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Geological and Geomorphological Factors at some Landslide Areas in Shikoku

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Abstract

From a geological and geomorphological point of view, the writer described some landslide areas, and pointed out their characters.

The one is an active landslide movement of high velocity and caused by a certain character of bedrocks and geological structures. This kind often causes a great deal of damage.

The other occurs at areas with the Quartarnary detrital deposits and exhibits a continuous landslide movement, which is not so violent as to cause damage to people and houses. The landslide activity of the latter mainly occurs in a buried topographical surface under debris and the depositional stucture of them. Seismic prospecting does not show so great a deference in seismic wave velocity between the deposits and the bedrock.

1. Introduction

It was stated that the landslide areas in Shikoku are concentrated at the zones of Sambagawa metamorphic rocks, Mikabu green rocks and Mesozoic Izumi group along the Median Tectonic line (Furuya, 1972).

In Eastern Shikoku, many landslide areas of the zone of Sambagwa metamorphic rocks, are found around the Northern and Southern Oboke flexure zones (Kojima & Mitsuno, 1966) mainly composed of pelitic schist, but such is never seen at Oboke anticline being composed of psammitic schist (apart from debris flow, rock fall and so on). In Western Shikoku, landslide areas are highly distributed at those places where basic and pelitic schist are widely distributed.

Landslide areas of the zone of Mikabu green-rocks are concentrated at the Minami Ogawa River basin and the Southern margin of the Motoyama basin etc., where

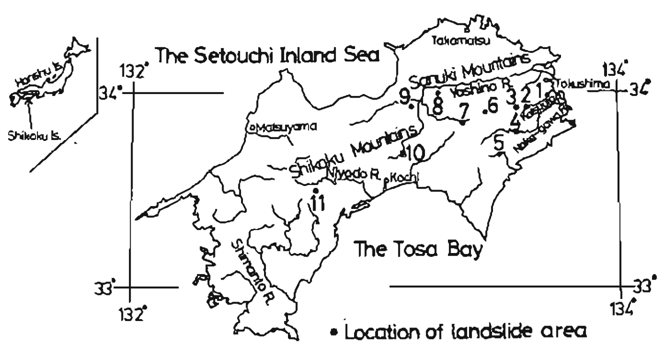

Fig. 1. Index map.

1: Hiura (Iitani-cho) 2: Hiura (Kamikatsu-cho) 3: Yamainu-dake
4: Takaiso-yama 5: Hose 6: Morito 7: Tairadani 8: Kuraishi
9: Shirakawa 10: Shigeto 11: Choja

Mikabu green-rocks are composed of pyroclastic flow deposits or fine-grained rocks (Suzuki, 1972).

Landslide areas of the zones of Mesozoic Izumi group are usually concentrated on the east facing slopes at the axis of bilge shaped structures with shale and sandstone alternation rather rich in shale.

The rock formations at the above cited areas, are abundant in fault, joints, cleavages and the like without exception. Thus the rocks are broken, though in a different extent according to the crustal movement. Based on such a rock condition, Koide (1955) named the landslide in Shikoku "shattered-zone type landslide".

Another condition of the landslide area is thick and wide detritus deposited on the bedrock. Nakamura (1955) stated that detrital materials have something to do with landslides. The writer has investigated several landslides in Shikoku based on this idea, and the results are presented in the present paper.

2. Geological and geomorphological conditions of each landslide area

Some investigators have reported about the geological conditions of the landslide areas. Summing up their opinions, fractured bedrock formations and covering thick deposits of debris are responsible for landslides.

As examples of landslides within bedrock formations, Mt. Takaiso landslide (Terado, 1970) and Shigeto landslide are pointed out. Both belong to the Chichibu zone. The former occurred at the midstream of the Naka River basin in 1892, the latter at the Ananai River basin, a tributary of the Yoshino River, in 1972, along highway Route 32. Furthermore, there are Hose and Yamainu-dake landslides (Terado, 1975). Hose landslide in the Shimanto zone occurred at the upstream of the Kaifu River in 1892, and Yamainu-dake landslide in the Chichibu zone occurred in 1701.

As examples of landslides within detrital material deposits, Morito and Kuraishi landslide in the Sambagawa metamorphic zone, Tairadani landslide in the Mikabu zone and Choja landslide in the Kurosegawa tectonic zone are cited. The details of these landslides are as follows.

1) Mt. Takaiso landslide

It is near the Nagayasuguchi reservoir at the midstream of the Naka River. The landslide was closely examined by Terado (1970). According to his report, it was caused by a heavy rainstorm which came on with the typhoon that struck Shikoku from July 22 to 25, 1892. It is one of the biggest landslides ever to have occured in Shikoku. The volume of earth which slid down is said to have amounted to approximatedly 4.3×10^6 m^3, by which the Naka River was dammed up into a natural reservoir. Two days later, the dam was broken, and the downstream area suffered great damage.

As to the landslide the following is noteworthy: 1) the landslide was initiated on the top of Mt. Takaiso 600 m above sea level, 2) the remains of the mountain top looks like a "knife ridge", 3) many blocks pushed to the river side measure about five meters in diameter, 4) there are now talus cones with their tops about 500 m high and water springs at a height of 330 m, discharging from not so thick talus deposits. These facts show that the landslide began within rock formations.

This area is geologically composed of alternated sandstone and shale of the

Mesozoic Harumori group. Butsuzo-itogawa tectonic line runs a few hundred meters away south of Mt. Takaiso. Accordingly, the formations are greatly distorted and fractured. They have a dip of about 70°N. The deposits thrusting up across the river are composed of crushed rocks, which are smaller angular shale and larger angular sandstone, chert and limestone. From these factors, Terado (1970) thinks that the original landslide occurred at fractures within the shale layer.

Now it is difficult to judge whether the character of the initial rupture surface of Mt. Takaiso landslide was bedding plane, joint plane or fault plane, because it is covered with talus deposits and fairly weathered. However, Terado's idea will be supported based on landform and remaining deposits of the area, that is, fractures within rock formations may have been a cause of Mt. Takaiso landslide.

2) Hose landslide

The Hose landslide is located at the right bank of the upstream of the Kaifu River. In the same way as Mt. Takaiso landslide, it was caused by a heavy rainstorm accompaning the typhoon in 1892. The area of collapse is estimated to be about 2.3×10^5 m^2, and the assumed thickness of slide mass is 10 m on average, its volume would be estimated to be about 2.3×10^6 m^3. Three houses on the left bank of the Kaifu river were buried by the landslide, and paddy and upland fields of about 4 ha were also destroyed. Furthermore, thirty six persons and three horses were buried alive. Landsliding detrital materials dammed up the Kaifu River and formed a

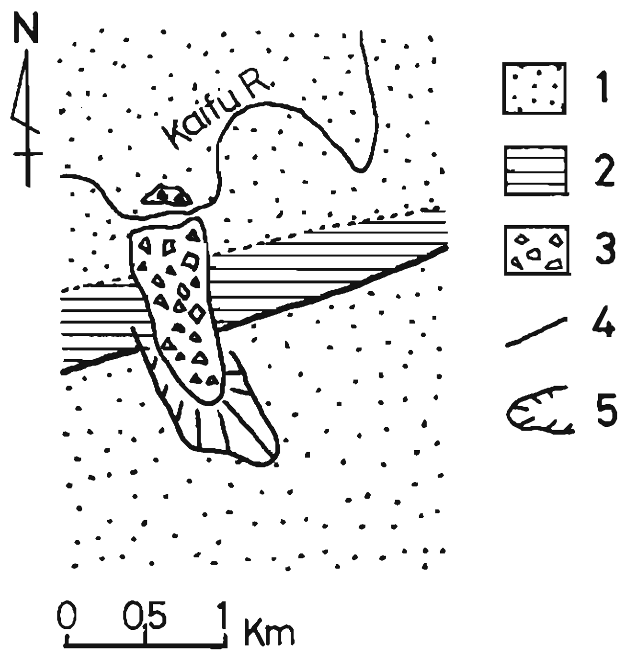

Fig. 2. The geological outline of Hose landslide area.

1: Sandstone rich formation 2: Mudstone rich formation 3: Detrital material deposit 4: Fault line 5: Landslide scarp temporary natural reservoir, which reached 5.5 km upstream, and eight houses were washed away by current. The reservoir broke the next day and the whole downstream drainage suffered flood and damage. Embankments were broken by the flood, and paddy and upland fields were washed away or buried by debris. The state of damage shows unexpected occurrence of landslide and rapid transportation of collapsed materials.

The landslide area is geologically composed of the upper Cretaceous Mugi formation of the Shimanto zone. The Mugi formation consists of alternated sandstone and mudstone, but is richer in sandstone. The area of Hose landslide is of sandstone and mudstone layers (Fig. 2). This area is located on the westward extension of Hose — Izari fault line (Tokushima Pref. 1972), and the fault is thought to pass through a mudstone layer at the center of the landslide, as observed from the disturbance of the formation. The strike of the formation is about N 80°E, and the dip about 75°N. The strike and dip of the fault are about N 80°E and 90°N.

The landslide occurred on the north facing slope 550 m above sea level, and spread to the direction of about N 80°E. The main slide scarp was between 500 m and 350 m in height. Collapsed materials were deposited between 350 m and 130 m above sea level on the bank of the Kaifu River. The main scarp is composed of a rock formation which was rid of slide. The east-facing part of the scarp gouged by the landslide, looks like "knife ridge" and the slid materials composed of sandstone and mudstone blocks, are not filled up.

The original factors which caused the landslide are not defined from the abovementioned findings. Perhaps, at first a part of the mountain top slid down because of heavy rainfall brought by a typhoon, which then developed into a crevice in the rock formation under the influence of the Hose — Izari fault.

3) Mt. Yamainu-dake landslide

This is located on the south facing slope of Mt. Yamainu-dake 1 km west of Ikumi landslide area. It began to collapse after seven days of heavy rain in 1701 (Fig. 3). The landslide scarp, ranging 600 m in width, is horse-shaped opening to the south, and the scarp has the altitude of about 130 m and slopes steeply from 60° to 70°. The western part of the ridge like a "knife ridge", and it seems that the landslide began at that part (Fig. 3). The detrital deposits named "Tsuka" in front of the landslide scarp are composed of blocks about 5 m in diameter. They have the appearance of a block field. The landslide is about 9.2 ha in area, and the detrital deposits are estimated to be about 2.5×10^6 m^3 in volume. This landslide area is geologically composed of sandstone, mudstone, schalstein, chert, etc, but strike, and from 40°N to 85°N in dip. Prominent fault structure is not recognized in this area. The landslide scarp is mainly composed of schalstein. The crown of the landslide nearly coincides with the boundary between schalstein and chert.

The geological factors of this landslide are thought to be as follows: 1) The first collapse probably began at the opning of the joint plane between chert and schalstein formations by the permiation of groundwater related to heavy rainfall. 2) Deep weathering of rock formations on the ridge of Mt. Yamainu-dake was not so effective to the slide, because the detrital materials are mainly composed of big boulders.

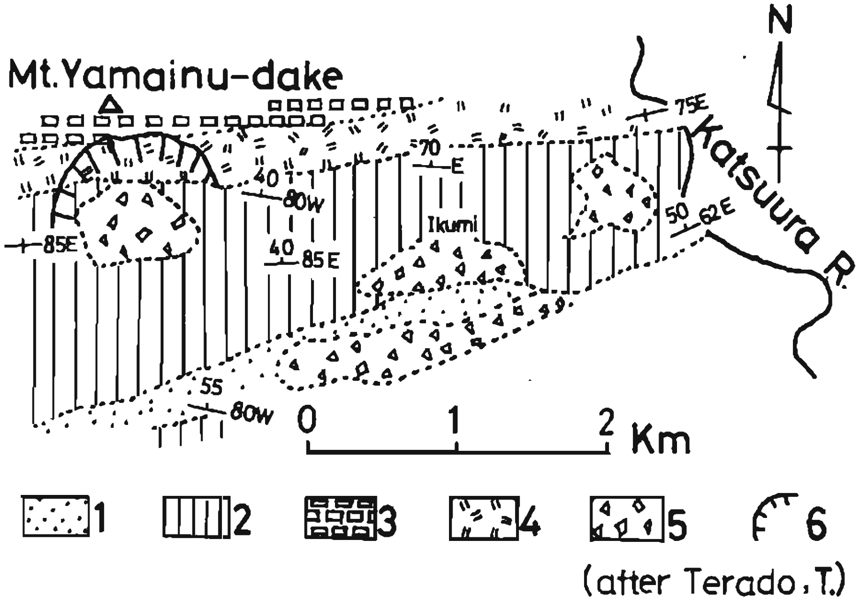

Fig. 3. Geological map of Yamainu-dake landslide area and its environs.
1: Sandstone 2: Mudstone 3: Chert 4: Schalstein 5: Detrital material deposit
6: Landslide scarp

4) Shigeto landslide

The Shigeto landslide occurred af the ridge of Mt. Oimawashi located midstream of the Ananai River, a tributary of the Yoshino River, Sixty persons were killed in this disaster as in the case of Mt. Takaiso landslide. Many workers have investigated and reported on this landslide.

Mt. Oimawashi, geologically consists of slate, in part sandstone and chert, which belong to the Kamiyakawa group of the Palaeozoic Chichibu formations, the strata are east-west in strike and 45°N in dip. Joints are much developed and intersect the strata. The sandstone layer show disturbance at the unconsolidated stage of strata, while the absense of noticeable crushed rock may mean the stability of strata since it has consolidated.

The landslide area is geologically composed of a slate layer and, in places, blocky sandstone layers. The rupture surface cuts the rock formations and is uneven. It is weathered strongly in the upper part, but little in the lower part. No clay is found around the landslide scarp. Much water gushes out of three fissures on the scarp (see photo 1). Detrital materials are deposited at the foot of the scarp, keeping trees tilted on the surface (see photo 2). Around the boundary of rupture surface and slid mass there were many blocks about 50 cm in diameter composed of sandstone and slate. Many cars and peaple were pushed away to the toe of the landslide, which reached as far as the river (see photo 2). On the basis of these facts, Shigeto landslide may have occurred along weaker fissures inside the rock formations.

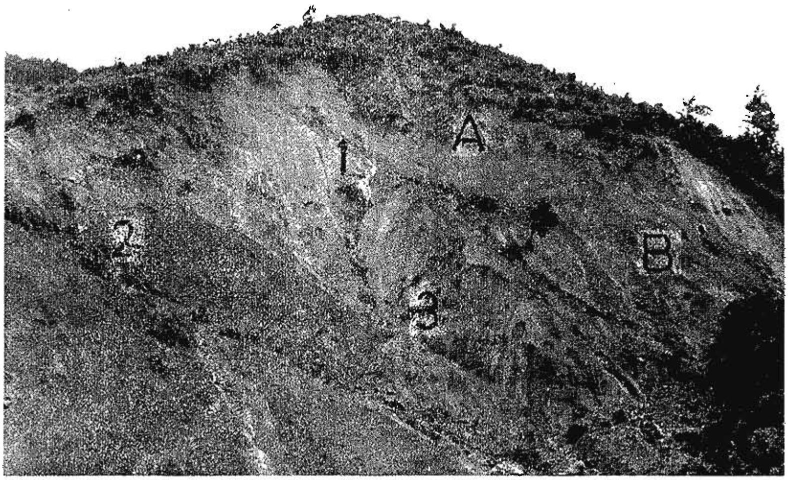

Photo 1. The upper part of Shigeto landslide area.
1∼3: Gushed water A: Chert B: Slate

Photo 2. The lower part of Shigeto landslide area.
1: Car 2: Train 3: People 4: The Ananai River 5: Debris 6: Railway

5) Morito landslide

This is located on the left side of the Koyadaira River upstream of the Anabuki, a tributary of the Yoshino River. The surface movement dates back to 1889 and 1938, and at the latest remarkable activity was in 1957 the road between Kawai and Anabuki was sunk and destroyed in part. At present some house based and breast-walls are deformed or fissured along the road near the tip of the landslide. Although the outside lank surface is a little deformed and in some places slopes about 25°, the lower part of the landslide area, east of the Morito-Hachiman shrine, is composed of a flat surface between 490 m and 510 m above sea level, which resembles a terrace surface.

Above the former surface is a talus slope, which stretches between 510 m and 630 m. At the height of more than 630 m a steep landslide scarp is seen, which looks like a cirque. The slid mass from 1957 is at the height of 490 m to the west of the Oshima-dani rivulet running through the landslide area.

The landslide area and its neighborhood are at the left bank of the Koyadaira River, whose left bank belongs to the Sambagawa zone while the right bank belongs to the Chichibu zone. The landslide area consists of pelitic schist of the Kashidaira formation, which belongs to the Sambagawa zone and the basic schist which is thought to be a part of Mikabu green rocks (Kenzan Research Group, 1963). The strata is east-west in strike and $10°\sim20°$N in dip, and the dipping direction equals the slope of the landslide area. The basic schist layer, perhaps of Mikabu green rock, occupies the upper part beyond 630 m. The schistosity around the basic schist layer is in part well developed, but in general it is crushed along the joint fissures. The debris from the layer contains great deal of large massive rocks. Further weathered, it will change into greyish-green colored clay. The lower part of the landslide area is composed of pelitic schist (with well developed schistosity). It is noticeably crushed at the height of 480 m to 530 m. This rock formations are the main source of debris.

Investigations by means of boring revealed thick detrital material deposits covering the bedrocks (Fig. 4,5). They are mainly composed of angular boulders of basic and pelitic schist supplied from the bedrocks. The openings between angular boulders are filled up with clayed or loamy soil. The depositional structure is composed of debris, clay and loamy soil, which lie side by side in an alternative order, showing the depositional structure of talus deposits. A buried beech gave the radio-carbon date of 15,400 yrs. B. P. (Lin & Yamaguchi, 1970), which was buried at the landslide. Other samples from Taira-shimo landslide area, Tokushima prefecture were dated older than 37,800 yrs. B. P. (N–1652, N–1692).

The detrital material deposits are distributed as in Fig. 4, which shows the subsurface structure clearly. The Morito landslide is active in part at the detrital materials. Especially, there was marked activity from 1953 to at the outlet of the valley which

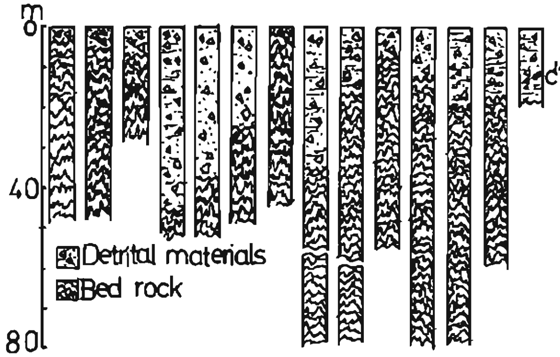

Fig. 4. Geological columnar section at Morito landslide area.

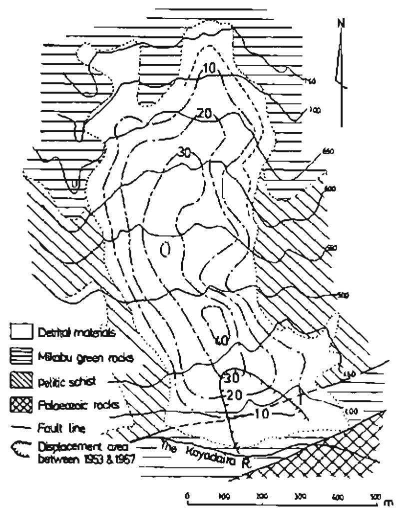

Fig. 5. Bedrock surface under a detrital materials at Morito landslide area.

is buried under the detrital material deposits, when they had not influenced to the bedrocks at the Koyadaira river bed and around.

6) Choja landslide

It is located at the midstream of the Choja River, a tributary of the Niyodo River. It is among the shattered-zone-type landslides well known for their conspicuous surface deformations. In its recent activity, it caused great damage along with the attack of typhoons in 1890, 1963 etc. Its tip reaches to the Choja River, resulting in a great change in the course of the main stream, which is a rare case. The area is about 200 m wide and 1 km long. The boundary line between the landslide scarp and the stable flank of the sliding mass can be clearly drawn. The latter is clearly bordered by a small tributary of the Choja River. There is a wide drainage basin to the south-east outside the displaced mass, spreading to the upper part of the east side.

The landslide area is within the Kurosegawa structure zone, and is composed of Palaeozoic slate, serpentinite and the lenticular body of Mitaki plutonic rocks. The major landslide occurred at the boundary between Palaeozoic slate and serpentinite and the boundary is composed of detrital material derived from both sides, the subsurface depositional structure of which is shown in Fig. 6,7. The detrital material are divided into two groups according to the origin of debris. One is mainly composed of serpentinite, and the other chiefly of slate, while the former is distributed deeper beneath the upper landslide area, and the latter is deposited thickly at the west of the sliding mass. The displacement on and below the ground surface has been investigated successfully (Kochi pref., 1972). The surface is grossly displaced at the east side of the landsliding mass. The rupture of surface exists along the boundary between the bedrocks and the detrital material deposits. Ground water is concentrated at the east of the sliding mass in consideration of water levels at boreholes and drainage condition in seven catchment wells, which were artificially set within the landsliding area (Fig. 8). This is consistent with the extensive distribution of

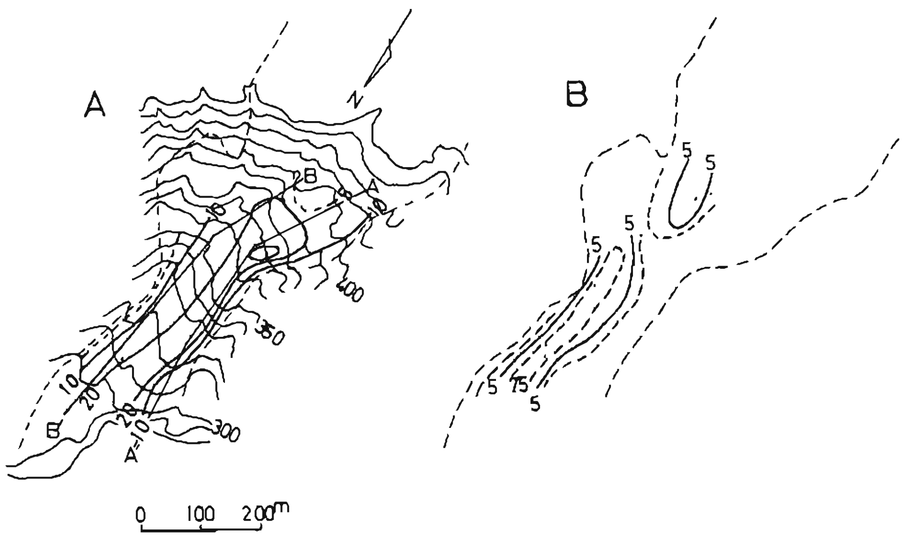

Fig. 6. Subsurface landform at Choja landslide area.

A: Buried bedrock surface by detrital materials B: Buried topographical surface by detrital materials derived from surpentinite A — A, B — B show the locations of geological profile showing Fig. 5.

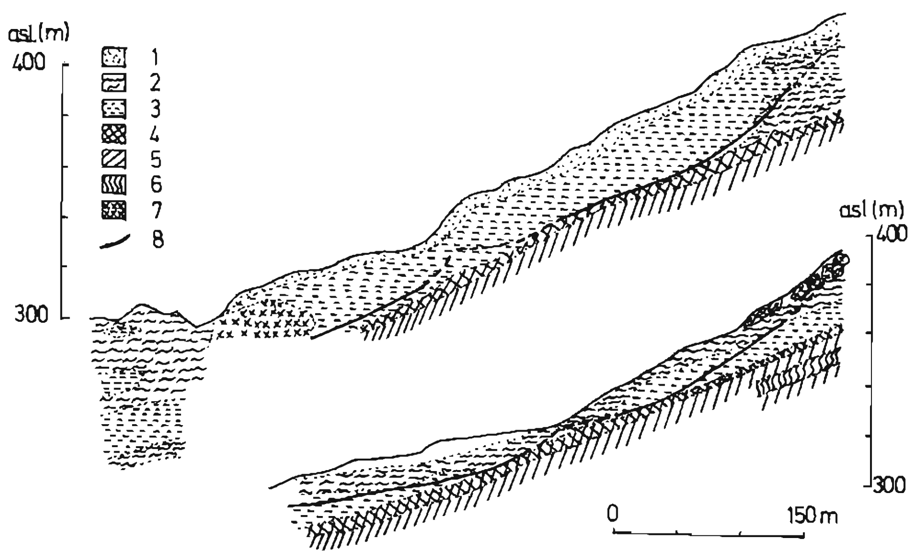

Fig. 7. Geological profile at Choja landslide area (after Kochi Pref., 1972).

1: Surface soil 2: Debris mainly derived from surpentinite 3: Debris mainly derived from slate 4: Weathered slate 5: Slate 6: Surpentinite 7: Mitaki plutonic rocks 8: Presumed slide surface

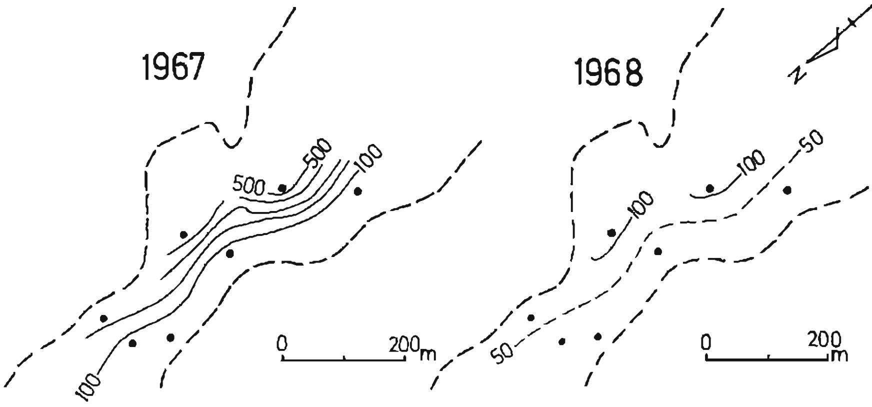

Fig. 8. Distribution of mean drained groundwater in 1967 and 1968 values are shown by l/min.

detrital material supplied from surpentinite.

As described above, a series of relations among detrital mateial, subsurface, drainage basins, groundwater and landslide displacements are represented in the Choja landslide area.

7) Kuraishi landslide

The landslide area, which is at the right bank of the Inouchi-dani river basin, a tributary of the Yoshino River, has been appointed a landslide-prevention area.

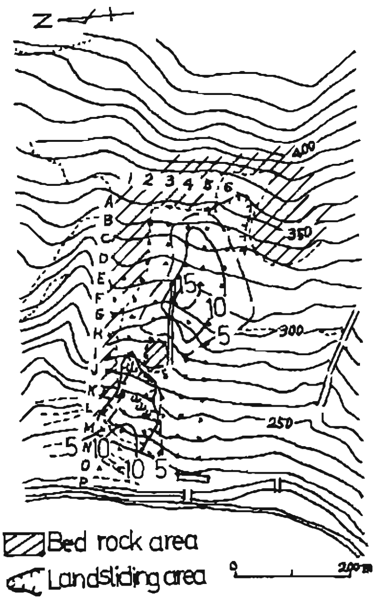

Fig. 9. The map showing a buried topographical surface, measured point of electric prospecting, and active landslide area.

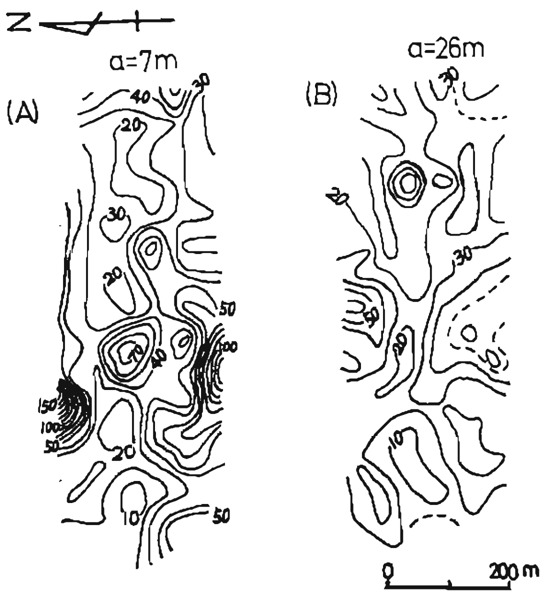

Fig. 10. The Distribution map of apparent resistivity values at Kuraishi landslide area. The map showing the distribution of apparent resistivity values of seven and twenty six meter in depth.

Geologically, the area is mainly composed of pelitic schist of the Sambagawa metamorphic rocks, and partially of basic and siliceous schist. They are covered by detrital materials, i. e. Quatarnary unconsolidated deposits.

This is a potential landslide area. When farming road was enlarged in 1968, a small landslide occurred at the lower part of the area. The geological investigation by means of drilling, electric prospecting and surface observation brought the following results. Electric prospecting detected a valley-like irregularity under the detrital material by showing a low value of specific resistance (Fig. 9, 10). As a result of boring and field investigations, a subsurface valley buried under the ground is expected. The active landslide is situated at the outlet of the subsurface valley and the slip surface is supposed to exist around the boundary between the bedrocks of pelitic schist and the detrital material deposits. Moreover, the percolation of ground water is observed under the main scarp at the upper end of the moving mass, hence the moving mass seems to be highly water soaked. As above, landslide activities seem to be related to detrital material, subsurface valley and groundwater.

3. Relationship between weathered rock and landslide

Needless to say, the weathering of a rock layer is responsible for landsliding. Thus, seismic prospecting is often used in order to know weathered conditions and ground strength. The quality of ground is evaluated by the propagation velocity of seismic waves. In the present paper, the response of bedrocks and detrital material to the seismic prospecting by Tokushima pref. (1971, 1972, 1973) and the Agency of Forestry (1965) at some landslide areas will be described.

1) Hiura landslide (Iitani-cho)

This landslide area is located at the left bank of the Hiura River, a tributary flowing into the Katsuura River. The drainage basin is geologically composed of sandstone, mudstone and diabase, which belong to the Chichibu zone, and the area is covered with detrital materials. The seismic prospecting distinguished four kinds of layers with seismic wave velocities of 0.3~0.6 km/sec, 0.8~1.5 km/sec, 1.8~2.5 km/sec and 3.8~5.8 km/sec (Fig. 11, 12). The low velocity layers of 0.3~2.5 km/sec are in

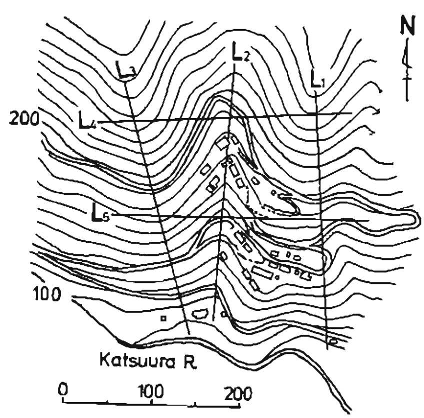

Fig. 11. The map showing the topography of Hiura (Iitani-cho) landslide area L_1 — L_5: Measuring lines of seismic prospecting.

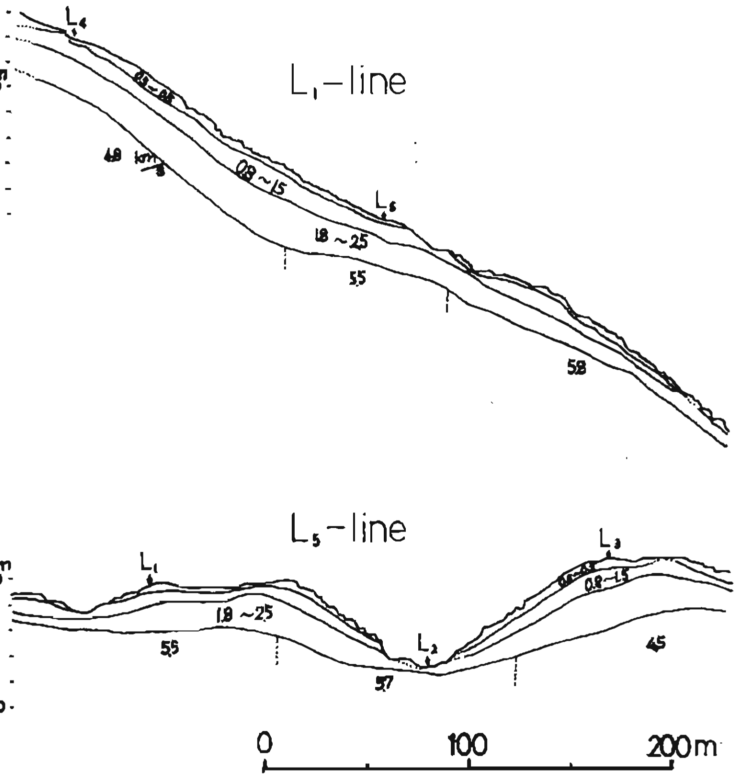

Fig. 12. Underground profile by seismic prospecting at Hiura (Iitani-cho) landslide area. Measuring lines are shown in Fig. 11. (after Tokushima Pref., 1973).

general detrital materials and weathered layers. The high velocity layers of 3.8~5.8 km/sec are hard bedrock based on these facts and possibility of landslide, the layers are divided into two groups: low velocity group (0.3~2.5 km/sec) and high velocity group (3.8~5.8 km/sec). By careful examination of underground structure down to the bedrock debris or weathered bedorck are certain to the depth of 30 m, sometimes of 60 m. The surface features such as convexity of ridge-like are related only to low velocity layers not to bedrock.

2) Hiura landslide (Kamikatsu-cho)

It is located at the left bank of the Katsuura River and a part (25 ha in area) of the Katsuura-gawa structural basin. It is geologically composed of mudstone, sandstone, conglomerate etc. which belong to the Cretaceous Hanoura formations. Mudstone and sandstone alternate. Mudstone is soft and well stratified, and rich in lamina, and sandstone, a kind of so-called hard sandstone, is developed in joint.

Underground layers are divided through the seismic prospecting into three: detrital material (0.3~0.5 km/sec), heavily weathered bedrock (1.9~2.1 km/sec) and unweathered bedrock (3.7~5.1 km/sec) (Fig. 13, 14). The last one is stable and on the average 30 m~40 m in depth. The surface features are related to the low velocity layer, which is thinner at the valley and thicker at the ridge. It noteworthy that unweathered bedrock has sometimes exceptionally velocities.

3) Tairadani landslide

Occurence are at the left side of the upper Iya River. The slid mass reached into the river bed, and remarkably heightened it at the upstream side, moreover greatly damaged the dam built on the river bed to prevent debris. The area is geologically composed of the Mikabu green rock and the landslide area is covered with clayey material and detrital material derived from the bedrock.

Seismic prospecting gave five layers: surfacial soil (0.3 km/sec), detrital material (0.6 km/sec), wet detrital or upper weathered layer (1.0～1.5 km/sec), lower weathered layer (2.0～2.5 km/sec) and unweathered bedrock (4.5～5.5 km/sec) (Fig. 15, 16). The layers between 0.3～2.5 km/sec, which seem to be related to landslide is 20 m to 50 m thick in general, however it measures 70 m at the thickest and rather thinner at the valley. The seismic wave velocity of 2～3.2 km/sec observed at many points within bedrock may indicate shattered or fractured zones.

4) Shirakawa landslide

It is located at the left side of the Shirakawa Valley, a tributary of the Yoshino River. The landslide area and its environs belong to the Sambagawa metamorphic zone mainly composed of psammitic, pelitic and basic schist etc. As to the geological structure, a synclinal axis runs along the Shirakawa Valley, and the inclination of valley wall is in accordance with the dip of strata. The area is covered with thick detrital material.

The underground structure is divided into four layers with seismic wave velocities of 0.2～0.4 km/sec, 0.4～1.2 km/sec, 1.2～3 km/sec and 3～5.5 km/sec (Fig. 17, 18).

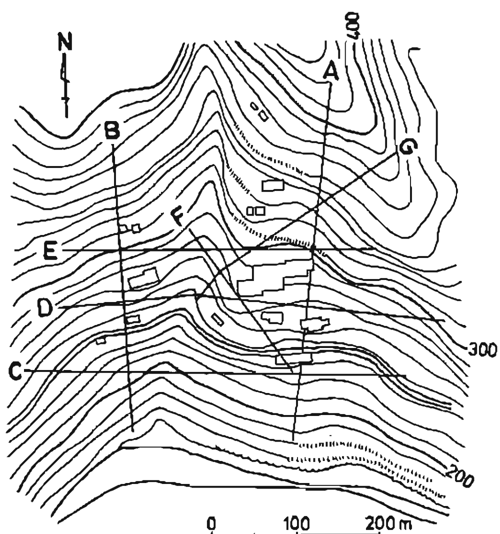

Fig. 13. The map showing the topography of Hiura (Kamikatsu-cho) landslide area
A — G: Measuring lines of seismic prospecting.

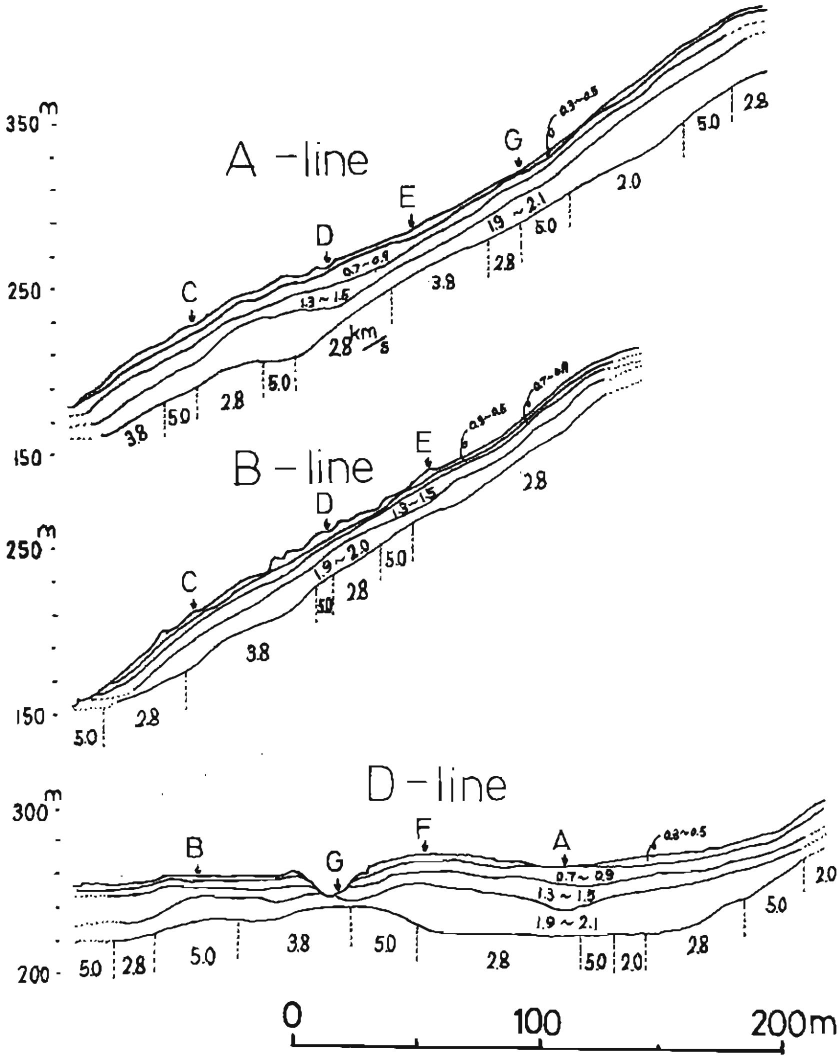

Fig. 14. Underground profile by seismic prospecting at Hiura (Kamikatsu-cho) landslide area. Measuring lines are shown Fig. 11. (after Tokushima pref., 1973).

That last one is expected to be the bedrock but it is rather thin around the valley. The wave velocity in detrital material measures somewhat lower. Both detrital material and weathered layer are common in low wave velocities and were hardly distinguishable. The low velocity layer extends as far as the ridge line and the mountain top, which is not covered with detrital material, and which seems to have a thick weathered layer. Therefore, there is no great difference in landslide possibility between the slope covered with detrital material and the slope covered with detrital material and the ridge and mountain top thickly weathered.

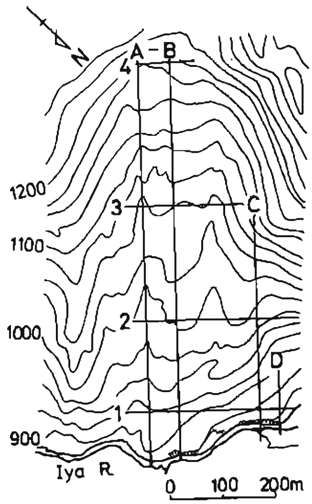

Fig. 15. The map showing the topography of Tairadani landslide area.
A — D, 1 — 4: Measuring lines of seismic prospecting.

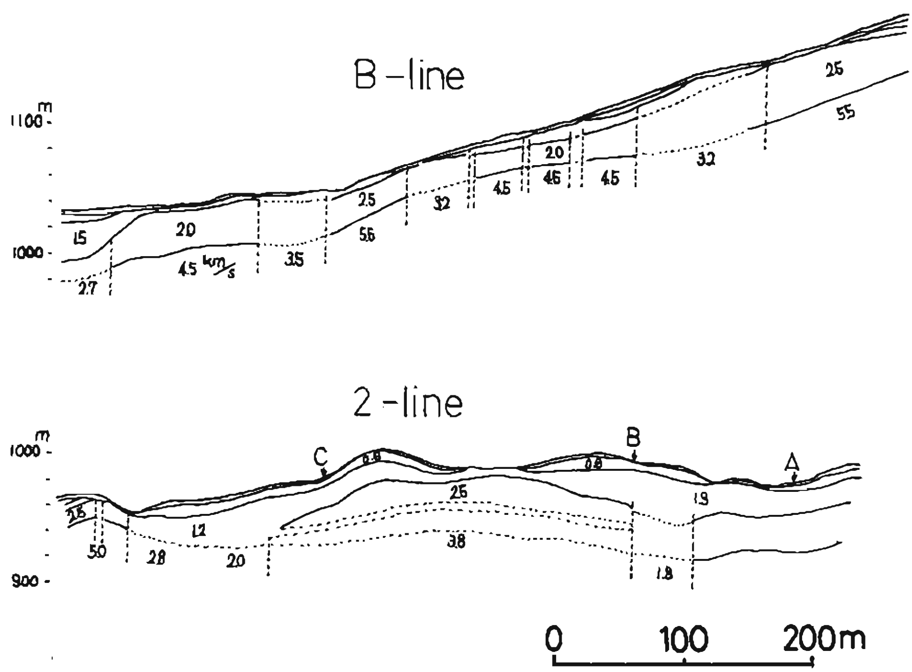

Fig. 16. Underground profile by seismic prospecting at Tairadani landslide area. Measuring lines are shown Fig. 13. (after the Forestry Agency 1965).

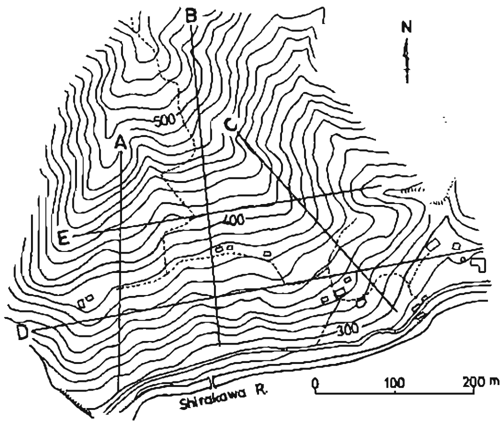

Fig. 17. The map showing the topography of Shirakawa landslide area. A — E: Measuring lines of seismic prospecting.

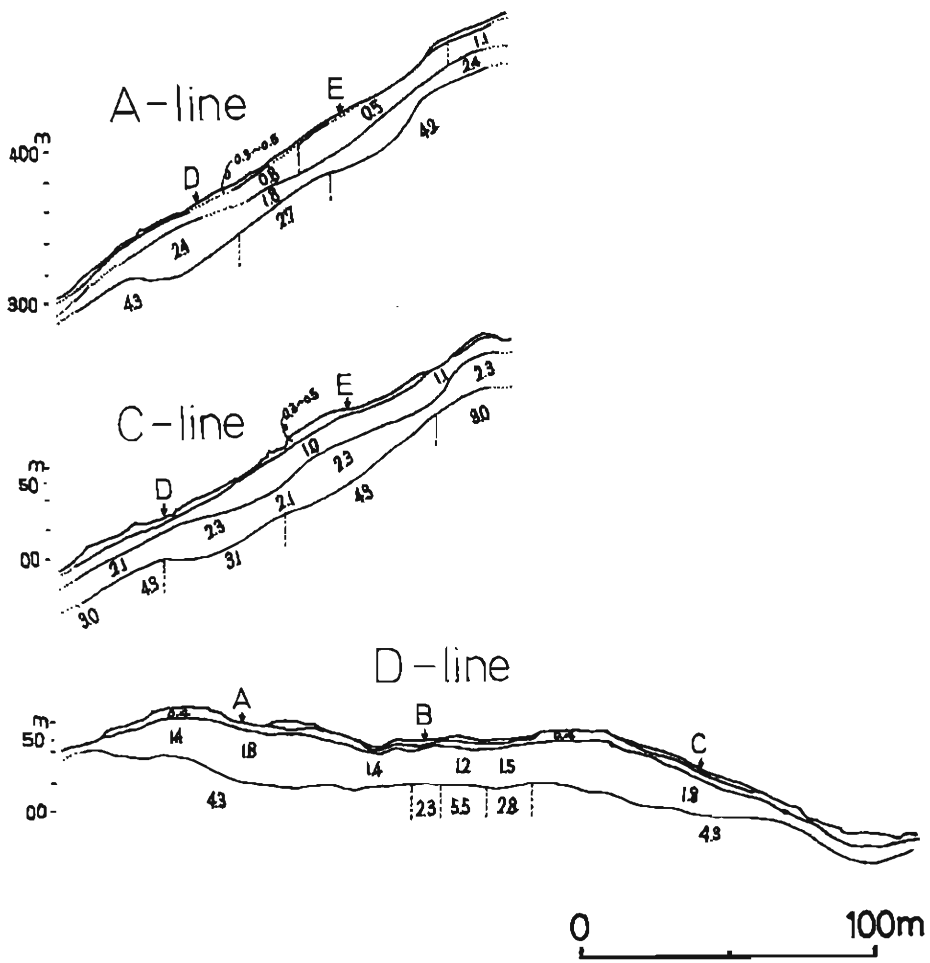

Fig. 18. Underground profile by seismic prospecting at Shirakawa landslide area. Measuring lines are shown in Fig. 15. (after Tokushima Pref., 1972).

4. Some considerations on the factors of landslide occurence

The relationship between landslide activity and geological conditions at some landslide areas previously stated are as follows.

The geological conditions cited here are fissure and weathered layer in rock formation, and detrital material with its depositional structure. Weathered layer and detrital deposit having low velocity in all cases, are not clearly defined from seismic wave velocity.

In the case of rainfall as the trigger, the process of infiltration and chemical and physical actions depend on geological conditions such as weathered layer and fissures in rock formations and properties and structure of detrital material.

For example, fissures act as veins for groundwater (fissure water), while hard rock is almost impermeable. The infiltration of groundwater brings about weathering into the rock formation with various physical and chemical processes, or it may expand fissures by water pressure, and if strongly weathered rock is soaked, the cohesivity of rock is nullified.

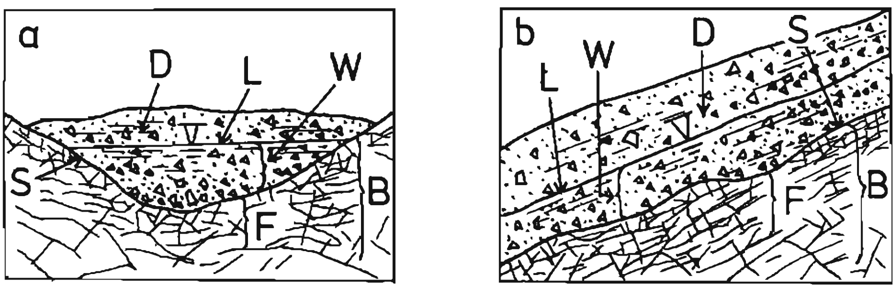

Fig. 19 a, b. Schematic profile of the hydrogeology of the landslide area composing of the detrital material deposits. B: Bedrock D: Detrital material deposit S: Subsurface landform L: Groundwater level (appearance) W: Water-bearing bundle F: Fissure water

Detrital material is an assemblage of debris fallen down or slipped down from higher rock formations, and it is composed of rock mass, boulders, sand and soil. In many cases, these deposits have not resulted from only one collapse but from many repeated collapses, and have very complicated depositional structure. Groundwater flows in accordance with the depositional structure. In general, detrital material deposits are considered as veins or reservoirs of groundwater. The occurence of landslides is related to the change of groundwater pressure or the enlargement of porosity by solution, or the reduction of soil strength.

Thus, according to bedrock formation or detrital material deposits, different process and different velocity may be expected for landslide occurence. The relationship between geology and groundwater for landslide occurence is schematically shown in Fig. 19a, b.

As exceptional cases, the slowly sliding landslides of bedrock, as at Nishi-ikawa and Kurokawa are very rare ones, and are waiting further investigation.

5. Conclusion

Some landslide areas in Shikoku have been surveyed from geological and geomorphological viewpoints and some conclusions are as follows:

The landslides in Shikoku are divided into two groups. One is referred to mainly according to the characters of the bedrocks and their geological structure. This type corresponds to the rapid-landslide type (Koide, 1955) and occurs usually at mountain tops and ridges. It is generally not predictable, and so violent that it often causes great and severe damage.

The other is referred to mainly according to detrital material deposits derived from bedrock by former landslides. The deposits are mostly of Pleistocene in origin. The activities of this type are closely controlled by the subsurface landform and the depositional structure of debris. They present in general a continuous slow displacement, not so violent as to damage people and houses.

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