Groundwater Aeration Sounds and Blow-off Phenomenon of Groundwater on Collapse Slopes

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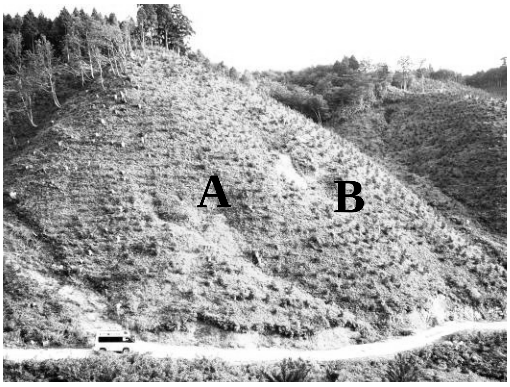
1. Overview

In the past, it has been described that rainwater descends and infiltrates through soil layers and when it reaches to an impermeable layer, a saturation zone forms on the bedrock. As this saturation zone expands, this causes a collapse. According to this manner, the closer to the leg of the slope the saturation zone expands, the easier a collapse happens. However, in actuality shallow landslides often occur around catchment boundaries where there is almost no catchment area. On the other hand, when thinking about the timing of the occurrence of rainfall and collapses, there are many cases in which collapses occur near the peak of rainfall intensity. In addition, immediately after the start of heavy rainfall, collapses may occur even when rainwater hasn't infiltrated adequately. In addition, it is well known that the estimated times of collapse, calculated by numerical calculation using a catchment model, lag behind the actual time of occurrences of collapse (Hiramatsu 1990). Furthermore, even if permeability and water retentivity are strictly measured, there are many cases in which the results of infiltration analysis do not match the observable data at the local site. As long as the reasons for discordance between the basic theories and the actual phenomenon in these present situations are not understood, we think it is hard to identify places in danger of collapse.

In this article, we carried out observations of the groundwater level on the routes of water paths in the collapse area which were identified by the groundwater aeration sound survey; and studied the relationship between the characteristic behavior of groundwater and the collapse positions.



Picture 1 Appearance of Studied Slopes

2. Investigation Site and Ovservation Method

An investigation was carried out in a forested area of Japanese cypress in Kagamino-cho, Okayama prefecture (Picture 1). Figure 1 shows the topography of the investigated slope. The investigated slope is a ridge type slope of an average gradient of approximately 30°. The geological features are granite and 1 m of volcanic ash has accumulated on the surface soil. There is a knick line around a relative height of 25 m and there are two collapses (A and B) below the knick line. Multiple springs are seen at the collapse legs and valleys, etc.

We set up measurement lines in the direction of contour lines on this slope and carried out the groundwater aeration sound survey (Figure 2).

- We carried out electric surveys and observations of the maximum groundwater level. As shown in Figure 1, it was revealed that collapse B occurred on the route of a water path (shown in black) where groundwater aeration sounds were strong (Tada and others 2006). We carried out observations of the groundwater level, electric surveys, and simple penetration tests on the route of the water path, which include this collapse B. Details of each measured item are as follows.

(1) Observation of groundwater level: We constructed observation wells on L1 to L2 shown as ○ in Figure 1 and installed electrical capacitance water gauges. The depth of observation wells was set to the bedrock of Nc＝40. Measurements were carried out in 20 minutes intervals from May through December, 2006.

(2) Electric survey: we surveyed the distribution of resistivity of the bedrock at the location indicated by the dashed line in Figure 1 using SYSCAL Kid Switch 24 (Oyo Corporation). The electrode configuration was accordance with the dipole-dipole method and electrode intervals were set at 1 m.

(3) Simple penetration test: In order to examine the depth of the observation wells and the validity of electric survey results, we carried out penetration tests until obtaining Nc＝40 at the location shown as ○ in Figure 1, where observation wells were installed.

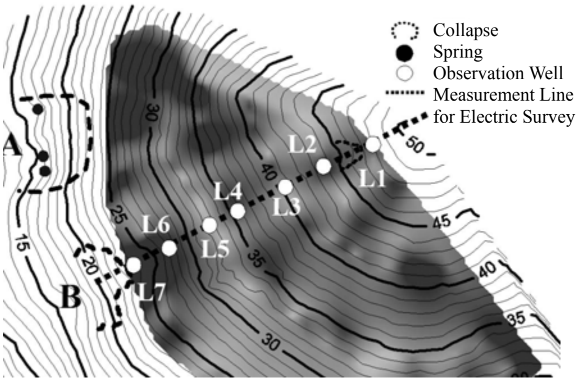


Figure 1 Estimated Routes of Water Paths and Observation Points of Groundwater

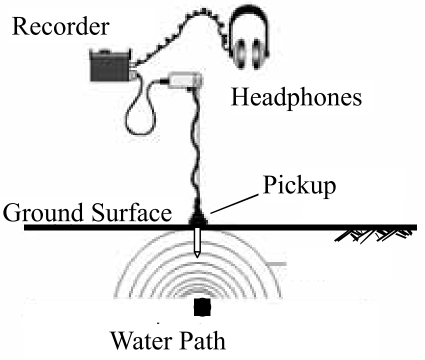


Figure 2 Schematic Depiction of Groundwater Aeration Sound Measurements

3. Result and Consideration

3.1 Observation Results of Groundwater

We examined the response of groundwater level to rainfall. Figure 3 shows rainfall events recorded during observation period and the response of groundwater level to the events. In addition, only rainfall of 60mm or more of cumulative rainfall was added to the rainfall figures. The following points can be ascertained from the figures.

a. When cumulative rainfall is 60mm or less (other than rainfall of ① to ⑥), there is little or no groundwater at L1, L3, L4, L5, and L6. On the other hand, even with little rainfall, the groundwater level at L2 and L7 rose to an extent of 100 cm.

b. During the rainfall of ②, which recorded a cumulative rainfall of 262 mm, groundwater levels were recorded at all levels from L1 at the top of the slope to L7 at the head of the collapse at the lower part of slope. Among them, the amount of rise of groundwater level was highest at L2 and L7 at the head of the collapse.

In this way, the responses of groundwater levels on slopes are not uniform. In particular, the groundwater levels at L2 and L7 responded with extreme sensitivity regardless of the rainfall intensity.

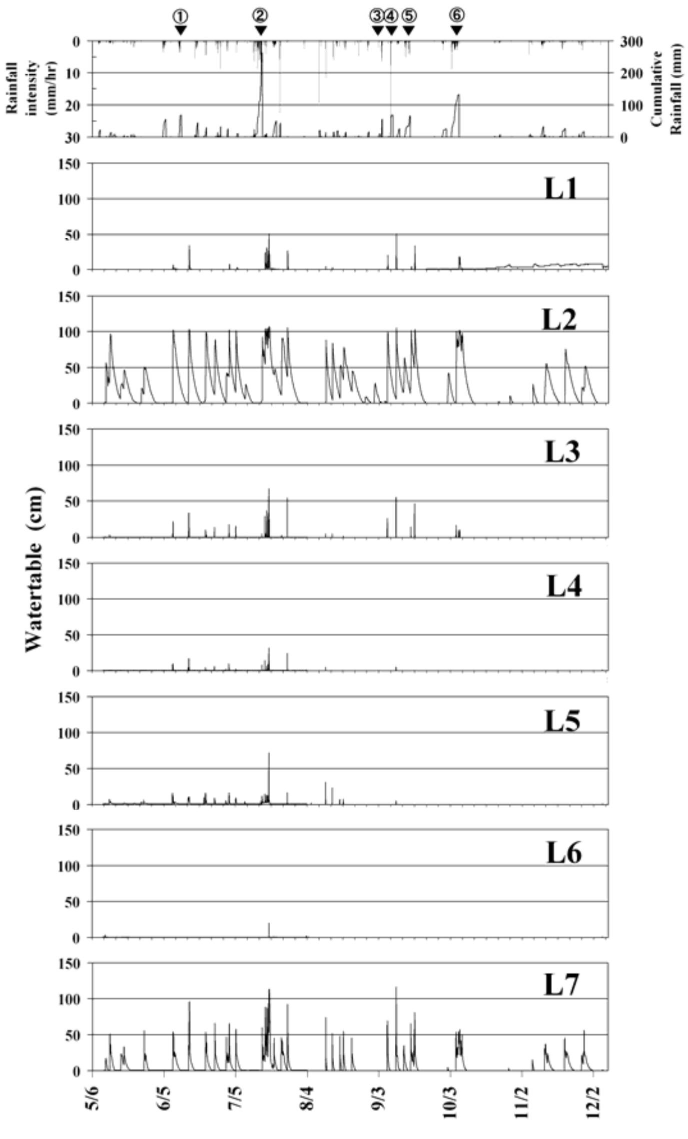


Figure 3 Response of Groundwater Level to Rainfall Events Which Were Observed at Each Observation Well

3.2 Results of Electric Survey

Figure 4 shows results of electric surveys carried out on measurement lines which include collapse B. Isopleths in the Figures represent the distribution of resistivity. The darker the color, the higher the resistivity and the dryer it is; and the paler the color, the lower the resistivity and the higher the water content. In addition, ● in the figures represent the locations of observation wells (Nc=40), and the area deeper than those consists of granite bedrock. Looking at the figure, the slopes consist of multiple granite blocks. The 2 granite blocks in particular, indicated in black, are thought to be highly resistant and dry. On the other hand, there are areas of high water content with low resistivity shown in white around these granite blocks, which inclines in the direction of the dashed line. Granite is a rock which develops joints and these low resistant areas are thought to be crevices in the bedrocks. L2 and L7 in the preceding paragraph, where the groundwater level responded sensitively to rainfall, were located near boundaries (dashed line) of resistivity which are thought to be crevices. The reason why groundwater occurs at both points in little rainfall is thought to be due to fissure water blowing off from crevices in the bedrock. The reason why a collapse occurred below L7 is thought to be the influence of fissure water originating from crevices in the bedrock.

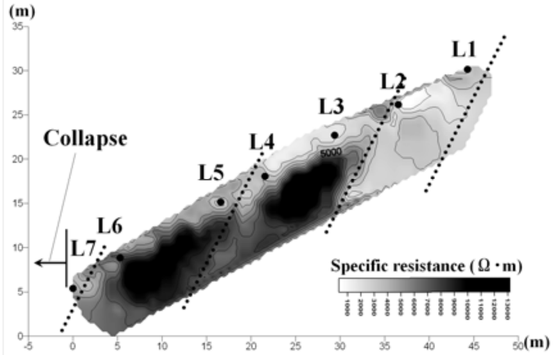


Figure 4 Distribution of Resistivity in Observed Slopes

4. Conclusion

In this article, we carried out observation of groundwater levels on the routes of water path in the areas of collapses and studied about relationship between the response of groundwater to rainfall and the collapse positions. The results showed that it is likely that collapses occurred at places where fissure water blows off from the crevices of granite bedrock.

Cited References

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