

風化花崗岩山地における基岩地下水の水質特性 Variability of the chemistry of streamwater and bedrock groundwater at a weathered granite mountain, Japan

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Introduction

Previous studies have noted that bedrock groundwater is one of the important factors influencing stream discharge and streamwater chemistry. However, most previous studies were conducted not by direct measurement of bedrock groundwater but by using indirect methods, such as solute tracers and water budget analysis. Thus, the movement and chemical characteristics of bedrock groundwater remain incompletely understood based on direct measurements of bedrock groundwater. To better understand the dynamics of bedrock groundwater, we investigated groundwater table movement and water chemistry of bedrock groundwater using dense borehole wells at a small catchment in a mountainous area.

Methods

The study was performed at the Fudoji Experimental Watershed located in the Tanakami Mountains in the southeastern part of Shiga Prefecture, central Japan. Precipitation was monitored using tipping-bucket rain gauges, and discharges were observed at eight small catchments, ranging in area from 0.1 to 2.3 ha. Seven small catchments (subcatchments) were included in the largest catchment (2.3 ha), within which we installed 61 borehole wells. The water table of bedrock groundwater was then observed at these borehole wells. Rainwater, streamwater from the small catchments and bedrock groundwater from the borehole wells were sampled, and the concentrations of major ions and SiO₂ as well as the water stable-isotope ratios d¹⁸O and dD were measured in the Graduate School of Agriculture, Kyoto University.

Results and Discussion

The results of the analysis of the groundwater table of bedrock groundwater indicated that there were several fluctuating characteristics and that these characteristics of groundwater table change had locality. At the area having higher altitude in the ridge, the bedrock groundwater-table changes were gradual but the ranges of fluctuation were larger than those of the lower wells. At the lower-altitude points, although the bedrock groundwater table responded rapidly, the ranges of fluctuation of the groundwater table were small relative to those of the higher points. Some areas responded only to peak rainfall over a short time. Based on the groundwater flux analysis, bedrock groundwater moves across the surface divide. A catchment inflowed by a neighboring catchment showed a high specific discharge. Additionally, the direction of groundwater movement changed during rainfall events, and such changes were similar for rainfall events of the same size.

The relationships among chemistries derived from the chemical weathering of bedrock indicated that although the weathering processes were similar in the catchment, the weathering level varied among the borehole wells. The chemistries of bedrock groundwater at each catchment and of streamwater at each catchment showed large variability. The concentrations of Na⁺ and Ca²⁺ had local characteristics, but no clear characteristics were observed among other bedrock groundwater components. The chemical concentrations of bedrock groundwater were higher than those of streamwater. We chose borehole wells that may contribute directly to the stream based on the direction of groundwater movement by an analysis of groundwater flux and distance from the borehole wells, and noticed that there were also large gaps between the chemistries of streamwater and bedrock groundwater. These results indicate that complex processes of chemical dynamics occur in the weathered bedrock and from the weathered bedrock to the stream.

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