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Comparative Study on the Runoff Process of Granite Drainage Basins in Korea and Mongolia

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ABSTRACT

This study revealed the differences in runoff processes of granite drainage basins in Korea and Mongolia by hydrological measurements in the field. The experimental drainage basins are chosen in Korea (K-basin) and Mongolia (M-basin). Occurrence of intermittent flow in K-basin possibly implies that very quick discharge dominates. The very high runoff coefficient implies that most of effective rainfall quickly discharge by throughflow or pipeflow. The Hortonian overlandflow is thought to almost not occur because of high infiltration capacity originated by coarse grain sized soils of K- basin. Very little baseflow and high runoff coefficient also suggest that rainfall almost does not infiltrate into bedrocks in K-basin.

Flood runoff coeficient in M-basin shows less than 1 %. This means that most of rainfall infiltrates or evaporates in M-basin. Runoff characteristics of constant and gradually increasing discharge imply that most of rainfall infiltrates into joint planes of bedrock and flow out from spring very slowly. The hydrograph peaks are sharp and their recession limbs steep. Very short time flood with less than 1-hour lag time in M-basin means that overland flow occurs only associating with rainfall intensity of more than 10 mm/hr. When peak lag time shows less than 1 hour for the size of drainage area of 1 to 10 km2, Hortonian overland flow causes peak discharge (Jones, 1997).

The results of electric conductivity suggest that residence time in soils or weathered mantles of M-basin is longer than that of K-basin. Qucik discharge caused by throughflow and pipeflow occurs dominantly in K-basin, whereas baseflow more dominantly occur than quick discharge in M-basin. Quick discharge caused by Hortonian overlandflow only associating with rainfall intensity of more than 10 mm/hr in M-basin.

Keywords : Korean Jurassic granite, Mongolian Triassic granite, hydrological experiment, runoff characteristics, baseflow, quickflow

Introduction

Water movement in hillslopes is not only hydrological problem but also geomorphological one, because water occupied important position as a geomorphic exogenic agent. Therefore, difference in runoff process must be resolved and examined comparatively in various areas in the world. Especially, it is necessary to compare runoff process in humid area with that in arid area. Granite drainage basins are favorable to the comparative study, because granite is distributed worldwide. The present study examined the difference

Fig. 1. Geomorphologic map of around experimental basins.
The left map shows Mongolian drainage basin (M-basin). The counter interval of the map is 20m.
The right map shows Korean drainage basin (K-basin). The counter interval of the map (b) is 5 m.

in runoff processes between relatively humid area (Korea) and arid area (Mongolia) through the comparative study based on field hydrological experiment in granite drainage basins.

Experimental Drainage Basins

1. Korean Basin (K-Basin)

The experimental drainage basin underlain by Jurassic granite, which is located north of Seoul (Fig 1). Jurassic granite (Daebo granite) shows biotite medium and coarse-grained granite (Korean Institute of Geology, Mining and Materials, 1999). The areas of granite basin (*K*-basin) is 0.0546 km^2. The maximum relief of *K*-basin is 150 m. The relief rations of *K*-basin is 0.35. Many sugar loaf bared rocks are distributed mainly in the upper part of granite mountain. The soil layer of is less than 1m. The results of grain size analysis of soils show that *K*-basin has much more content of coarse particle size (Wakatsuki 2001). The infiltration capacity of granite soil shows the values from 10^{-2} to 10^{-3}cm/s.

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.

2. Mongolian Basin (M-Basin)

The experimental drainage basins are located around Ulaanbaatar city, i.e., Triassic granite basin (Fig 1.) is located about 30 km east of Ulaanbaatar city. The areas of M-basin show 1.675km^2. The maximum relief of M- basin show 450m. The granite is composed of medium or coarse porphyritic granite(Gorkhi granite)

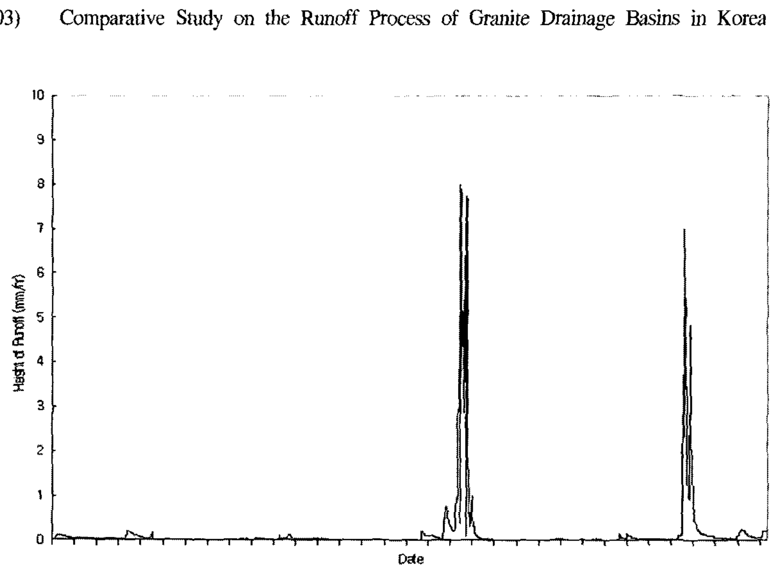

Fig. 2. Hydro- and Hyeto- graph of Korean granite basin (K-basin) of 1999. The total precipitation and total runoff of the experimental periods show 1138.4mm and 574.9 mm, respectively. The experimental period is from May 02 to Oct 08 1999

with weathered mantle of about 5 m depths. In granite mountains, valleys similar with U-shaped valley are found: tors and bared rocks occur in upper part of steep slopes and gentle and flat wide valley floor with springs and wetland.

Climate of around Ulaanbaatar is characterized by very cold and dry winter, cool and relatively humid summer and very large annual variation of temperature: The mean annual temperature at Ulaanbaatar city is about 2 degree in centigrade with a mean annual range of 50 degree in centigrade. Maximum mean temperature at Ulaanbaatar city is about 18 degree in centigrade in July and minimum mean temperature is 25 degree in centigrade in January. Annual precipitation averages 250 mm with about 80 % falling in June September period (Institute of Geography, 1990). Study area is located in the transitional zone from Taiga to Steppe. Vegetations of study area are mainly composed of grassland and coniferous (*Larix*) forests. Coniferous forests occur on northward slope and grassland on southward slope in mountainous area around study area.

Methods of Experiments

Water levels and precipitations were measured at the outlet of experimental drainage basins. The water levels and precipitations were measured by the 50 cm depth probe(Unidata U6521) and tipping bucket rain gauge(TBRG Davis 0.2 mm tipping bucket rain gauge), respectively. The depth of probe was set in the 6 inch Parshall flume. The power of these experimental equipments was obtained from solar panel (Solarex MSX-10L). The data of water level and precipitations were logged at the interval of 10 minutes, automatically. The relationships between discharge, Q (l/s) and water level obtained by the depth probe, H (cm) is calculated as follows (Japan Society of Civil Engineers, 1985): $Q=0.264H^{1.58}$.

Results

1. Korean Granite

Fig 2 shows the example of the results of hy-

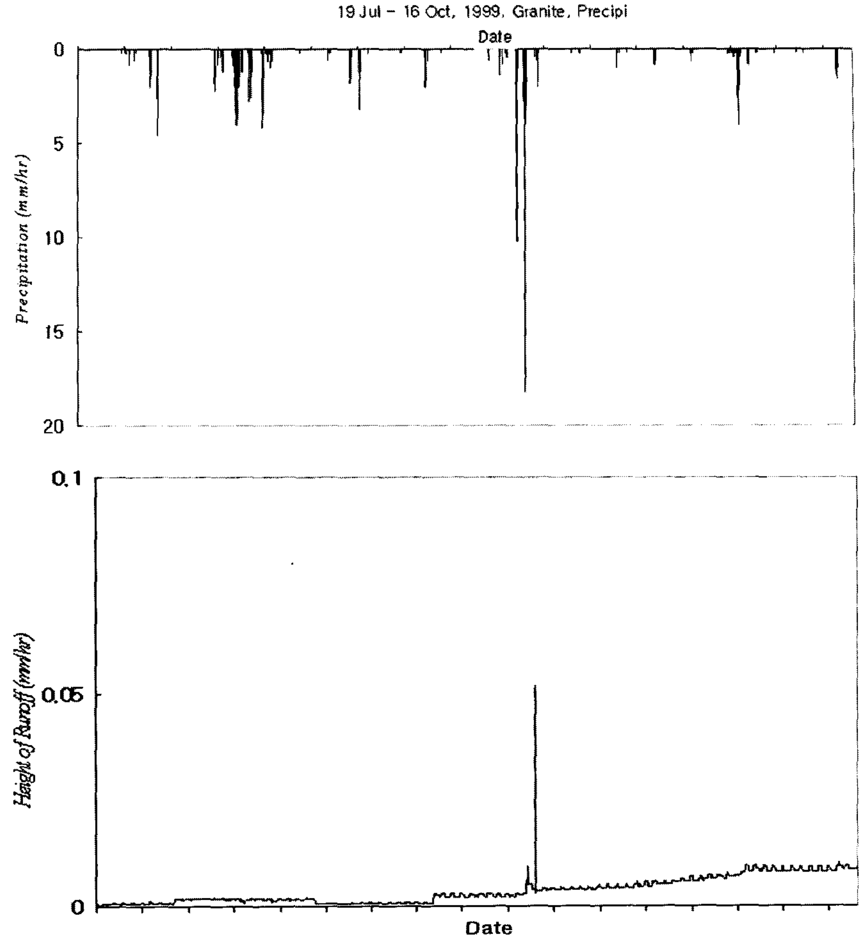

Fig. 3. Hydro- and Hyeto- graph of Mongolian granite basin (M-basin) of 1999. The total precipitation and total runoff of the experimental period show 264mm and 19 mm, respectively. The experimental period is from Jul 19 to Oct 16 1999

drological measurements obtained from May 02 to October 08 1999. The total precipitations of *K*-basin show 1138.4 mm. Peak discharges of *K*-basin occurred only associating with the rainfall of more than 5 mm/hr. But, no or very little water flow (almost 0 mm/hr) only occurred without rainfall in *K*-basin. The electric conductivity of river water of *K*- basin is 28.7-39.4 μs/cm. The results of the experiments are summarized as follows; 1) very little or no water flows in *K*-basin without rainfalls, 2) delayed flow does not occur in *K*-basin, 3) peak discharge is characterized by very quick response to rainfall, 4) The runoff ratios of *K*-basin in 1999 showed 50.5%.

2. Mongolian Granite

Figure 3 shows the results of hydrological measurements. The results are summarized as follows; 1) total amount of precipitations of M-basin in 1999 showed 264.8 mm, 2) The runoff ratios of M-basin in 1999 showed 7.15%, 3) the distinct peak height of runoff of 0.01 and 0.05 (mm/hr) occurred on 4 and 5 Sep

Table 1. Characteristics of Experimental Drainage Basins.

	K-Basin	M-Basin
Drainage Area (㎢)	0.0546	1.645
Relief (m)	150	450
Depth of Regolith (m)	Less than 0.2	More than 5
Vegetation	Pine and Deciduous trees	Coniferous (Larix) trees and Grassland
Age of Granite	Jurassic	Triassic
Annual Total Precipitation (mm)	1250	300

Table 2. Runoff Characteristics of Korean and Mongolian Granite Drainage Basins.

	K-Basin	M-Basin
Runoff Coefficient	0.50	0.072
Direct Runoff	Associating with the rainfall intensity more than 5 mm/hr	Associating with the rainfall intensity more than 10 mm/hr
Baseflow	Little	Constant and Gradually Increasing
Dominant Runoff Process	Quickflow (throughflow and pipeflow)	Baseflow (Hortonian overlandflow only associating with high rainfall intensity)
Response to Rainfall	Sensitive	Not Sensitive

tember associating with the rainfall intensity of 10 and 18 (mm/hr), respectively in 1999. Except these cases, the height of runoff of M-basin shows almost constant or gradually increasing tendency, for example, the height of runoff of July 19 shows 0.00057 (mm/hr) and gradually increased to 0.01 (mm/hr) on Oct.10 in 1999, 4) The electric conductivity of river water of *M*- basin shows 45.7-55.6 ㎲/㎝.

Discussions

Occurrence of intermittent flow in *K*-basin possibly implies that very quick discharge dominates. The very high runoff coefficient implies that most of effective rainfall quickly discharge by throughflow or pipeflow. The Hortonian overlandflow is thought to almost not occur because of high infiltration capacity originated by coarse grain sized soils of *K*- basin. Very little baseflow also suggests that rainfall almost does not infiltrate into bedrocks in *K*-basin.

Flood runoff ratio in *M*-basin shows less than 1%. This means that most of rainfall infiltrates or evaporates in *M*-basin. Runoff characteristics of constant and gradually increasing discharge imply that most of rainfall infiltrates into joint planes of bedrock and flow out from spring very slowly. The hydrograph peaks are sharp and their recession limbs steep. Very short time flood with less than 1-hour lag time in *M*-basin means that overland flow occurs only associating with rainfall intensity of more than 10 mm/hr. When peak lag time shows less than 1 hour for the size of drainage area of 1 to 10 km^2, Hortonian overland flow causes peak discharge (Jones, 1997).

The results of electric conductivity suggest that residence time in soils or weathered mantles of *M*-basin is longer than that of *K*-basin. Qucik discharge caused by throughflow and pipeflow occurs dominantly in *K*-basin, whereas baseflow more dominantly occur than quick discharge in *M*-basin. Quick discharge caused by Hortonian overlandflow only associating with rainfall intensity of more than 10 mm/hr in *M*-basin. The differences in runoff processes between K- and M-basins are summarized in Table 2.

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