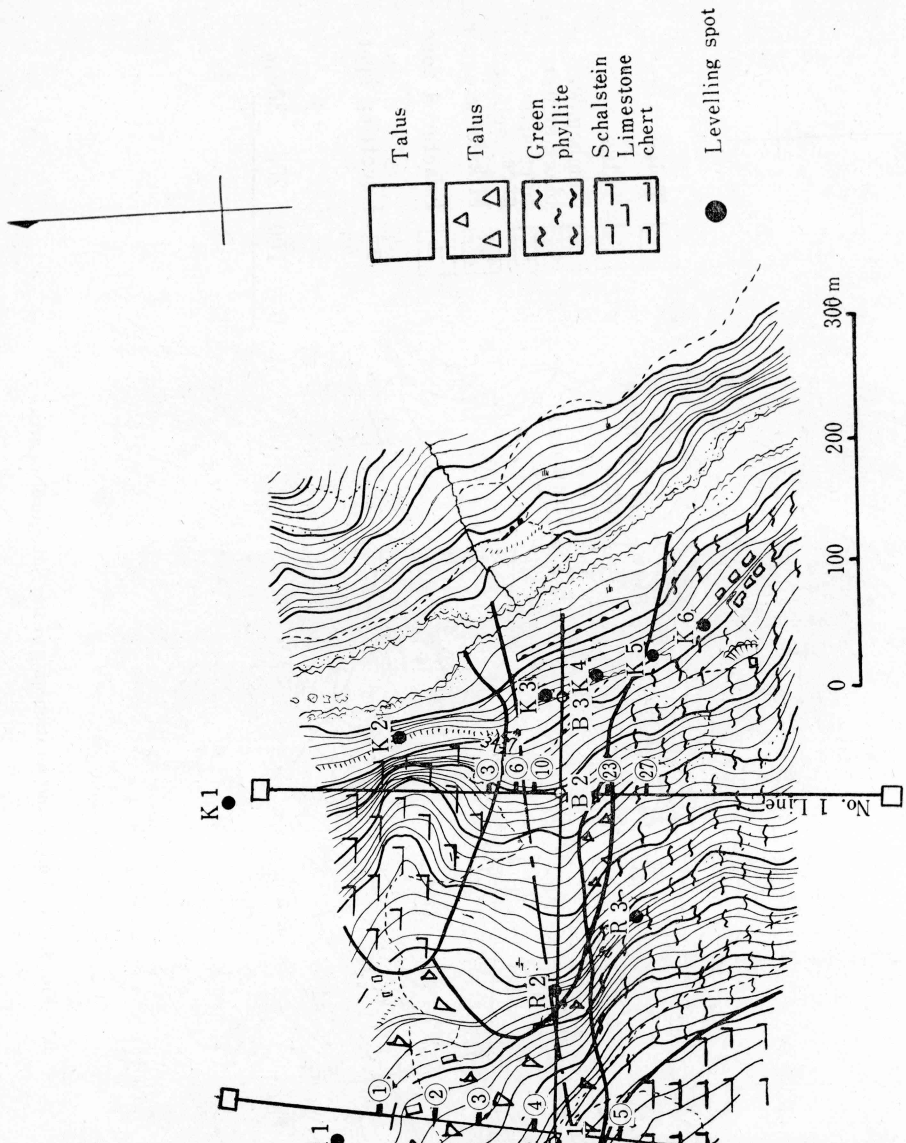

FIG. 4. Geologic and location map of the Kassen area.

(1) Geology

Geology hidden under the mantle of soils within the terrain including three areas mentioned above composes mainly of the basement rocks, and the talus and alluvial deposits.

(a) Basement rocks

The rocks concerned are distributed in three parts: the northern part locating from Mimido to the Sawatari-Nakaguroiwa fault, the middle locating from the southern side of the fault to the Kassen fault and the southern locating on the southern side of the latter fault.

The rocks in question consist respectively of the Sambagawa crystalline schists comprising quartz-schist, limestone-schist, black-colored schist, green-colored schist and so on with monoclinal structure pointing roughly to EW in strike with dip of $40^{\circ}\sim 60^{\circ}$ N in the northern part, of the Mikabu green-colored rocks, accompanying somewhat laminated ultra-basic rocks, chert, black-colored phyllite and so on comprised in a sort of fractured zone with bulk of minor faults revealing NS trend in the middle part, and of schalstein, chert, and lenticular limestone with gentle dip of $20^{\circ}\pm$ S in the southern part. On the other hand, local folds of small scale as well as lineation, especially on crystalline schists, are found developed within the region and, however, large-scaled ones are not recognized.

Of all, the black-colored schist composing microscopically of graphite, muscovite, albite, quartz and some others is laminated, cleavable, and rich in minor folds. The green colored schist composing of chlorite, epidote, actinolite, albite, quartz, calcite and so forth is used to revealing either well-developed lamination or conspicuous lineation of EW trend with plunge of $10^{\circ}\sim 20^{\circ}$ E and often subjected to weathering or altered into bluish clay through hydration. The greenrocks pertaining to the Mikabu metamorphics compose mainly of basaltic lava, basaltic aglomerate, and schalstein associated with basic intrusives such as gabbro and diabase as well as ultra-basic ones such as peridotite and serpentinite, while these rocks are not conspicuously demarcated with one another. Basaltic lavas comprising saussurite, augite, hornblende, chlorite, epidote, actinolite, leucoxene and so forth are found converted into green-colored rocks probably through alteration of augite or olivine, whereas, because of the remained textures disclosed by phenocrysts of chlorite, relics of augite or volcanic matrices, the related rocks are distinguishable from the green-colored schists of the Sambagawa metamorphics and furthermore characterized with intense green color, massive occurrence and remarkable alteration into clayey matters through weathering. Gabbro is generally altered, containing saussurite, hornblende and diallage. Chert is white, red, greyish white, pale green and so on in color, accompanying the banded intercalations of chlorite, muscovite, and graphite. Schalstein is green and reddish brown in color and scaly in habit. Moreover, the younger andesitic dikes composing of augite, hypersthene and albite are observed penetrating locally across the fractured zone of the Sawatari-Nakaguroiwa fault, across the part near the fault appearing south of the Sawatari bridge, and across the part on the southern side of the boring hole No. 2 in the Mimido area.

(b) Talus and alluvial deposits

The talus and alluvial deposits lying over the slope of the matured topography along the Omogo and Kuma Rivers reveal the sandy or clayey formations composing of the boulders, gravels, sands and clays derived from the basement rocks broken through weathering and are found not stratified. Those observed in Nakaguroiwa and Mimido areas consist of the fractured rocks disclosing severe alteration to clayey materials because of situating in or near the Mikabu tectonic lines, and those recognized in the fractured zone of Kassen fault contain the boulders, gravels and sands accompanied with sandy clay or a few amount of clay. The sliding is liable to take place in these parts.

(2) Geologic structure

The region under consideration is geotectonically divided into three areas by two major faults referred to already: one is found traversing across the area from Sawatari to Nakaguroiwa and the others along the southern part of Kassen area.

The fractured zone of the former, more than 50 m in width, is found running across the black-colored schist intercalating quartz-schist together with porphyrite and comprises the main fault bearing the green-colored clay as well as some minor ones. In that of the latter, the green-colored rocks of the Mikabu metamorphics are observed fractured into lustered, tranparent, scaly (ca. 1 mm in width), and green-colored fragments. An extension of this zone splitted in the western part is considered to be combined with the former in the southern part of the boring hole No. 2 and to pass between the black-colored schist and cleavable green-colored rock of the Mikabu metamorphics, accompanying the injection of andesite. Moreover, a fault regarded as a part of the Kassen fault is recognized in severely fractured schalstein accompanying lenticular limestone at the cutting between No. 2, and No. 3, of the boring hole pertaining to the Kassen area. Some minor faults other than the above-mentioned pointing to N $30^\circ \sim 60^\circ$ W with dip of $30^\circ \pm$ are observed in the part intervening between Nakaguroiwa and Kassen areas.

Excepting minor foldings appeared in the crystalline schist, major ones are not conspicuously observable. The strata are used to displaying a sort of monoclinal trend with the northward dip of high angle in the northern area and with the southward dip of low angle on the southern side of the intervening area as well as in the southern area.

IV. Data for Some Measurements

(1) Velocity of seismic waves

Propagating velocities of the seismic waves artificially produced have been compared with one another in use of the relative values representing the respective areas.

(a) Mimido area

2,200~3,200 m/sec has been taken as the velocity for the basement rock composing of the green-colored schist, 1,700~1,800 m/sec as that for the weathered basement together with a part of the talus deposits, and 300~500 m/sec as that simply for the talus deposits (see Fig. 5a). This assumption is agreeable with the results obtained from boring. For instance, the underground geology consists, at No. 1, of the talus deposits of the sandy clays and clays mixed with gravels from 0 m to −3.8 m, of the weathered schist including a part of the mantle from −3.8 m to −7.8 m, and of the unaltered schist below −7.8 m and, at No. 2, of the sandy and cohesive soils associating the boulders and gravels even in the depth of −30 m. The profile along this route indicates the surface of the basement rock with an inclination higher than that of the land-surface. The thickness of the talus deposits is estimated about 40 m in maximum, and the basement show the slope from west to east (see Fig. 5b).

(b) Nakaguroiwa area

4,700~5,000 m/sec has been taken as the velocity for the basement rock composing of green-colored rock, 1,600~2,000 m/sec as that for weathered basement, and 400~800 m/sec as that for the talus deposits (see Fig. 6).

The results obtained from boring indicate that the underground geology composes, at No. 2, of the sandy soil, sand and gravels in the depth from 0 m to −8 m, of boulders and gravels mixed with sandy and cohesive soils from −8 m to −18 m, and of green-colored rock below −18 m. As is similar to in the former area, the weathered part of the basement rock is hardly distinguished from the talus deposits in their apparent property. The geologic relation observed at No. 3 is nearly some as that at No. 2. The part assumed the weathered basement is obtainable in the depth of 11.2~12.2 m and covered with the mantle distinguishable hardly either from the weathered rocks or from the talus deposits. It seems general in this area that the mantle becomes thinner with altitude.

(c) Kassen area

4,000~4,800 m/sec has been taken as the velocity for the basement rock, 2,000~2,200 m/sec as that for the weathered basement, and 300~1,200 m/sec as that for the talus deposits accompanying a part of the weathered rock (see Fig. 8a).

The results of boring manifest that, at No. 2, the underground geology comprises the mantle composing of the sandy soil mixing the gravels in the depth from 0 m to −10.2 m together with the weathered basement beneath −10.2 m while, at No. 3, these data are substituted respectively by 0 −18.2 m and −18.2 m. The part displaying the most remarkable sliding is situated on the gentle slope lower than the spot between No. 1 and No. 2.

(2) Lateral and vertical movements of land-surface.

Lateral movement of the land-surface along No. 1 line in the Mimido area indicates a definite variation since April in '61 till March in '62 (see Figs. 5b and 10). The quantity of variation is arranged in descending order of No. 27 (95 mm in extension), No. 26, No. 32, No. 35 (19 mm) and No. 45, revealing that, nearly indifferent to the surface topography, the inclination of the basement concealed under the mantle rather plays an important role, while the minimum variation seems to appear upon the hollow of the basement rock.

The data of levelling taken along the Kuma River in this area since October in '61 till April in '62 show either positive or negative deviation from the standard level, for instance, -69 mm at No. 4 and $+6$ mm at No. 2 (see Fig. 5a).

Both lateral and vertical variation appeared in the related area seems to have no considerable relation to the quantity of precipitation in each season.

The results obtained for the lateral movemont along No. 1 line in the Nakaguro-iwa area indicate a variation in the range from 20 mm (at No. 45) to 37 mm (at No. 33) mainly since May till October in an year (see Figs. 7b and 11). Because the variation is not local but balanced for each spot and small in range, its relation to seasonal precipitation is also hardly ascertainable.

The vertical variation observed at each point along the same line is not remarkable and in the range of 20 mm $\pm$ from the standard level.

On the other hand, the data for the lateral variation measured along No. 2 line in the same area reveal such a marked fact that, for instance, the quantity of dislocation appeared mainly since August till November is estimated 155 mm (maximum) at No. 5 and No. 14, 70 mm at No. 30, and 20 mm (minimum) at No. 20 (see Fig. 20). In relation to this, a stream is found running between No. 5 and No. 14, and the latter point is situated on the slope inclining toward the center of the underground hollow while No. 30 is on the opposite slope. It seems common that the lateral movement recognized on the slope of the basement rock is of a scale larger than that appeared on the central part and considerably related to the quantity of precipitation. That the sliding is liable to take place in the part, where the talus deposits with permeable property and the basement rock are clearly demarcated, is also worth mentioning.

The quantities of the lateral dislocation ascertained along No. 1 line in the Kassen area are 480 mm at No. 10, 330 mm at No. 23, and less than 50 mm at No. 4, No. 6 and No. 27 (see Figs. 8b and 12), while those observed along No. 2 line are generally small since 34 mm at No. 4 is the maximum of all.

The vertical movement revealed along the national highway in this area is estimated -74 mm (maximum) at No. 3 and No. 4 situating near No. 10 and No. 23 on No. 1 line referred to above and happenly $+5$ mm at No. 1, while its amount along a line is in the range from $+26$ mm to -25 mm during an year (see Fig. 12).

A fact clarified in this area is that the dislocation is accustomed to evolving on the part connecting with accumulative current of the underground water and to propagating from higher to lower altitude.

(2) Relation of variation of water-table to precipitation

Variations observed on the level of water-table have been inspected particularly

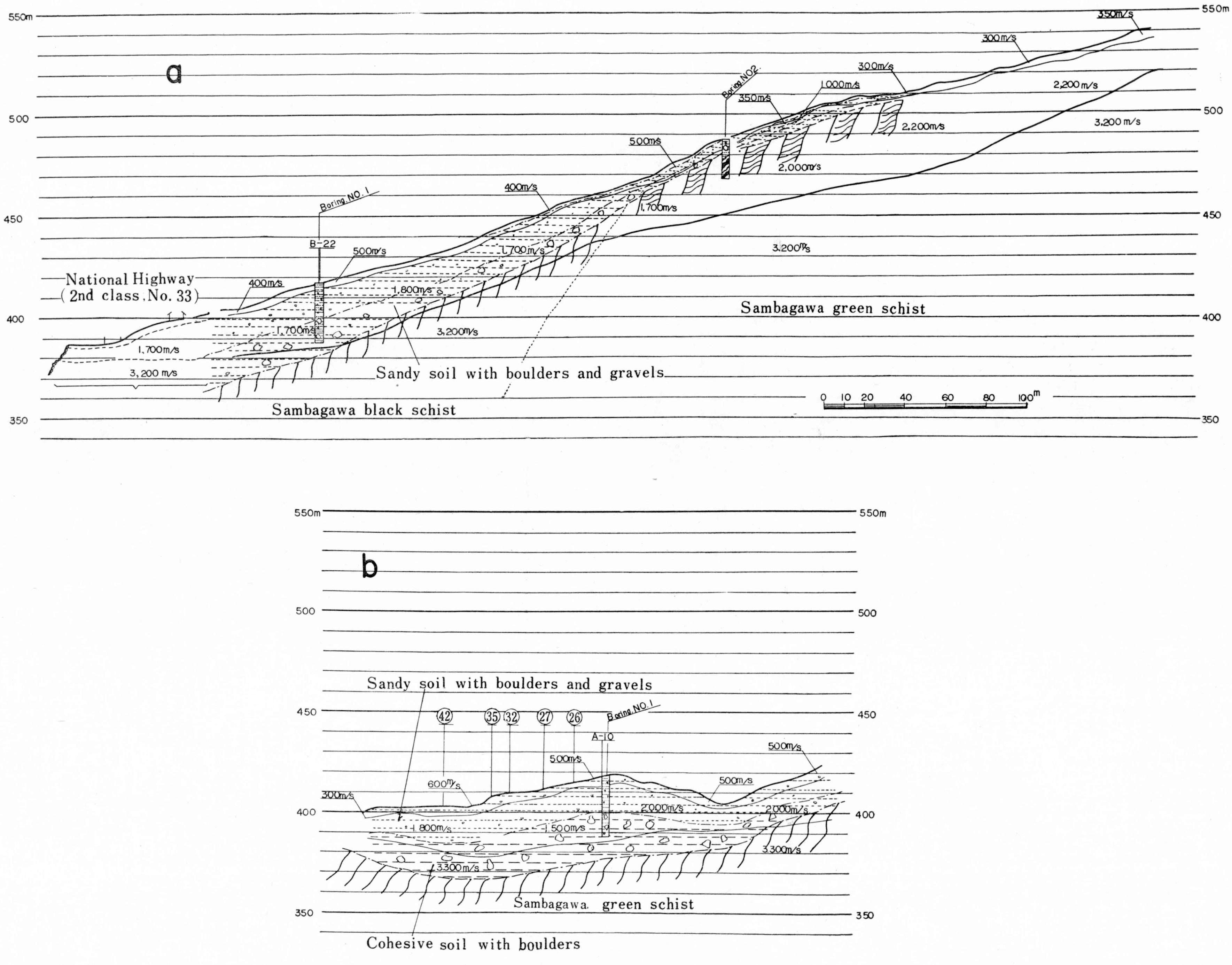

Fig. 5. a : Section normal to the slope at Mimido.
b : Section along the slope at Mimido.

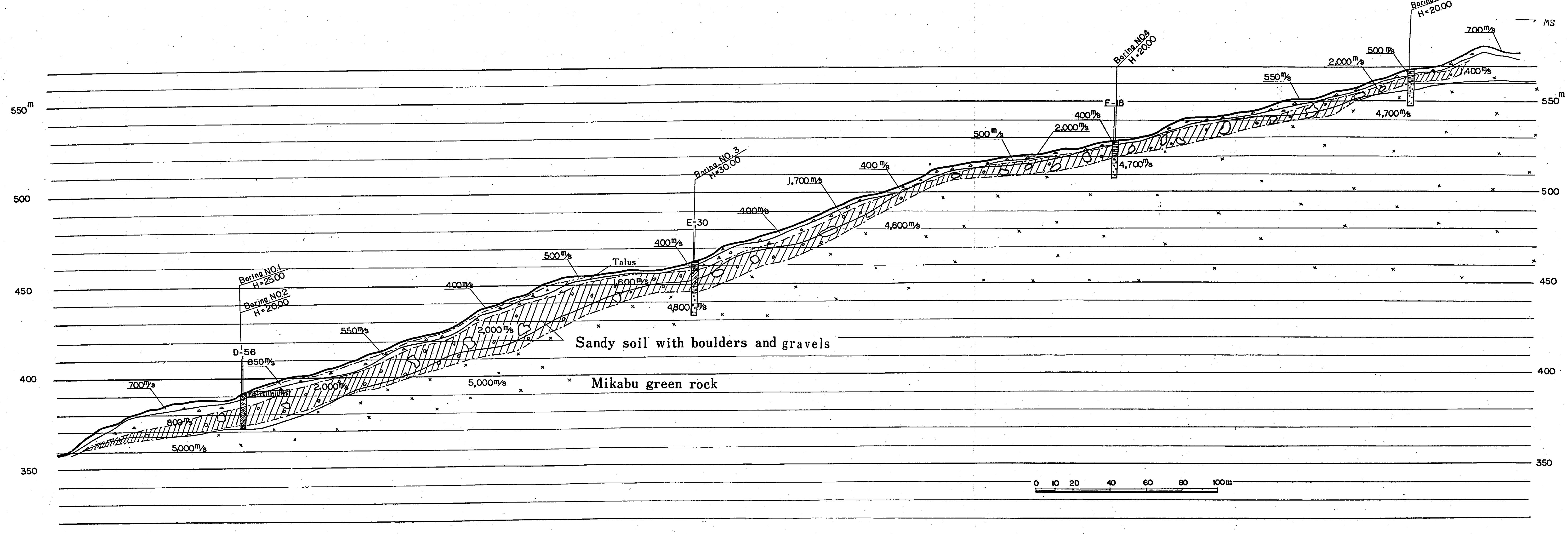

Fig. 6. Section normal to the slope at Nakaguroiwa.

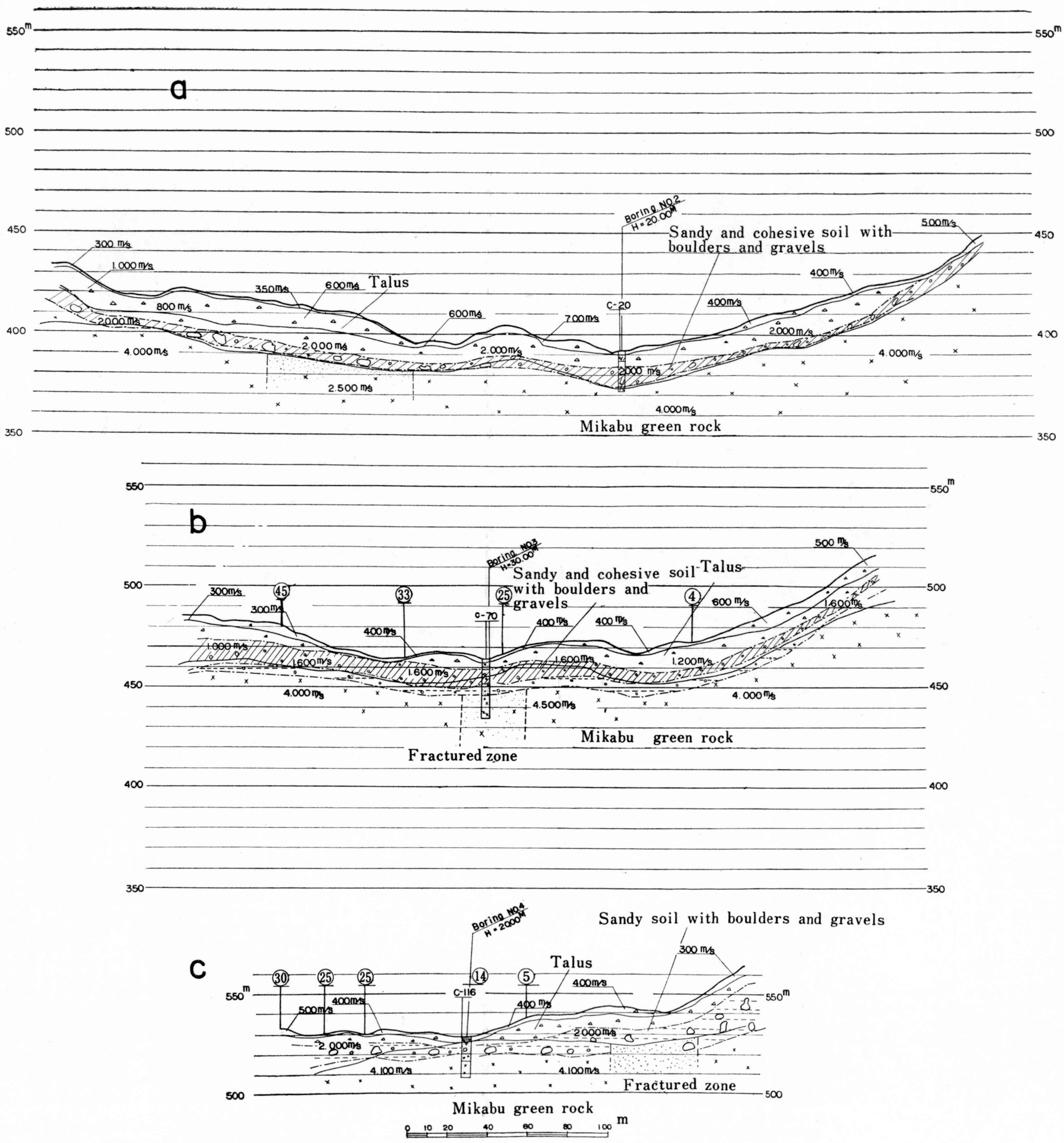

FIG. 7. a : Section on the lowest level along the slope at Nakaguroiwa.
b : Section on the middle level along the slope at Nakaguroiwa.
c : Section on the highest level along the slope at Nakaguroiwa.

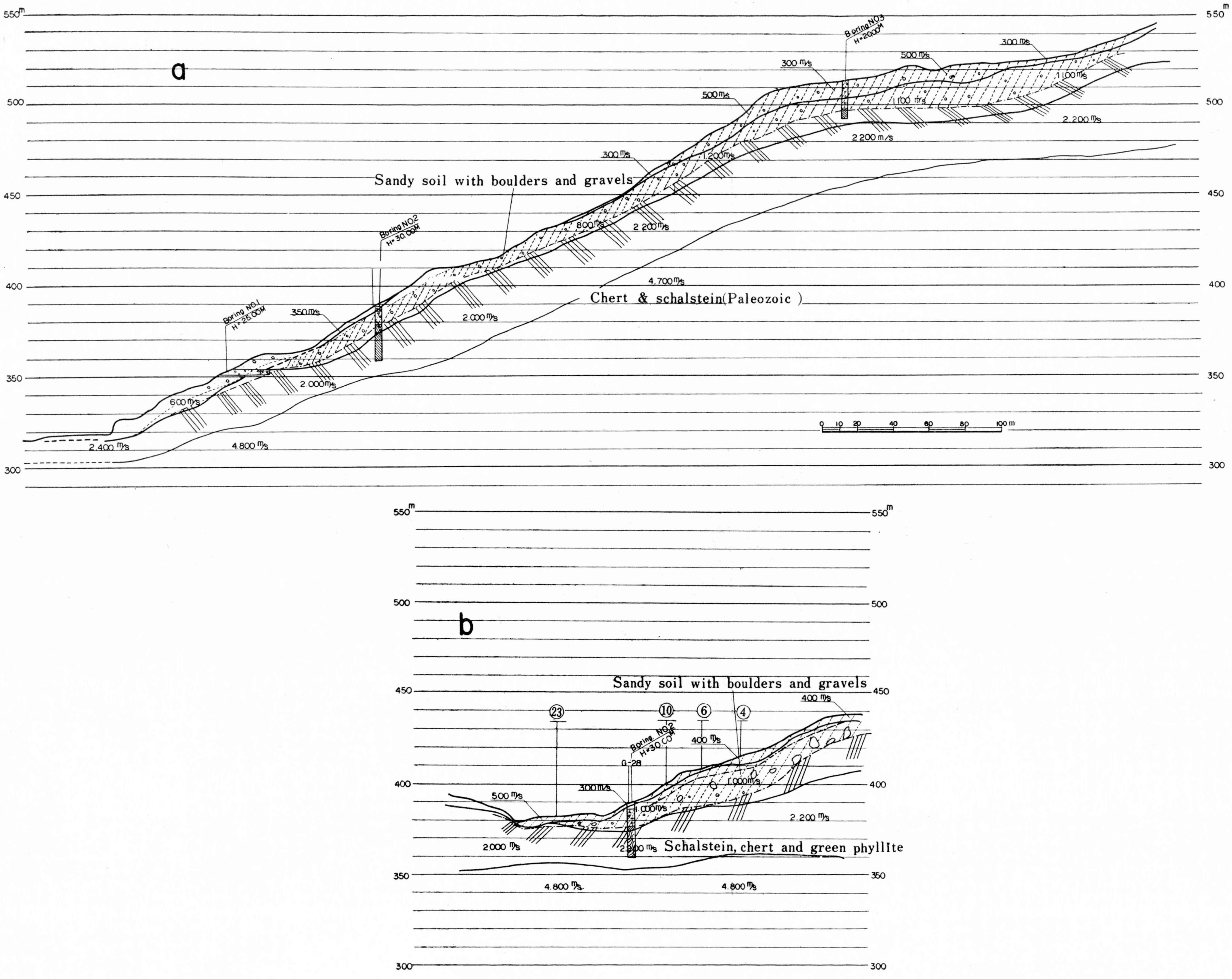

FIG. 8. a : Section normal to the slope at Kassen.
b : Section along the slope at Kassen.

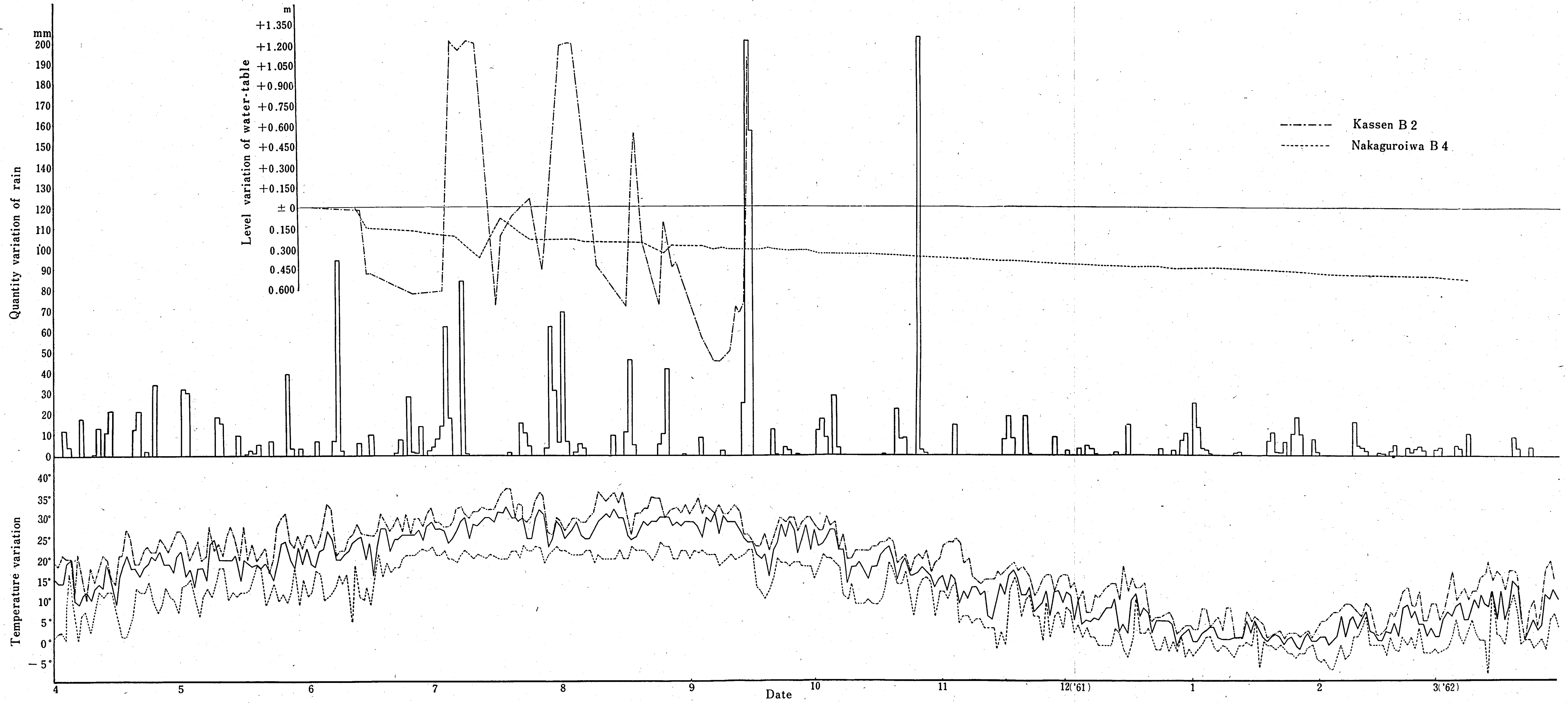

FIG. 9. Diagrams indicating the relations among anual variations of temperature, precipitation and water-table.

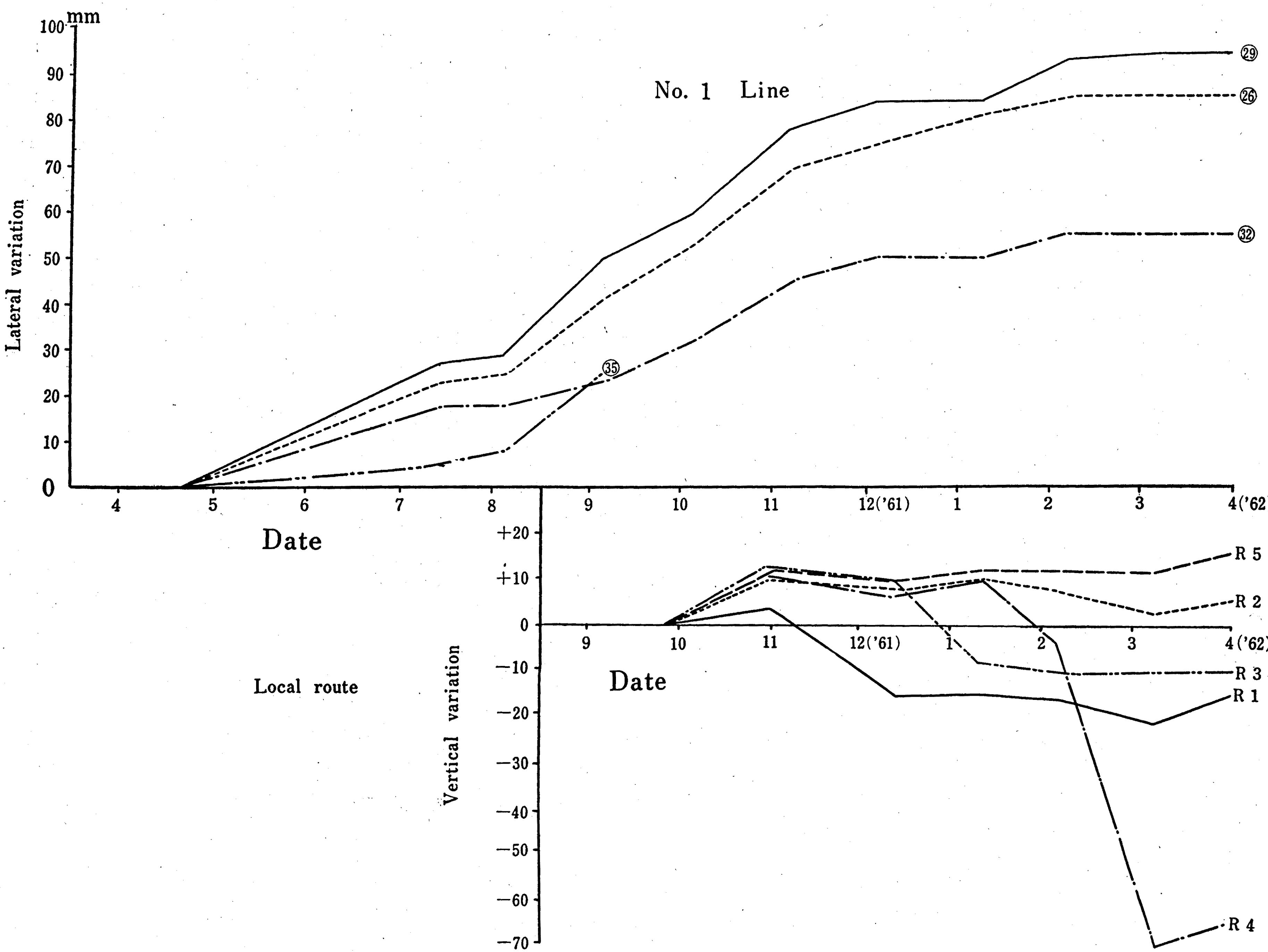

FIG. 10. Lateral and vertical movements observed in the Kassen area.
The data for variation at 29 and 35 on No. 1 line show the absolute ones recalculated under consideration of negative values happening to appear.

at the boring hole No. 4 in Nakaguroiwa area and at No. 2 in Kassen area. In the former case, a gradual descension of the water-table has, in no relation to the amount of rain, been ascertainable continuously during a definite interval of time and, in consequence, variation of the water-table as well as of precipitation is proven to have been indifferent to the land-sliding in the related terrain. In the latter case, however, a rapid ascension estimated 2 m in maximum difference has

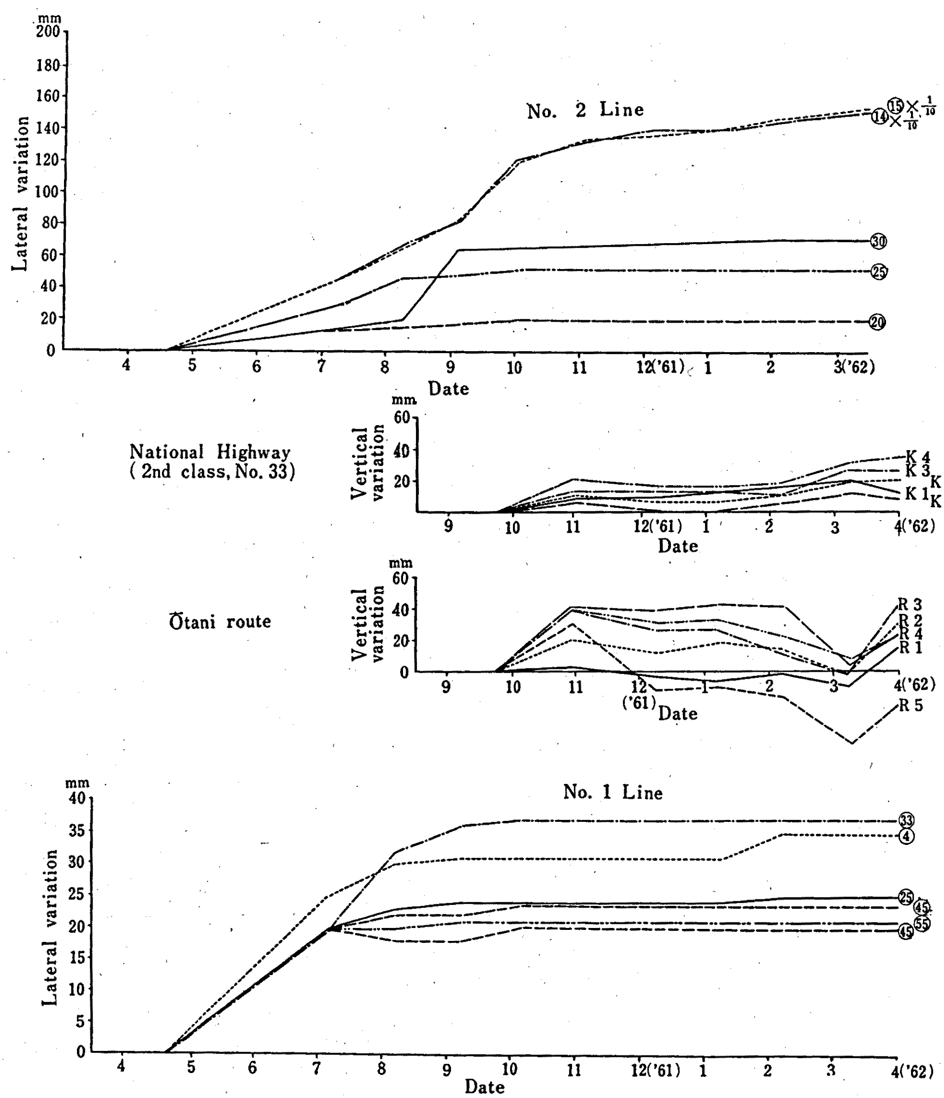

FIG. 11. Lateral and vertical movements in the Nakaguroiwa area.
The data for variation at 25 on No. 2 line show the absolute ones recalculated under consideration of negative values happening to appear, and those obtained at 14 and 15 are a tenth of the real values.

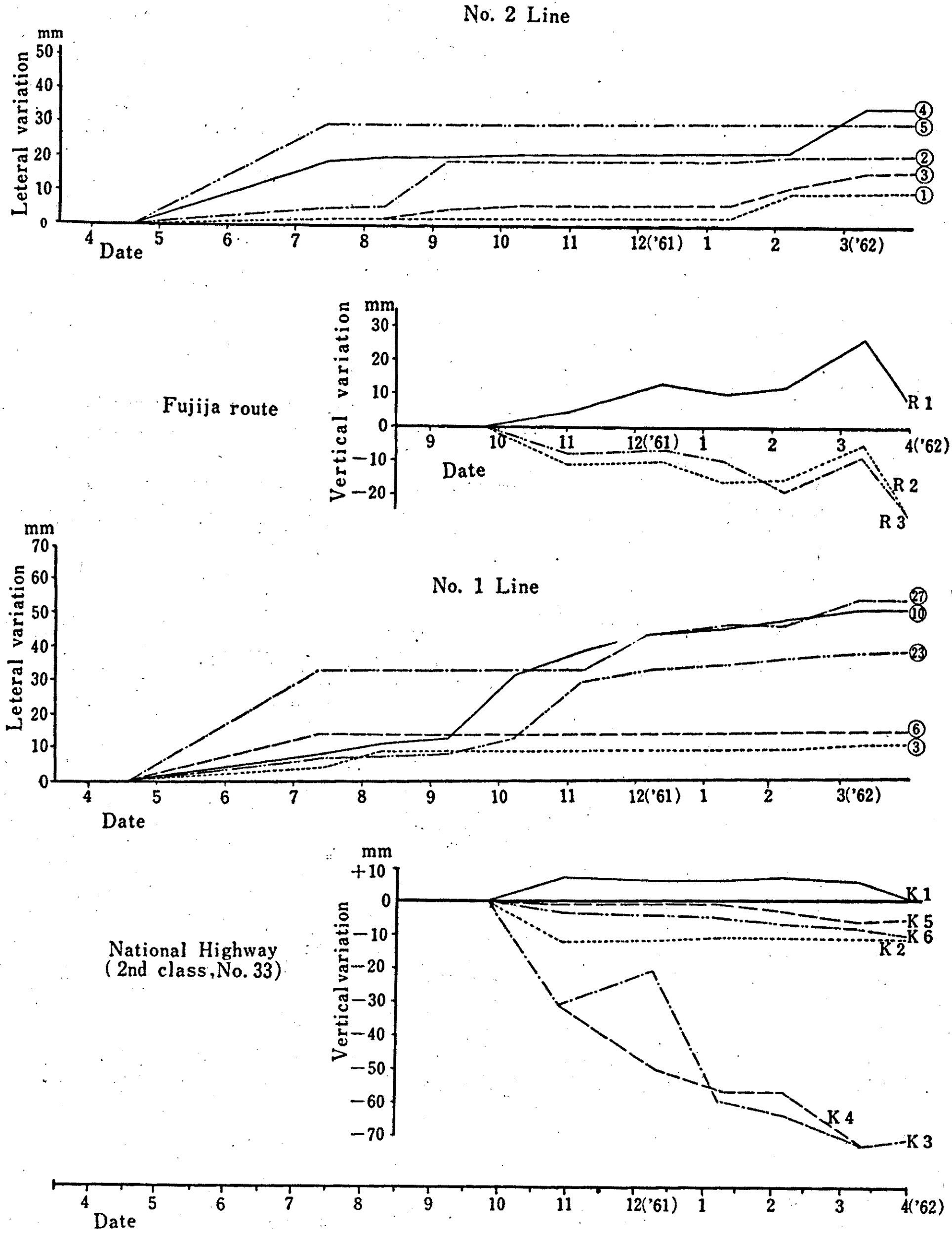

FIG. 12. Lateral and vertical movements observed in the Kassen area.

been recognizable almost simultaneously with precipitation surely owing to permeability resulted from composition of the talus deposits without clayey matters. Of due significance is that, in the Kassen area, parallelism of dislocation to precipitation has been conspicuous along a line since June till October and strikingly remarkable especially since September till November because of being overtaken by typhoons and accumulated precipitation.

(3) Examination concerning characteristics of cohesive soils.

In pursuit of the mechanical factors playing any role in the landslide, grain-size analyses based on the Mississippian rule together with determination of LL (liquid limit), PL (plastic limit) and PI (plasticity index) have preliminarily been put into operation cencerning a few specimens.

The representative data obtained are tabulated as follows:

Locality	Mimido	Nakaguroiwa	
		surface	underground
proportion of grainsize in %	Clay 14 Silt 20	Clay 47 Silt 10	Clay 20 Silt 15 Sand 32
Classification	Sandy loam	Clay	Sandy clay loam
LL in %	44.10	52.50	46.20
PL in %	17.02	25.94	14.42
PI in %	27.06	26.56	31.78

Inasmuch as the present data are too few to clarify the relation to the objective, it seems difficult to reach any conclusion. At any rate, inspection of the table indicates certain contradictions in that, inspite of less amount of clayey component, PI values illustrated in the first and third columns fall into the area of clay in classification; that for the second with more content of clay is less than that for the third; and, as far as PI merely is concerned, it follows that the third specimen is most plastic in property or, in other words, most unsuitable for sliding but comprises less amount of clay in grain-size analysis. Taking these relations into account, the above-mentioned or other associated factors provided ordinarily for soil engineering remain yet to be rescrutinized from pure scientific standpoint.

(4) X-ray analyses of clay minerals.

Examinations of clays by means of X-ray analysis accompanied with heat and reagent treatments have been executed restrictively for three specimens of the superficial soils obtained from the boring hole No. 2 in Mimido, from No. 4 in Nakaguroiwa and from No. 1 in Kassen.

(a) The data for untreated specimens are shown in Table 1 and Figs. 13, 14, and 15. In ordinary condition without any treatments, interplaner spacings representing chlorite, micaceous clay mineral, actinolite and quartz are, though in more or less amount, recognized in each specimen.

Table 1. X-ray Diffraction Data for Untreated Specimens.

Mimido		Nakaguroiwa		Kassen		Minerals identified
d (Å)	I	d (Å)	I	d (Å)	I	
14.4	48	14.4	23	14.4	9	C.
				10.0	25	M.
8.5	11	8.5	13			A.
7.1	59	7.1	37	7.1	26	C.
				4.97	13	M.
4.75	34	4.75	18	4.72	12	C.
				4.50	4	M.
		4.23	2			Q.
3.56	51	3.56	28	3.55	23	C. M.
3.40	2	3.39	3			A.
		3.34	6			Q.
				3.31	43	M.
3.28	5	3.28	3			A.
				3.25	4	
				3.21	4	M.
3.14	25	3.13	26			A.
2.95	4			2.99	5	M.
				2.86	4	M.
2.85	11	2.84	7	2.84	5	C. M.
2.71	4	2.72	6	2.70	3	C. A.
2.60	3	2.59	3	2.59, 2.58	4	C. M. A.
2.56, 2.54	3	2.55, 2.54	4			C. A.
				2.49	4	M.
		2.45				C. Q.
2.39	3	2.39	4	2.39	3	C. M.
2.34	3	2.34	3			A.

C.: Chorite, M.: Micaceous clay mineral, A.: Actinolite, Q.: Quartz
X-ray: CuKα with Ni filter, 30 KV, 15 mA.

(b) In case of the specimens from Mimido, the spacing of 14.4 Å reveals a little weakening in intensity with heating at 150°C but, after heated at 600°C for an hour, its intensity becomes contradictorily much stronger, broad and faint spacing of 9.6 Å is newly appered, and other ones are weaken. In consequence, presence of chlorite may, for the present, be deduced.

In case of the specimen from Nakaguroiwa, all spacings indicate almost no variation at 150°C but those other than 14.4 Å display a striking decrease in intensity with heating at 600°C for an hour.

In case of the specimen from Kassen, behavior of 14.4 Å is quite similar to that of the first specimen with heating, although, after heated at higher temperature for an hour, 10.0 Å discloses a gradual increase in intensity and 7.1 Å is completely

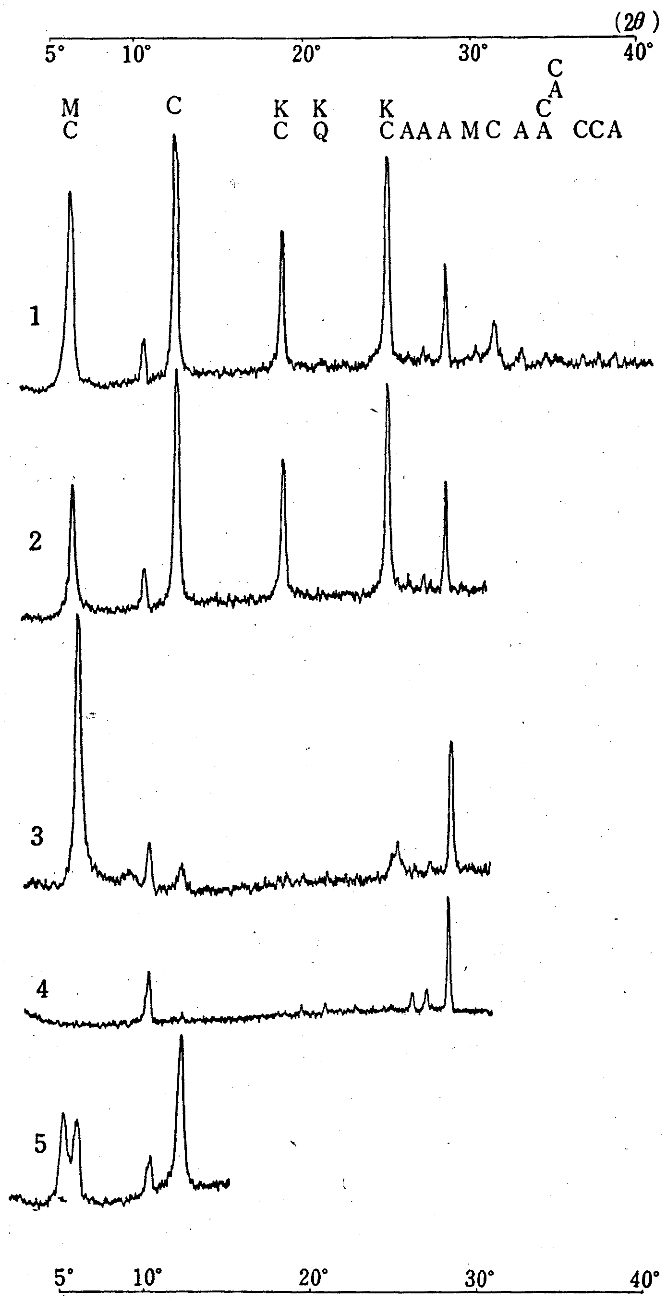

Fig. 13. The data for the specimen obtained from the Mimido area.
1. Untreated. 2. heated at 150°C.
3. heated at 600°C. 4. treated with HCl.
5. treated with ethylene glycol.

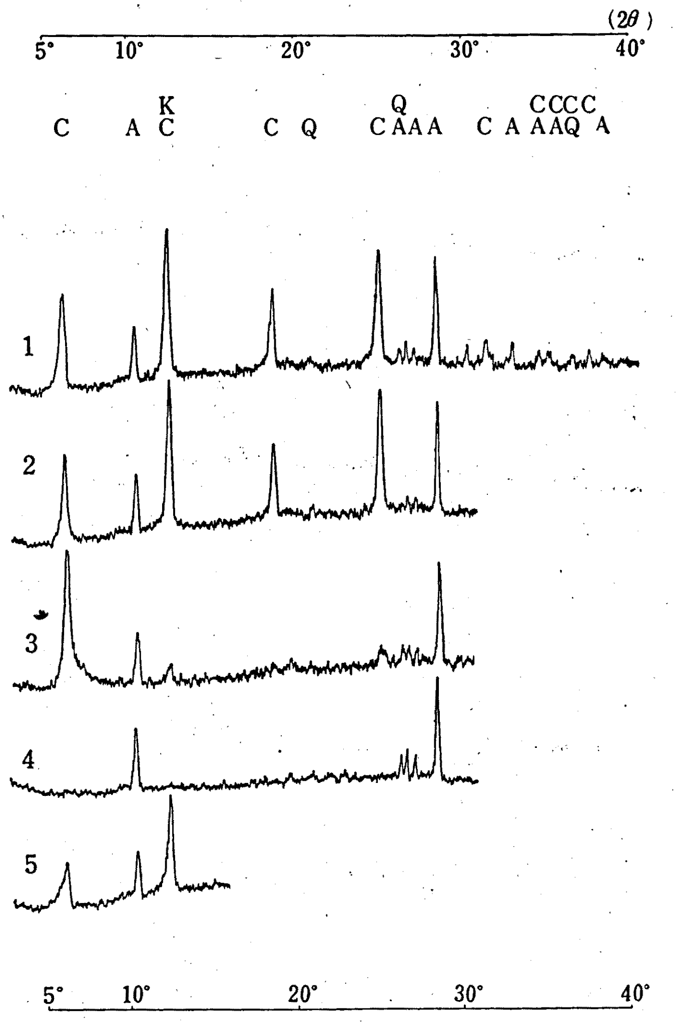

FIG. 14. The data for the specimen obtained from the Nakaguroiwa area.
1. Untreated
2. heated at 150°C
3. heated at 600°C
4. treated with HCl
5. treated with ethylene glycol.

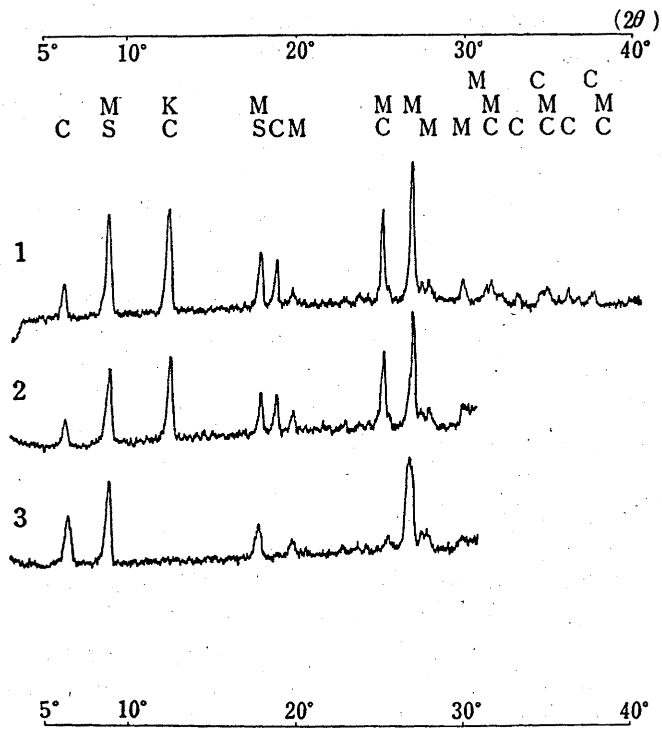

FIG. 15. The data for the specimen obtained from the Kassen area.
1. Untreated
2. heated at 150°C
3. heated at 600°C

vanished. This may suggest the coexistence of chlorite, micaceous mineral and kaolin group in the specimen concerned.

(c) After treated with HCl, 14.4 Å disappears and 7.1 Å faintly remains in the first specimen, indicating the mixing of kaolin in a little quantity. Treatment with ethylene glycol seems to take part in weakening of all spacings as well as in splitting of 14.4 Å into 16.8 Å and 14.5 Å. In view of this, actinolite, kaolin in a scarce amount, and chlorite with swelling feature are probably expectable.

HCl treatment for the second specimen causes a complete vanishing of 14.4 Å together with nearly perfect disappearance of other spacings excepting the remainder of 7.1 Å, wherefore presence of kaolin group in a few amounts is inferable. The effect brought about on the very specimen with use of ethylene glycol is almost same as that observed in the first case, pointing to the content of actinolite, chlorite with somewhat swelling character, quartz in a few amount, and kaolin in an extremely few amount.

Scrutiny with use of reagents regarding the specimen from Kassen area has been impossible on account of its scarce quantity.

In the limitted data alluded to above, remarkable differences in mineralic assemblage are not recognizable in the specimens picked up from respective areas exclusive of the content of actinolite (less) and micaceous mineral (more) in the last one.

V. Consideration

(1) The land-sliding so far emerged in the region under research is considered to have been caused by average, variable, and composite movements during a definite period and, as a matter of course, to have been controled mainly by composition, and construction, of the superficial geology as well as the associated conditions resulted from the structural and lithologic features, and the relief, of the basement rocks hidden beneath the mantles.

(2) It seems general that the sliding is, or might have been, liable to evolve more easily on the talus covering the scooped surface of the basal rocks and especially in the valley situating on the hollow of the basement than in other parts, while less content of clayey materials in the overlying deposits including the weathered rocks in depth and, accordingly, permeability of the mantle evidently afford more facilities for sliding.

(3) Though from a few data, it may be significantly deduced that the soil specimens bearing similar content of clayey matters or similar proportion in grain-size often reveal the different plasticity represented by, for instance, LL, PL, and PI whereas, contradictorily, those with similar plasticity indicate the different proportion of clayey component in grain-size. Moreover, it is also the fact that the same mineralic constituents happen to yield the different permeability but the similar permeability is sometimes derived from different minerals. For enlightening this, it seems requisite to determine the kind of clayey minerals contained in the soils and of ions or any others absorbed on the former.

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