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Difference in Threshold of Occurrences for Peak and Sediment Discharges in Forested Drainage Basins Made of Granite and Gneiss, Korea

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1. Introduction

Hillslope process in Korea, whose area of about 70 % is underlain by granite and gneiss, has not been resolved sufficiently and quantitatively based on field or laboratory measurements. Therefore, the present study revealed the differences in runoff characteristics and sediment discharge between granite and gneiss drainage basins by hydrological observations in the field. The rainfall threshold values of occurrence of sediment discharge and peak discharge in both basins were also examined.

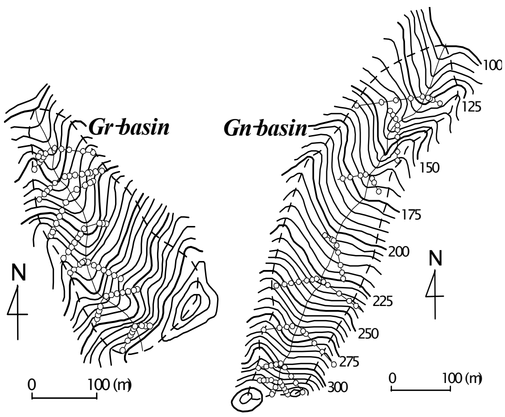

Fig. 1. Drainage basins observed.

2. Observed Drainage Basins

The observed drainage basins (Fig.1) made of granite (Gr-basin) and gneiss (Gn-basin), are located at the north and east of Seoul, respectively. Gr- and Gn-basins are composed of Jurassic granite and Precambrian banded gneiss (the Precambrian Kyeonggi metamorphic complex), respectively. The areas of Gr- and Gn-basins have 0.0546 and 0.0764 km^2, respectively More than 70 % area of Korea is underlain by granite and gneiss. Both drainage basins are covered by deciduous trees (mainly composed of *Quercus* and *Castanea*) and coniferous trees (*Pinus*). The geomorphic characteristics of the two basins are summarized in Table1. Tanaka, et al. (2002) pointed out the outline of difference in runoff characteristics between Gr- and Gn-basins based on field hydrological

Table 1. Characteristics of observed drainage basins.

	Gr-basin	*Gn-basin*
Area (km^2)	0.0546	0.0754
Relief (m)	176	150
Drainage density (km/km^2)	12.6	9.1
Depth of regolith (cm)	<50	50-100
Vegetation	Pine and deciduous trees	Pine and deciduous trees

measurements: 1) constant discharge occurs in Gn-basin but distinct discharge occurs only associating with rainfall event in Gr-basin, 2) electric conductivity of water of Gn-basin shows twice value as that of Gr-basin, 3) baseflow is dominant in Gn-basin, but only quickflow occurs in Gr-basin, 4) grain size of soil layer in Gn-basin shows finer frictions than that of Gr-basin (Wakatsuki et, al.,2005), so, the soil layer in Gn-basin can store much more water than Gr-basin. Orkhonselenge et al. (2006) revealed that soil erosion occurs more actively in Gr-basin than Gn-basin by measuring the concentration of Cs137 of soil layers.

3. Hydrological Measurements

Water discharge and rain fall were measured by 6 inch parshal flume equipped with water depth probe and rain gauge, respectively. The data were automatically logged every 5 minutes. Sediment discharge was measured by sediment trap put in the channel of observed drainage basins. Pressure head of soil layer was automatically measured and logged by tensiometer and data logger, respectively.

3. Results and Discussion

The results of the measurements (Figs.2, 3, 4 and 5) are summarized as follows; 1) perennial water flow occurs in Gn-basin, whereas very little or no water flows in Gr-basin without rainfalls, 2) delayed flow occurs in Gn-basin and not in Gr-basin, and 3) the electric conductivity of river water of Gn-basin shows about 2 times as high as that of Gr-basin: the electric conductivity of river water of Gr- and Gn- basins were 28.7-39.4 ㎲/㎝and 53.9-65.0 ㎲/㎝, respectively, 4) peak discharges occur more frequently in Gr-basin, while larger baseflow occurs in Gn-basin, i.e., Gr-basin has large range of discharge and Gn-basin has small one, 5) runoff

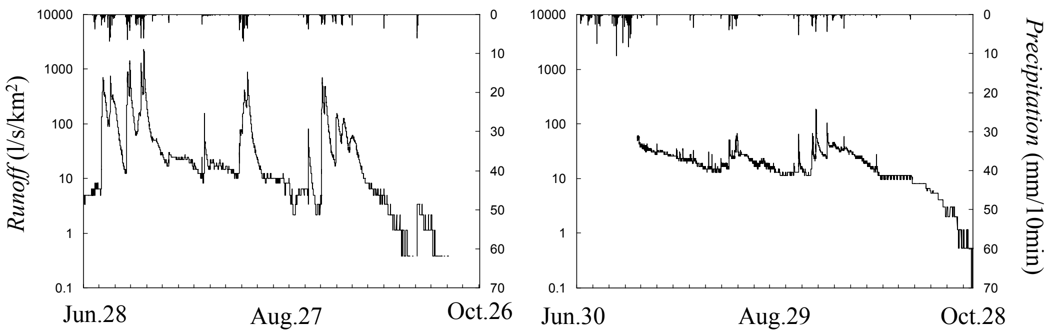

Fig. 2 Example of the hydrograph of 2004.

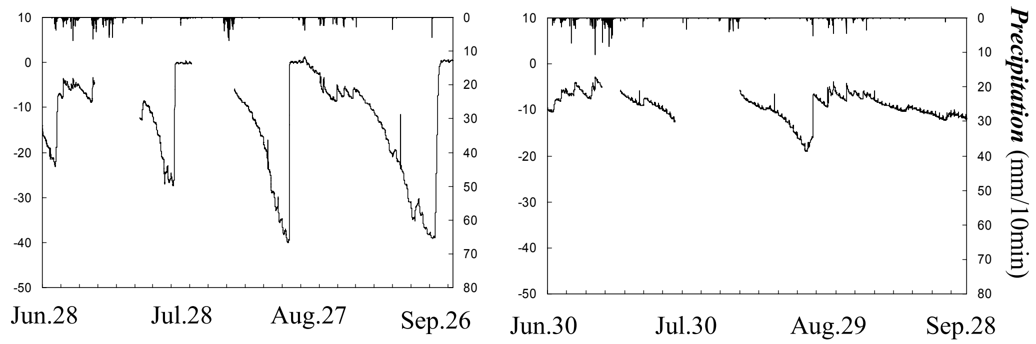

Fig. 3 Changes of pressure head of soil layer (depth of 45 cm)

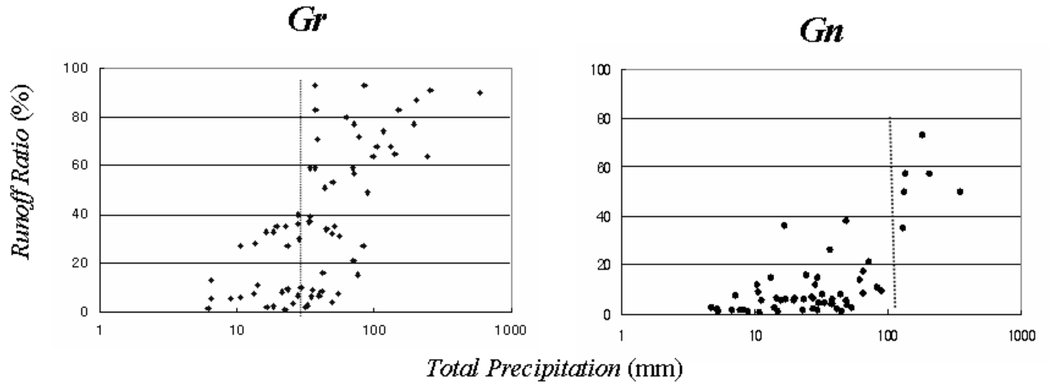

Fig. 4. The relationship between total precipitation and runoff ratio.

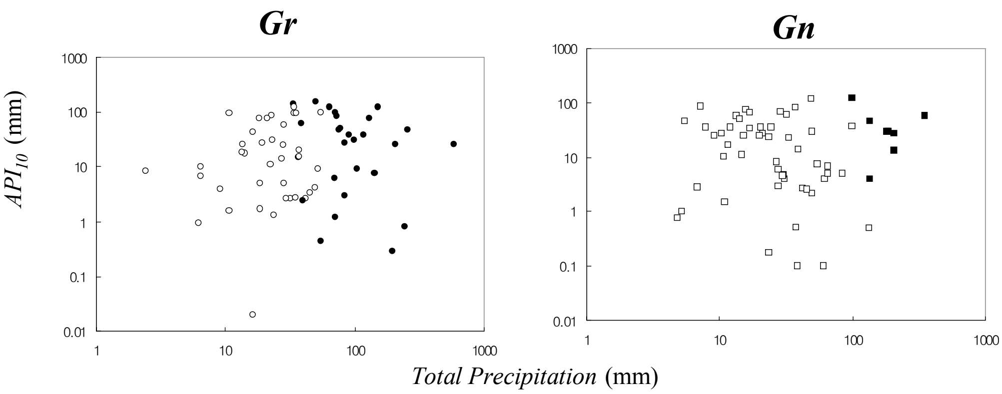

Fig. 5. Threshold of occurrence of sediment discharge Solid circles show the event with apparent sediment discharge.

ratio increases with threshold of about 30 mm of total precipiation in Gr-basin, while with about 100 mm in Gn-basin, 6) sediment discharge occurs with total precipitation of more than 30 mm in Gr-basin, whereas more than 100 mm in Gn-basin, 7) changes in pressure head of soil layers show that water strorage capacity of Gr-basin is much smaller than that of Gn-basin.

These findings suggest that the threshold of quick-flow occurences in Gr-basin takes much smaller value than that in Gn-basin, because of small capacity of water strorage of Gr-basin. Sediment discharge in Gr-basin seems to be generated by soil erosion on hillslopes. Occurrence of intermittent flow in Gr-basin possibly implies that very quick discharge dominates. Grain size analyses show that the grain size of soils in Gn-basin is smaller than that of Gr-basin (Wakatsuki et al., 2005). The difference of grain size provides that the infiltration capacity of soils of Gr- basin shows higher values than that of Gn-basin. Results of measurement of suction show that the soil layer of Gn-basin is wetter than that of Gr-basin. Variation of suction show that soil layer in the Gr-basin is dry without rainfall, but wet in Gn-basin. Perennial flow of Gn-basin implies that rainfalls were stored in soil or weathered mantle, whereas intermittent flow of Gr-basin implies that the water rapidly pass through the soil layer only associating rainfall. The results of electric conductivity suggest that residence time in soils or weathered mantles of Gn-basin is longer than that of Gr-basin. Sediment discharge of both basins occur mainly associationg summer rainy seasons. The volume of sediment discharge of Gn-basin shows about 8 times as much as that of Gr-basin. The conclusions are summarized as follows: Intermittent flow occurred in Gr-basin, whereas perennial flow in Gn-basin. Stored water in soil or weathered mantles in Gn-basin flow out, but rainfalls discharge quickly through weathered rocks or flow out as surface flow in Gr-basin. Sediment discharge occurs in mainly summer seasons and the volume of Gn-basin shows about 8 times as much as that of Gr-basin.

5. Conclusions

1) Peak discharges occur more frequently in Gr-basin, while larger baseflow occurs in Gn-basin, i.e., Gr-basin has large range of discharge and Gn-basin has small one.
2) Runoff ratio increseases with threshold of about 30 mm of total precipiation in Gr-basin, while with about 100 mm in Gn-basin.
3) Sediment discharge occurs with total precipitation of more than 30 mm in Gr-basin, whereas more than 100 mm in Gn-basin.
4) Changes in pressure head of soil layers show that water strorage capacity of Gr-basin is much smaller than that of Gn-basin.
5) Concentration of Cs134 suggests that soil erosion occurs more active in Gr-basin than in Gn-basin. These findings suggest that the threshold of quickflow occurences in Gr-basin takes much smaller value than that in Gn-basin, because of small capacity of water strorage of Gr-basin. Sediment discharge in Gr-basin seems to be generated by soil erosion on hillslopes.
6) These findings suggest that the threshold of quickflow occurences in Gr-basin takes much smaller value than that in Gn-basin, because of small capacity of water strorage of Gr-basin. Sediment discharge in Gr-basin seems to be generated by soil erosion on hillslopes.

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