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Geochemistry and isotope compositions of the Han River, Korea

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ABSTRACT

In order to investigate processes and factors controlling the chemical and isotopic compositions of the Han River, seasonal studies were carried out. The North Han River was much lower in the concentrations of total dissolved solids (TDS), dissolved inorganic carbon (DIC) and major ions than the South Han River, but higher in SiO_2 concentration, $\delta^{34}S_{SO4}$ value and $^{87}Sr/^{86}Sr$ ratio. This indicates that the chemical and isotopic compositions of the Han River were strongly controlled by the geology of their drainage basins: silicate rocks in the North Han River and carbonate rocks in the South Han River. The $\delta^{34}S_{SO4}$ values were relatively higher in the North Han River (5.90±1.46‰) than in the South Han River (3.48±0.73‰). This implies that dissolved SO_4^{2-} in the North Han River might be mostly derived from deposition of atmospheric sulfates, whereas in the South Han River from oxidation of sulfide minerals in the abandoned poly-metallic deposits and the coal-bearing sedimentary rocks distributed over the upstream as well as deposition of atmospheric sulfates. The $^{87}Sr/^{86}Sr$ ratios in the North Han River were distinctly higher than those in the South Han River, reflecting water-rock interaction with different rock types.

Key words : Geochemistry, Stable isotopic compositions, Water-rock interaction, Strontium isotopes, Han River

1. Introduction

The Han River is the largest river in South Korea and supports a variety of industrial and agricultural activities, including freshwater supply for over 10 million inhabitants living in a metropolitan city, Seoul. It consists of two major rivers (the North and South Han Rivers) and many tributaries. The North Han River drains Precambrian gneissic basements and Mesozoic granites, whereas the South Han River drains Paleozoic sedimentary rocks (carbonates and clastic sediments) in the upper, and Precambrian gneissic basements and Mesozoic granites in the lower. Because of such a big difference in geology between the two river basins, the Han River system can be an ideal, natural laboratory to understand processes of weathering and influence of basin geology affecting water quality.

The objectives of the study are to investigate the hydrogeochemical characteristics of the Han River, and to determine processes and factors controlling its chemistry using geochemical and isotopic data. The water samples were collected from 14-23 sites along the North and South Han Rivers through the 3 field trips carried out in August 2000 (summer), December 2000 (winter) and March 2001 (spring).

2. Chemical composition of river water

The major ion chemistry of the Han River shows little seasonal variation and seems to be strongly influenced by its tributaries and dams located along the river. They have medium pH values (7.32-9.33) showing little seasonal variation and low total dissolved solid (TDS) values (22.9-215.7 mg/l). The average TDS value of the South Han River (148.7±23.6 mg/l, n=26) was about three times higher than that of the North Han River (55.0±17.9 mg/l, n=24). Seasonal variation in TDS was observed in the upstream where the average ion composition was more diluted by the heavy precipitation in summer. However, seasonal variation in TDS appears to be greatly damped or obscure in the downstream where several flood control dams are located along the river.

Although no evaporates are found in sedimentary rocks of the South Han River basin, their SO_4^{2-} contents abruptly increase as waters flow through clastic sediments and limestones (Fig. 1). This is because a lot of coalfields and abandoned poly-metallic deposits containing disseminated sulfides such as pyrite are distributed in the sedimentary rocks. Thus, high SO_4^{2-} contents in the South Han River probably originate from oxidation of such sulfides.

On a TDS vs. Na/(Na+Ca) diagram, except for one sample taken from the headwaters, all of the data from the South Han River plot in the rock dominance field, whereas the data from the North Han River plot around the boundary between rock dominance field and precipitation dominance field (Gibbs, 1970). This indicates that the major mechanism controlling the water chemistry of the South Han River is the chemical weathering of rock-forming minerals. However, in the North Han River, both chemical weathering and atmospheric input are the major factors controlling its water chemistry.

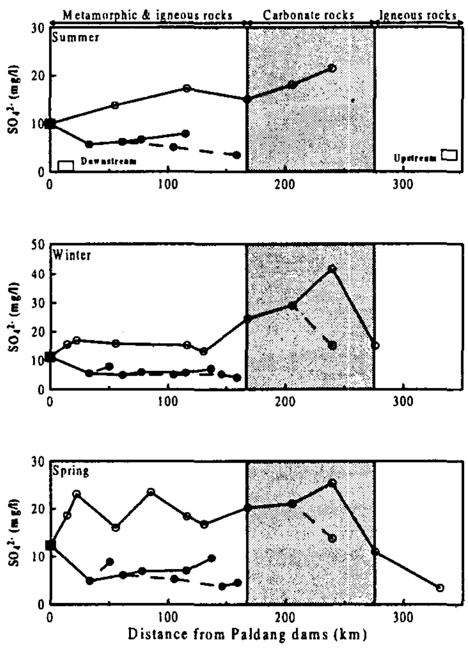

Fig. 1. Relationship between SO_4^{2-} and distance along the Han River.

3. Isotope geochemistry

During the study period, the stable isotopic compositions of water samples were quite similar between the North and South Han Rivers, with $\delta^{18}O$ ranging from -11.7 to -8.9‰ and δD from -80 to -66‰. No seasonal variation was recognized in the oxygen and hydrogen isotopic data. Most of the water samples obtained plot closed to the local meteoric water line (LMWL). However, six summer samples collected from dams in the North Han River were distinctly enriched in their stable isotopic compositions and deviate significantly from the LMWL. They appear to have undergone varying degrees of evaporation and define an evaporation line with a slope of 5.53 (n=6; r^2=0.90), significantly less than that of LMWL.

The evaluation of the water lost by evaporation from the North Han River during summer is calculated as 6.1%, whereas from the South Han River calculated as 2.0%. This result indicates that the evaporation loss is much higher in the North Han River than in the South Han River. This is probably because there are several flood control dams in the North Han River, but only one dam in the South Han River.

Considering SO_4^{2-} concentration (0.6-14.2 mg/l) and $\delta^{34}S_{SO4}$ value (3.9-8.2‰) of rainfalls collected in Chuncheon (Yu and Park; in press), rainfall source seems to be major contributor of SO_4^{2-} in the Han River basin. Because the North Han River basin entirely consists of gneissic and granitic basements with no sedimentary rocks, possible sources of river water sulfates are atmospheric input and oxidation of sulfide minerals in silicate rocks. Relatively low SO_4^{2-} concentration (5.90±1.46 mg/l, n=28) and high $\delta^{34}S_{SO4}$ values (6.23±0.87‰, n=15) of the North Han River are compatible with the rainfall data of Yu and Park (in press), indicating that river sulfates originate from atmospheric sources (Karim and Veizer, 2000). Whereas relatively high SO_4^{2-} concentration (19.10±6.19 mg/l, n=26) and low $\delta^{34}S_{SO4}$ values (3.48±0.73‰, n=13) in the South Han River suggest that sources are likely related to oxidation of sulfides in the abandoned poly-metallic deposits and coal-bearing sedimentary rocks distributed in the upstream as well as deposition of atmospheric sulfates.

The average Sr concentration of the South Han River (134.4 μg/l) was about three times higher than that of the North Han River (46.8 μg/l). On the contrary, 87Sr/86Sr ratios of the South Han River (0.716 to 0.718) were distinctly lower than those of the North Han River (0.723 to 0.725). No seasonal variation in the $^{87}Sr/^{86}Sr$ ratios was observed in the Han River waters, indicating that water-rock interactions in the Han River take place constantly.

4. References

Gibbs, R.J., 1970, Mechanisms controlling world water chemistry, science, 17, 1088-1090.

Karim, A. and Veizer, J., 2000. Weathering processes in the Indus River Basin: implications from riverine carbon, sulfur, oxygen, and strontium isotopes. Chem. Geol. 170, 153-177.

Yu, J.Y. and Park, Y., Sulphur isotopic and chemical compositions of the natural waters in Chuncheon area, Korea. Applied Geochemistry (in press).

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