Transition of Water and Sediment Discharge From the Rokko Mountains, Japan

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INTRODUCTION

During the Meiji Era (1867–1912), the Rokko Mountains were bare land due to over cutting. In 1938 and 1967, landslides and debris flows occurred with heavy rainfalls. Currently, the Rokko Mountains are re-covered with vegetation by plantation. In this study, we examine whether the mountains are able to withstand future landslides and debris flows. We first analyzed the historical transition of water and sediment transport in the mountain streams of the Rokko Mountains. Next, we examined the changes in the Rokko Mountains since this transition from the standpoint of bare land ratios and soil development. Lastly, we discuss the risks arising from sediment yield and runoff from the Rokko Mountains.

METHOD

The Rokko Mountains are located in western Japan. From 2003 onwards, hydrologic and sediment observations have been carried out using water gauges, pipe hydrophones, and turbidity meters in the main mountain streams. Incidentally, the head source in the Shiramizudani Valley is now bare land. The suspended load was observed in these streams during flooding. We calculated the bare land ratio (r_a) or the ratio of the bare land area in the watershed area on the Sumiyoshi River Basin using serial aerial photographs over time and compared the ratio with the observations. We investigated the change in sediment discharge from the Rokko Mountains, using the observations, the bare land ratio and past data of disasters. To examine soil development on the slopes, we selected three areas where the period of soil development was known and then measured the soil depth.

RESULTS

The change in specific annual sediment discharge as compared with the rainfall from the Rokko Mountains, from the Meiji Era to the present, is shown in **Fig. 1**. The Rokko Mountains yielded 11,000 $m^3/km^2/y$ of sediment during the Meiji Era. After this, not including the 1938 and 1967 sediment disasters, the amount of transported sediment successively decreased and is currently 50 $m^3/km^2/y$. The change in the amount of transported sediment is not related to the amount of rainfall. The decrease in sediment discharge is investigated from the viewpoint of reduced suspended load due to vegetation recovery. A relationship between suspended load Q_s and the flow rate Q exists, where $Q_s = \alpha \times Q^2$. **Fig. 2** depicts the relationship between the bare land ratio r_a and α. As r_a increases, α and the suspended load also increase. **Fig. 3** depicts the average value of the current soil depth in the area that had previously been forested during the Meiji Era and the areas where the landslides occurred in 1938 and 1967. Soil layers have developed over time.

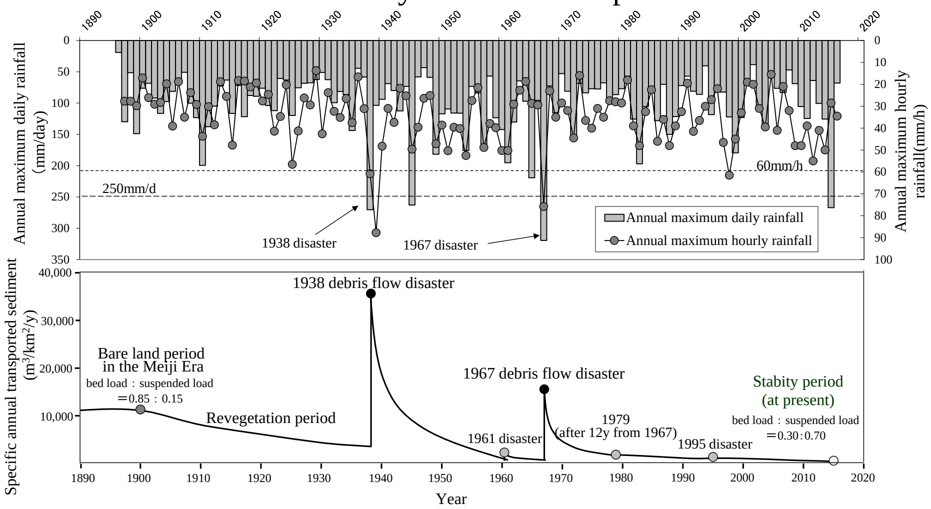
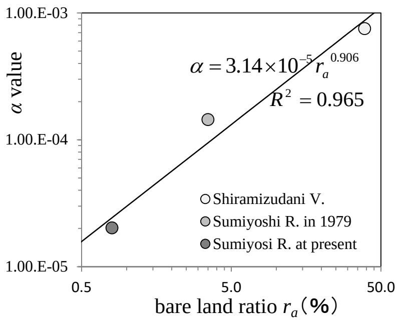


Fig. 1 Historical transition of sediment transport in the Rokko Mountains



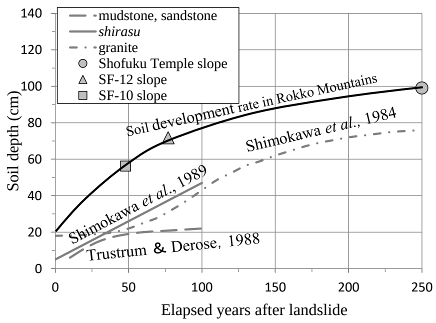


Fig. 2 The relationship between bare land ratio r_a and α **Fig. 3** Soil development rate (Matsukura, 1994)

DISCUSSION

The volume of sediment discharge in the Rokko Mountains has gradually decreased and is currently almost negligible. Vegetation recovery is a major factor contributing to the decrease in the amount of discharged sediment. As the soil layer develops, the peak runoff coefficient decreases. As a result, the peak discharge at the time of flooding and the sediment discharge decrease. Meanwhile, the soil development on the slope in the watershed shows increased unstable sediment volume. During past disasters, landslides and debris flows occurred when the total amount of rainfall was large and was of high intensity. Such rainfall has not occurred to date. It is suggested that landslides and debris flows could occur in the future if rainfall, as experienced during the past disasters, occurs again.

CONCLUSIONS

To judge the current risk of the occurrence of landslides and debris flows from the Rokko Mountains, it is necessary to evaluate the current situation based on the historical transition and determine the state of the current watershed.

Keywords: Rokko Mountains, sediment observation, bare land, soil development