Effects of Bedrock Groundwater and Geological Structure on Hydrological Processes in Mountainous Watersheds

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INTRODUCTION

Bedrock groundwater is reported to have significant effects on discharge hydrographs and landslide occurrences in mountainous watersheds. To clarify the role of bedrock groundwater flow, the observation of water chemistry is effective because it reflects the geological structure of groundwater flow path as a natural tracer. In this study, ion concentrations and isotope ratios were measured in watersheds having different geological structure.

METHOD

Observations were performed in the Hirudani experimental basin (82.1 ha) in the Hodaka Sedimentation Observatory, Kyoto University (Fig. 1). The basin contains three small watersheds referred as WS1, 2, and 3, the areas of which were 8.5, 15.3, and 25.8 ha, respectively. To understand the spatial variation in water chemistry of the basin, water samples were collected at 17 points from the stream and springs (Fig. 1). Additionally, one sample was collected at the outlet of Warudani basin (108.2 ha), which is adjacent to the Hirudani basin. The concentrations of major anions and cations were measured by using ion chromatography. The isotope ratio was measured by using infrared emission spectrometry.

RESULTS AND DISCUSSION

We report a part of hydrochemical observation in this abstract. The ion concentrations were shown by hexa-diagrams in Figure 1. Small watersheds WS1, 2, 3 had different characteristics in ion concentration, while samples in the same watershed showed similar trend. In WS1, Ca^{2+} and HCO_3^- showed high concentrations. In WS2, all ions showed lower concentrations compared to those of other watersheds. In WS3, slightly high concentration of SO_4^{2-} was detected, which was similar to the trend in W-1 sample. These differences in trends can be related to the differences in geological structure in each small watershed shown in Figure 2. WS1 was composed mainly of granite. Both WS2 and 3 were composed mainly of Mesozoic melange, and WS3 had higher percentage of lava similar to Warudani basin.

As shown in Figure 3, the $\delta^{18}O$ values showed correlation with the altitude of sampling points. However, the $\delta^{18}O$ values in WS 2 and 3 were low compared to the altitude, indicating the groundwater flow through relatively longer and deeper pathway and also suggesting the existence of groundwater flow from high altitudes to WS 2 and 3. Thus, the groundwater flow path in the basin was suggested by using the hydrochemical observations.

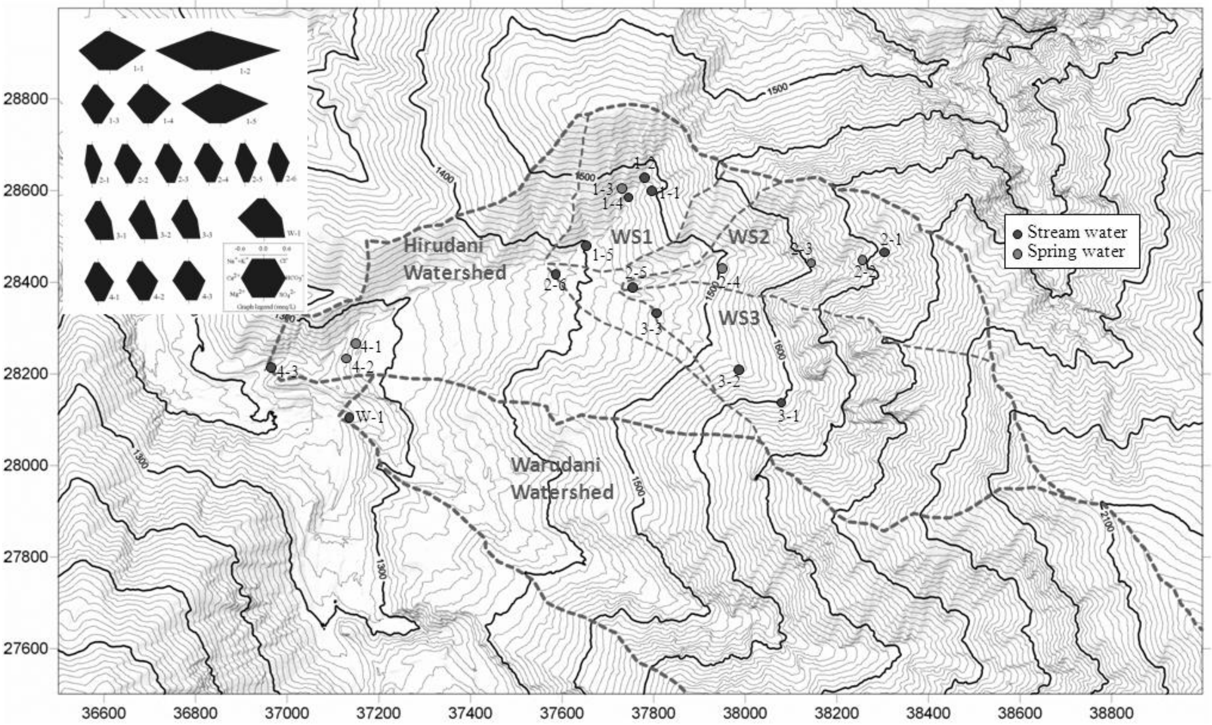

Fig. 1 Map of the Hirudani basin and surrounding area. Circles indicate locations of water sampling. Broken lines indicate the boundary of watersheds. Hexa-diagrams for water samples are also shown in the figure.

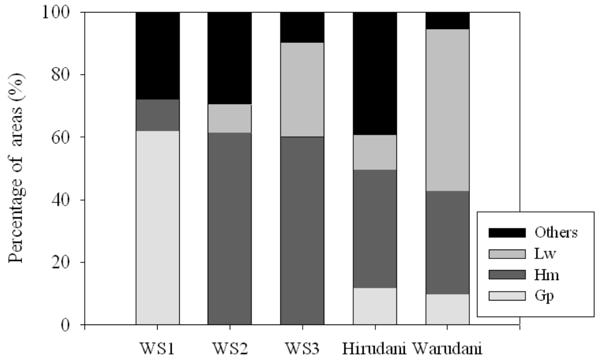

Fig. 2 Geology of each watershed. Gp: granitic ring dike, Hm: Mesozoic melange, Lw: Warudani lava.

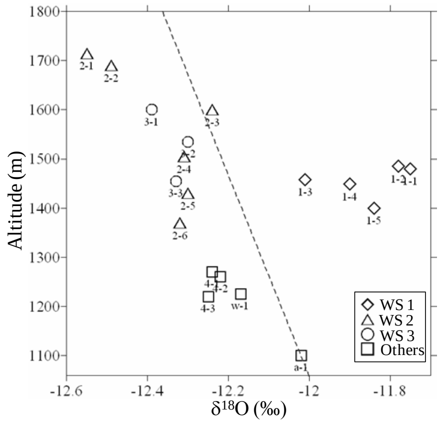

Fig. 3 Relationship between $\delta^{18}O$ values and altitudes of sampling point. Broken line denotes a simple linear regression

Keywords: Bedrock groundwater, geological structure, ion concentration, isotope ratio