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山地源流域における基岩地下水と表層水文プロセス・地形形成プロセスとの相互作用
Interaction between bedrock groundwater and surface-hydrological and geomorphological processes in mountainous headwater

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Enormous landslides with deep slipping surfaces, which are likely to be triggered by the huge storms expected with climate change, can be one of the major geomorphological processes in the temperate climate zone. This study focuses on groundwater in mountainous headwater regions as a potential cause of such landslides. Recent hydrological studies have revealed that large amounts of rainwater infiltrate into bedrock, suggesting the possibility that steep mountains could contain greater amounts of groundwater than previously thought. The decline in groundwater levels due to water harvesting should be effective for the prevention of landslides. At the same time, the exploitation of groundwater resources in mountainous regions may contribute to establish a sustainable supply of safe water; that is, groundwater in mountainous regions is of better quality and less vulnerable to pollution because human activities are limited in the source areas. Thus, the exploitation of groundwater resources in mountainous regions should produce a win?win situation that achieves both disaster mitigation and a sustainable water supply. This study investigates hydrological methods for observing and analyzing quantitative and qualitative signals in mountain streams that can be used for detecting groundwater dynamics in steep mountains. Such hydrological methods are effectively combined with geophysical surveys.

In the steep Rokko mountain range of central Japan, which consists of granite and has been greatly affected by diastrophic activities, discharge hydrographs are characterized by significant amount of baseflow. In order to elucidate contributions of bedrock groundwater to the hydrograph formation, long-term hydrological observations were conducted by using bedrock wells with depths of 7-78 m drilled at 31 points within a 2.1-ha headwater catchment in the Rokko mountain range. Results indicated a fairly regionalized distribution of bedrock groundwater; that is, upper, middle, and lower aquifers were present. We observed large differences in water level among the aquifers, instead of a gradual and continuous decline in water level. Discharge hydrograph from the catchment was notably characterized by gentle and significant variations in base flow and exhibited triple-peak responses. Flashy first peaks occurred just after rainfall peaks, while the second peaks lagged behind the rainfall peaks by a few days. Broad peaks in the base-flow discharge corresponded to the third peaks, which occurred once or twice in each hydrological year. The triple-peak discharge responses were explained by three types of water pathways: the first peak was caused by the peak in soil mantle groundwater around the outlet of the watershed; the second peak was caused by the first peak in the lower aquifer, which was fed by vertical rainwater infiltration; and the third peak was caused by the second peak in the lower aquifer, resulting from an increased lateral water supply from the middle aquifer. The middle aquifer was recharged by vertical infiltration through weathered bedrock and lateral flow from the upper aquifer. Because of its broad regional expanse and large capacity, the middle aquifer had a dominant effect on formation of the discharge hydrograph. Thus, this study has demonstrated how discharge from the steep headwater catchment is dominated by complex flow systems within bedrock groundwater; the spatial expanse of bedrock aquifers and interaction among aquifers are key factors.

キーワード: 大崩壊, 地形形成, 源流域, 基岩地下水, 水資源
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