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SYMPOSIUM 4 – LE ROLE DE L'EAU DANS L'EVOLUTION MORPHOLOGIQUE DES VERSANTS

RUISSELLEMENT ET FAÇONNAGE DES VERSANTS

PRECIPITATION-DISCHARGE PROCESSES OF THE SUBSURFACE WATER AND HYDROGEOMORPHOLOGICAL CHARACTERISTICS IN THE MULTI-LAYERED HILLSLOPE NEAR TOKYO

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ABSTRACT In this study author investigated the behavior of the subsurface water in the multi-layered hillslope by the detailed hydrological observation and made clear the role of the subsurface water in the process of the valley development. The results of this study are summarized as follows. On the slope foot, the subsurface water stored in the hill was always drained. Therefore the erosion by soil pipes always occurred and the small slope failure occurred. The repetition of these phenomenon made the middle slope unstable. During the storm in the wet season, the pressure head in the hill drastically increased more than 15 m and the lateral flow was generated in permeable layers. This lateral flow has one of the important role for the occurrence of the slope failure on the permeable layers.

INTRODUCTION

One of main research subiects in geomorphology is to make clear processes and mechanisms of the growth of valleys or the slope evolution. In the recent years, there were some researches that the valley is formed by the piping (Dunne,1980) or the slope failure (Moriya, 1972) and in the valley formation the subsurface water has important role in the humid region. Then it is important to observe the precipitation-discharge process in the slope, in order to verify the role of the subsurface water in the slope evolution.
The purpose of this study is to observe the behavior of the subsurface water in the multi-layered hills and to verify the role of the subsurface water in the development of the valley.

THE MICRO-SCALE GEOMORPHOLOGICAL CLASSIFICATION IN THE STUDY AREA

The study area is located on the western edge of Tama Hills near Tokyo in JAPAN. The topography is typical of a head-water basin in Tama Hills having steep hillslope with an angle of 25° and flat valley bottom with an angle of 5°. The experimental hillslope has relief of 30 m (the elevation of the hillslope is from 180 m to 150 m above sea level). The slope failures digtributing on the study area were classified into the three types. That is, on the level of two gravel beds and the slope foot. The micro-scale geomorphological classification in the study area is showed in Fig. 1. From this classification, slope evolution process in this area is supposed that at the first step the pipings and small slope failures (A in Fig. 1) occur on the slope foot, at the second step after the repetition of there phenomenon the small slope failures (B in Fig. 1) occur on the middle slope and at the last step the head hollows (C in Fig. 1) are formed.

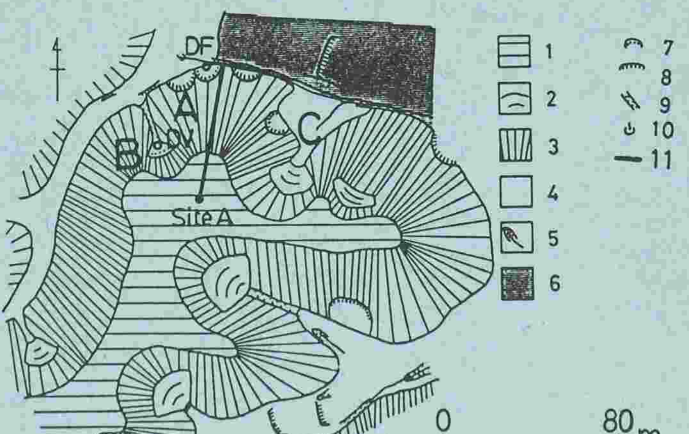

Fig. 1 Distribution of micro-scale geomorphological units in the experimental area: 1; crest slope 2; valley head hollow 3; valley side slope 4; valley head floor 5; channel way 6; valley bottomland 7; small landslide 8; scarplet 9; discontinuous gully 10; springlet 11; the experimental slope A; scarplet on the slope foot B; hollow on the side slope C; valley head hollow

OBSERVATION OF THE BEHAVIOR OF THE SUBSURFACE WATER IN THE HILLSLOPE

The behavior of the subsurface water is measured on the sideslope near the slope failure. Pressure heads in the slope were measured by many tensiometer and piezometer nets from the hill ridge (Site A) to the slope foot (Fig.1; 11). The subsurface water discharge from this slope were measured by the tipping bucket runoff gauges on the slope foot (DF) and on the hollow formed by the slope failure (DV).
The basin lies within the Tama Hills which are underlain by the Pliocene Miura Group and the Pleistocene Narita Group(Juen & Harada, 1961). These are well layered. This hill, to describe from the lower layer, is composed of silty sand layer(saturation hydraulic conductivity; (10-4 cm/s), alternating beds of gravel (10-3 cm/s) and mud (10-5 cm/s), gravel layer included clay matrix (10-4 cm/s), and airborne tephras (10-5 cm/s). Two gravel beds may be defined as permeable layer.

Change in the flux In the slope during the wet season

The flux in the slope foot gradually increased during the Baiu season and the changes in these fluxes showed tendency to agree with the change in the subsurface water discharge from the slope foot during the Baiu season. The dominant fluxes in

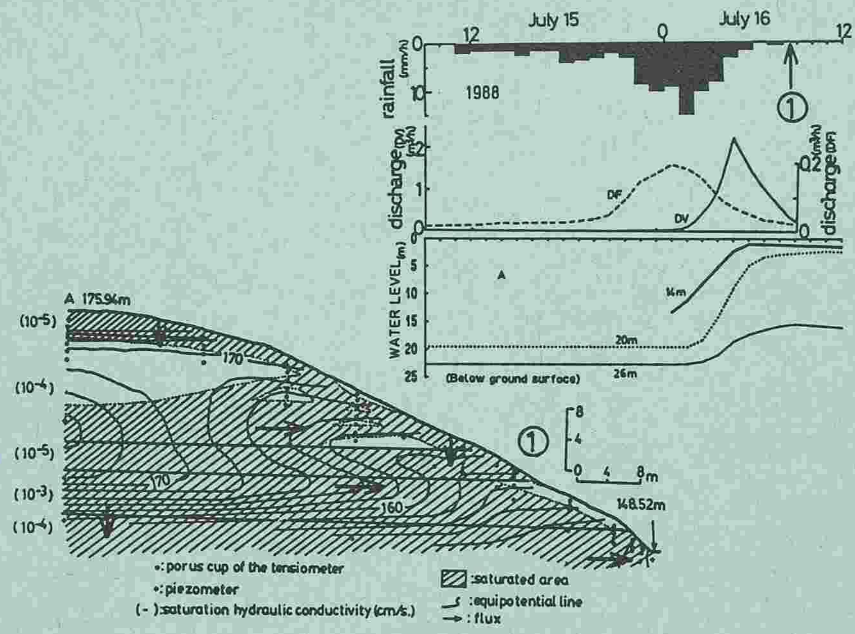

Fig. 2 Change in the subsurface water discharge amount at DV and DF and the water level of three piezometers at Site A and the distribution of hydraulic head in the slope during the storm (July 15-16, 1988).

the slope foot were the upward direction to the stream bottow during the first half of the Baiu season in 1988, but were the upward direction to the bank of the stream during the latter half. The discharge area extended from the stream bottom to the bank of the stream during the Baiu season and the several pipes were formed in this slope foot. From these results and the result of the distribution of the slope failures described above, it is supposed that the upward flow in the slope foot would cause the pipe erosion and the small slope failures would be caused on the slope foot when the slope was unstable by means of the development of the pipe on the slope foot (Shindo & Onda, 1988).

Behavior of the subsurface water at the storm (July 15-16.1988)

The storm event of July 15-16, 1988 was a 95 mm rainfall (peak rainfall intensity; 15 mm/h) following a relatively wet antecedent condition. The results of the response to this storm are showed Fig. 2. Subsurface water discharge from the head hollow (DV) radically began to increase at 1:00 on July 16, began to decrease at 5:00 on July 16 when this storm finished. The direct runoff ratio exceeded 50%. Water level at the 20 m-depth piezometer of Site A also radically rose more than 17 m since 1:00 on July 16 and reached near the ground surface at 11:00 on July 16. The direction of the subsurface flow was downward in the slope at 20:00 on July 15 but was lateral in two gravel beds of the hill at 9:00 on July 16. From the above results, it has been pointed out that after the peak of the storm the pressure head radically increased in the hill, the lateral flow of the subsurface water occurred in the permeable layers of the hill and the subsurface water discharge from the slope radically increased. From these results and the result of the distribution of the slope failures described above, it is supposed that this lateral flow would cause the slope failure on the middle slope.

CONCLUSION

The results of this study are summarized as follows:

a) it is supposed about the valley development process that at the first step the slope foot is made steep by the piping and small slope failure, at the second step the slope is made steeper by the repetition of the first step and the small valley head hollow is formed by the small slope failure.
b) In the wet season the subsurface water was drained from the slope foot by means of the supply of the water stored in the hill, during the 100 mm-storm in the wet season the pressure head radically increased in the hill and lateral flow generated in the permeable layers was drained in quantity from the middle slope.
c) The pipings and small slope failures on the slope foot was continuously caused by the upward flow gradually increased during the wet season. The slope failures on the permeable layers of the middle slope may be caused by the lateral flow in the permeable layers and formed the small valley head hollow. The geomorphological evolution of larger scale and longer recurrence interval on the valley head may be caused by the concentration flow of the through flow in the surface layer and the lateral flow in the permeable layers.

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REFERENCES

Dunne, T. (1980) Formation and controls of channel networks. *Process in Physical Geography 4*, 211-239

Juen, S. & Harada, S. (1960) Groundwater investigation in *Hakyuuti Experiment Area. Hakvuuti Agriculture Institute Report in Tokyo University of Agriculture and Technology 3*, 50-56

Moriya, I. (1972) Geomorphological classification defined the slope failure scar as unit and slope development of the mountain slope. *Japan Geogra. Con.* 2, 168-169

Shindo, S. & Onda, Y. (1988) Hydrogeomorphological role of piping erosion on slope processes (2). Trasactions. *Japan. Geomor. Union 9*, 58