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Difference in Runoff Process between Granite and Gneiss Drainage Basins in Korea

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Abstract - Many slope failures and debris flows occur in granite and gneiss mountains associating heavy rains in summer almost every year. Therefore, the present study revealed the differences in runoff characteristics between granite and gneiss drainage basins by hydrological experiments in the field. The results are summarized as follows: 1) base flow of gneiss basin is much more than that of granite, and 2) response of runoff to rain fall of gneiss basin is more sensitive than that of granite one, 3) the differences in grain-size of soil layers between granite and gneiss controls the difference in runoff characteristics.

I. Introduction

Granite and gneiss, which are the typical rocks in Korea, cover approximately 70% area of Korean peninsula [1].

Many slope failures and debris flows occurred in the granite and gneiss mountains north of Seoul, central Korea, because of heavy rain in summer of 1998 and 1999. These heavy rains brought huge damages to human lives such as cultivated area, houses, transportation equipments [2]. Moreover, so many debris flows occurred in the drainage basins in the south area of Seoul associating with heavy rain in the summer of 2000. Slope failures and debris flows associating with summer heavy rain brought severe damages every year. To prevent these natural hazards, it is necessary to resolve the runoff process of hillslopes quantitatively.

Some studies related to runoff process in granite drainage basins have been reported in except Korea (e.g., [3, 4, 5, 6, 7]). Although some runoff analyses using runoff models (e.g., [8, 9]) and geochemical study [10] have been performed, few quantitative studies concerned with runoff processes have been carried out in Korea. The present study revealed the differences in runoff characteristics between granite and gneiss drainage basins by hydrological experiments in the field as a beginning of basic study for the counterplan to natural hazard.

II. Study Area

The experimental drainage basins underlain by Jurassic granite and Precambrian metamorphic rocks, which are located north and east of Seoul (Fig.1). Jurassic granite (Daebo granite) shows biotite medium and coarse-grained granite. Precambrian metamorphic rocks (Kyeonggi metamorphic complex) are characterized by banded gneiss [11]. The areas of granite basin (*Gr*-basin) and gneiss basin (*Gn*-basin) are 0.0546 km^2 and 0.0754 km^2, respectively. The maximum relief of *Gr*- and *Gn*-basins are 150 m and 230 m, respectively. The relief rations of *Gr*- and *Gn*-basins are 0.35 and 0.36, respectively. Many sugar loaf bared rocks are distributed mainly in the upper part of granite mountain, whereas in gneiss mountains almost without bared rocks. The soil layer of *Gn*-basin is thicker than that of *Gr*-basin, but the granite is more deeply weathered granite are observed than the gneiss. The results of grain size analysis of soils show that *Gr*-basin has much more content of coarse particle size than the case of *Gn*-basin [12]. The infiltration capacity of granite soil shows the values from 10^{-2} to 10^{-3}cm/s, whereas the value shows about 10^{-3}cm/s in the case of gneiss soil.

The experimental drainage basins climatologically belong to humid temperate area characterized by hot and humid summer and cold and dry winter: i.e., the average annual temperature is 11 degree in centigrade. The maximum and minimum temperatures show 26 degree in centigrade in August and −5 degree in centigrade in January, respectively. The average annual precipitation around Seoul is 1300 mm with about 70 % falling in June-September period often associated with seasonal rain fronts and typhoon. Both of drainage basins are almost covered with deciduous and pine trees.

III. Method of Hydrological Experiments

Parshall flumes were set at the outlet of experimental drainage basins. Depth probe (Unidata, 50 cm long) measuring water level of river water was put in the box of parshall flume. Rainfalls were measured by tipping bucket rain gauges put near the parshall flume. The data were logged automatically for every 5 minutes from May to October and 10 minutes from November to April. Electric conductivities of river water were also measured by handy EC-meter. The electric conductivities have been corrected for temperature (25 degree in centigrade). These hydrological measurements were started from May 1 1999 and are continued on now.

IV. Results and Discussions

Fig. 2 shows the example of the results of hydrological measurements obtained from July 11 to August 2 2000. The total precipitations of *Gr*- and *Gn*-basins show 96.6 mm and 103.8 mm, respectively. Peak discharges of *Gr*-basin occurred associating with the rainfall of July 11-12 (15.8mm), July 19-20 (40mm) and 22 (38.6mm). But, no or very little water flow (less than 0.2 $l/s/km^2$) only occurred except these three peak discharges in spite of small amount rainfalls of July 29-31(2.6mm) in *Gr*-basin. Distinct peak discharges of *Gn*-basin occurred with large amount of rainfall of July 22-23 (65mm). On the contrary to the case of *Gr*-basin, perennial flow occurs in *Gn*-basin. Besides, in *Gn*-basin, before the peak discharge of July 22-23, the discharge showed about 4 -10 $l/s/km^2$, but the discharge after the peak discharge increased to about two times of before. The electric conductivity of river water of *Gr*- and *Gn*- basins were 28.7-39.4 μ s/cm and 53.9-65.0 μ s/cm, respectively. The results of the experiments 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.

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 [12]. The difference of grain size provides that the infiltration capacity of soils of *Gr*- basin shows higher values than that of *Gn*-basin. This causes that water does not flow associating with small amount of rainfall such as that of 29-31 July. Besides, there is a possibility that rainfalls infiltrate deeply weathered mantles of more than 5m in thickness and not flow out.

Perennial flow of *Gn*-basin implies that rainfalls were stored in soil or weathered mantle, but did not infiltrated deeply. The stored water recharged baseflow, consequently the discharge increased after large amount of rainfalls of 22-23 July. The results of electric conductivity suggest that residence time in soils or weathered mantles of *Gn*-basin is longer than that of *Gr*-basin.

V. Conclusions

The conclusions are summarized as follows:

1) Intermittent flow occurred in *Gr*-basin, whereas perennial flow in *Gn*-basin
2) Stored water in soil or weathered mantles in *Gn*-basin flow out, but rainfalls discharge quickly or infiltrate into deeply weathered rocks in *Gr*-basin.
3) Water movement in soil layer or weathered mantles must be resolved to clarify the differences in runoff characteristics between *Gr*- and *Gn*- basins.

Acknowledgements

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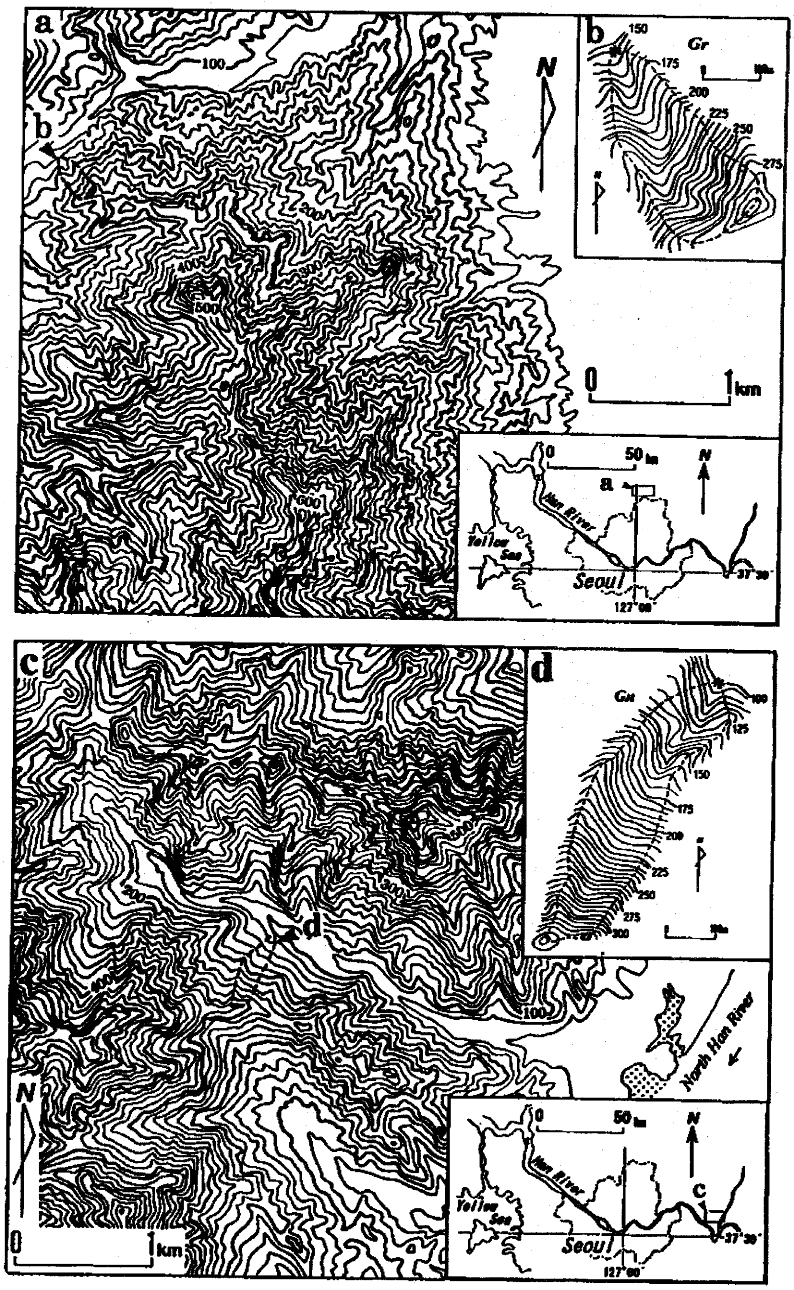

Fig. 1 Locations of experimental drainage basins of granite (**a,b**) and gneiss (**c,d**) (Tanaka et. al, 2000) Contour intervals of are 20m (**a,c**) and 5m (**b,d**). Asterisks show the experimental sites.

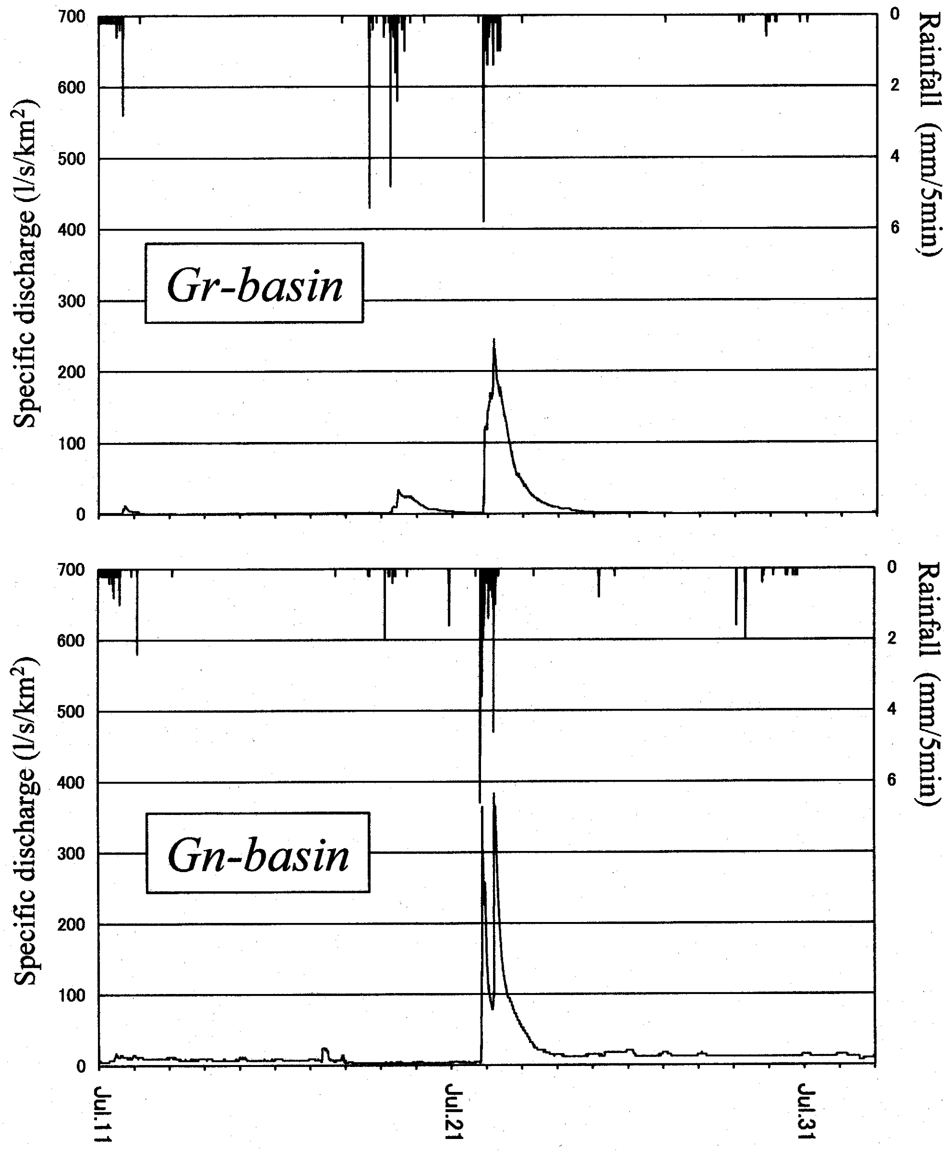

Fig. 2. Examples of the results of experiment from 11 Jul. to Aug. 2 2000.