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

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Abstract : Dissected erosional surfaces are widely distributed in the western part of Korea (e.g., Icheon, Chungju, Jecheon, Seosan). The deposits with thickness of less than 2m occur on the smooth bedrock surface are composed of poorly sorted subangular gravels with less than 20cm diameter. However, only weathered mantle of granites without the gravel layer are observed at some outcrops. The results of grain size analysis of deposits of Icheon district revealed that the characteristic of the grain size distribution is very similar with the results of sheetflood deposits presented by Blair (1999) in the Death Valley.

Loess layer with buried soil layers of MIS7 covers the sheetflood deposits. The loess layer implies that the sheetflood deposits occurred before MIS7 based on the typical Loess sequences presented by Naruse *et al.* (2003). On the other hand, the climate of Korean Peninsula in MIS2 was very dry and cold (Yoon and Hwang, 2003) by pollen analysis. This is because Yellow Sea was completely emerged during the MIS2 (e.g. Saito, 1998). So, it is thought that the climate in Korean Peninsula of not only MIS2 but also other glacial ages such as MIS8 was similar with present Mongolian climates. Tanaka *et al.* (2005) pointed out that Hortonian overlandflow occurs in grass vegetated granite basin in Mongolia. Therefore, dissected piedmont gentle slopes in the western Korea were possibly formed by sheetflood erosion during probably MIS8 as pediment widely distributed in Mongolia.

Key Words : Korean, Mongolia, granite, Hortonian overlandflow, Interflow, Pediment

I. 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 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.

II. 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.

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 5m.

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 30km 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) with weathered mantle of about 5m 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 250mm with about 80% falling in June - September period (Institute of Geography, 1990). Study area is located in the transitional zone from Taiga to Steppe. Vegeta-tions 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.

III. 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 50cm depth probe (Unidata U6521) and tipping bucket rain gauge (TBRG Davis 0.2mm 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 10minutes, automatically. The relationships between discharge, Q(l/s) and water level obtained by the depth probe, H(cm) is calculated as follows: $Q=0.264H^{1.58}$.

IV. Results

1. Korean Granite

Fig. 2 shows the example of the peak height of runoff occurred on 27 Jun -30 Jun. The peak discharge is characterized by the lag time of 5 hours and gentle recession curve continuing for more than 24 hours. The runoff ratio shows more than 50%. The electric conductivity of river water of *K*- basin is 28.7-39.4 μs/cm.

2. Mongolian Granite

Fig. 3 shows the distinct peak height of runoff of 0.01 and 0.05 (mm/hr) occurred on 4 and 5

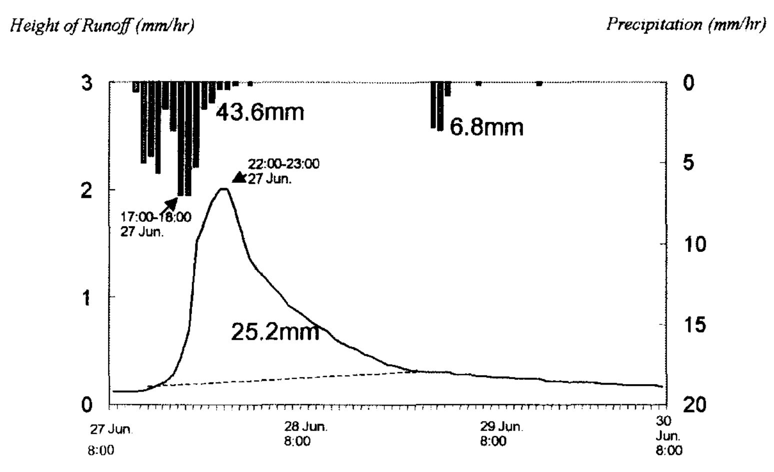

Fig. 2. Hydro- and Hyeto- graph of Korean granite basin(K-basin) of 27 Jun. - 30 Jun. 2003.
The lag time shows 5 hours and the direct runoff continued more than 24 hours.

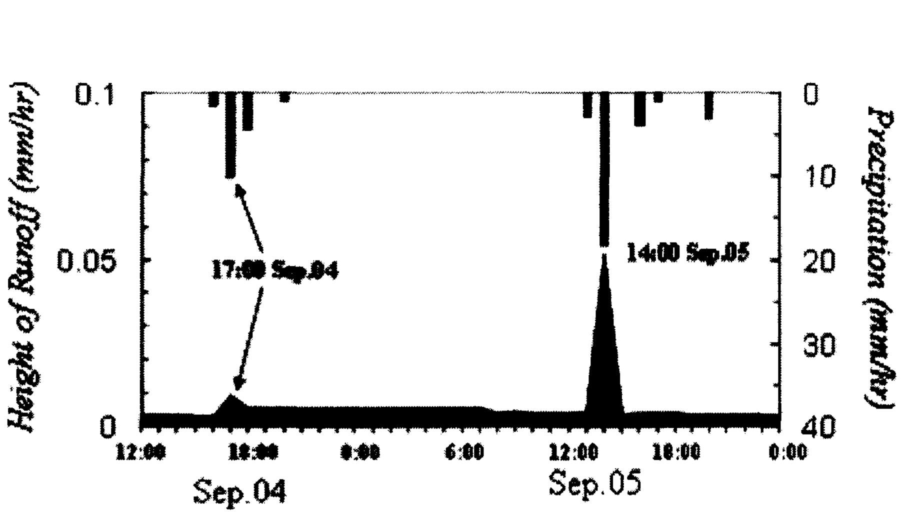

Fig. 3. Hydro- and Hyeto- graph of Mongolian granite basin(M-basin) of Sep. 4 and 5, 1999.
The peak discharges are characterized by very short lag time and very steep recession curves (Tanaka *et al.* 2005)

September 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. The electric conductivity of river water of *M*-basin shows 45.7-55.6μs/cm.

V. Discussions and Conclusions

1. Runoff Process

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 not much 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 10mm/hr. When peak lag time shows less than 1 hour for the size of drainage area of 1 to 10km^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 10mm/hr in *M*-basin.

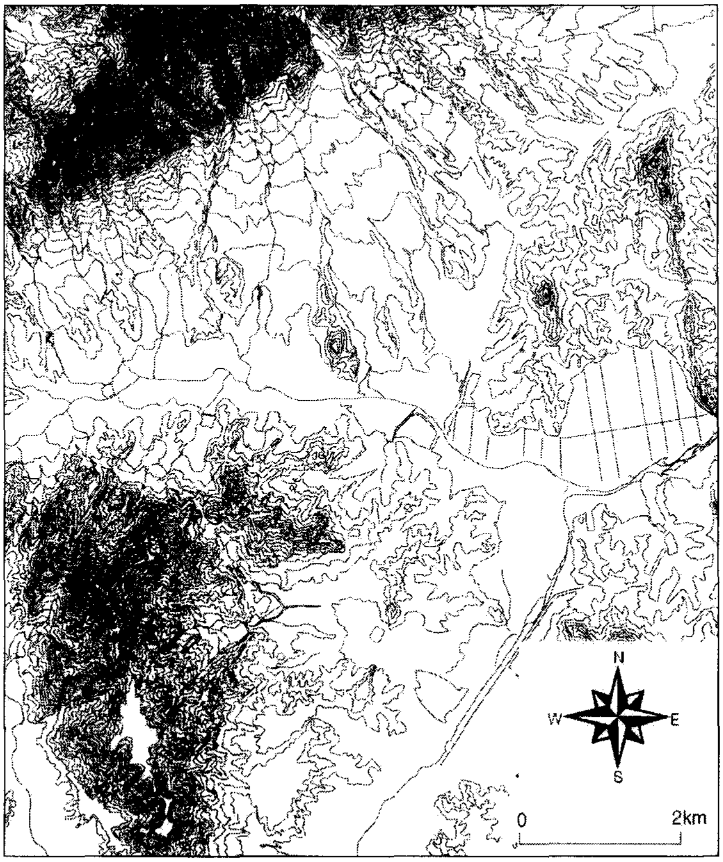

Fig. 4. Topographic map of dissected piedmont gentle slopes of Icheon district. Contour interval is 10m.

2. Korean Hillslope Process in Glacial Age and Possibility of Pediment Formation

Dissected erosional surfaces are widely distributed in the western part of Korea(e.g., Icheon, Chungju, Jecheon, Seosan). Fig. 4 shows the map of piedmont gentle slopes of the Icheon district, Kyonggi-Do, central Korea. Some ridges elongating to southeast direction with small relative height are recognized on the slopes, leaving these ridges with flattened surfaces at approximately the same height. These ridges, i.e., the original surfaces of piedmont gentle slopes, have been free from the dissection by streams(e.g., Chang, 1997; Akagi, 1975). The streams dissecting the original surfaces have formed alluvial fans between ridges.

The field observation showed that the poorly sorted subangular gravels with less than 20cm diameter and layer with thickness of less than 2m occurs on the smooth bedrock surface. However, only weathered mantle of granites without the gravel layer are observed at some outcrops. These facts suggest that the piedmont gentle slopes of the Icheon district is thought to erosional surfaces, i.e., pediment.

As many researchers have pointed out(e.g., Akagi, 1975; Chang, 1997), the piedmont gentle slope, occur in granite areas. The mountain area

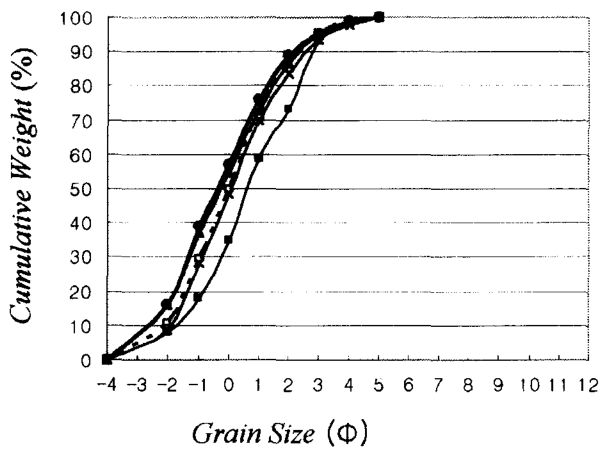

Fig. 5. Results of grain size analysis of deposits of piedmont gentle slopes of Icheon.

behind piedmont gentle slopes is composed of Precambrian banded gneiss; the piedmont gentle slope is composed of Jurassic Taebo granite (Geolo-gical and Mineral Institute of Korea, 1999). The boundary between the mountain and piedmont gentle slopes very clearly corresponds to the lithologic boundary. The deep weathered zone of the bedrock is recognized as previous works pointed out(e.g., Akagi, 1975; Chang, 1997).

3. Grain Analysis of Deposits

Fig. 5 shows the results of grain size analysis of deposits of Icheon district. The characteristic of the grain size distribution is very similar with the results of sheetflood deposits presented by Blair(1999) in the Death Valley. Results of grain size distribution, plotted on a normal-probability scale, show only one lognormal population. Resultantly, the deposits of dissected piedmont gentle slopes of Icheon were formed by one depositional process, i.e., sheetflood occurred in arid environment.

4. Age and Formative Processes of Piedmont Gentle Slopes

Loess layer with buried soil layers of MIS7 covers the sheetflood deposits. The loess layer implies that the sheetflood deposits occurred before MIS7 based on the typical Loess sequences presented by Naruse *et al.*(2003).

On the other hand, the climate of Korean Peninsula in MIS2 was very dry and cold(Yoon and Hwang, 2003) by pollen analysis. This is because Yellow Sea was completely emerged during the MIS2(e.g., Saito, 1998). So, it is thought that the climate in Korean Peninsula of not only MIS2 but also other glacial ages such as MIS8 was similar with present Mongolian climates. Tanaka *et al.*(in printing) pointed out that Hortonian overlandflow occurs in grass vegetated granite basin in Mongolia. Therefore, dissected piedmont gentle slopes in the western Korea were possibly formed by sheetflood erosion during probably MIS8 as pediment widely distributed in Mongolia.

References

Akagi, Y., 1975, Dissected pediments as an indicator of arid climate during the Riss-Würm interglacial in East Asia. *Journal of Geography*, 84, 20-35.

Blair, T. C., 1999, Cause of dominance by sheetflood vs. debris-flow processes on two adjoining alluvial fans, Death Valley, California. *Sedimentology*, 46, 1015-1028.

Chang, C. H., 1997, A geomorphic study on piedmont gentle slopes in south western area of Namwoen. *Geographical Journal of Korea*, 30, 87-102.

Institute of Geography, Mongolian Academy of Science, 1990, *National Atlas of Mongolia*. Ulaanbaatar.

Jones, J. A. A., 1997, Subsurface flow and subsurface erosion, in D.R. Stoddart(ed) *Process and form in geomorphology*. Loutledge, London.

Korean Institute of Geology, Mining and Materials, 1999, Geological map of 1:250000 scale, *Seoul-Namchonjeom sheet*.

Naruse, T., Bae, K., Yu, K., Matsufuji, K., Danhara, T., Hayashida, A., Hwang, S., Yum, J., and Shin, J., 2003, Loess-paleosol sequence in the Chongokni paleolithic site. *Geological formation of the Chongokni paleolithic site and paleolithic archeology in East Asia(Han yang Univ.)*, 143-156.

Saito, Y., 1998, Sea levels of the Last Glacial in the East China Sea continental shelf. *The Quarternary Research*, 37, 235-242.

Tanaka, Y., Matsukura, Y., N. Batnasan, and D. Tuvshinjargal, 2005, Distinct runoff processes in granite and sandstone drainage basins near Ulaanbaatar, Mongolia. *Environmental Geology*, 47, 640-646.

Wakatsuki, T., 2001, The difference in formation of soil layers and its effect on soil slips on Korean granite and gneiss slopes: *Dissertation for Tsukuba Univ.*, 97p.(in Japanese with English abstract).

Yoon, S. O. and Hwang S. I., 2003, The natural environment during the Last Glacial Maximum Age around Korea and adjacent area. *Proceedings of 2nd Korea-Mongolia joint seminar on global environmental changes of northeast Asia*, 16-20.