4.8 Permafrost Study on Mt. Fuji

Atsushi Ikeda
University of Tsukuba

1. Introduction

Permafrost is ground that stays below 0 °C all year round, and it is commonly found at high latitudes in the Northern Hemisphere and in the Tibetan plateau because of the low temperature and low amount of snowfall. Permafrost often controls ground hydrology and thus the ecology above the permafrost. Rapid recent warming in the Arctic has disturbed the ground thermal equilibrium, and related changes in the hydrological cycle and carbon cycle are becoming an important issue for the Arctic. In addition, increasing attention is being paid to permafrost on high mountains because the warming and thawing of permafrost destabilizes steep slopes and occasionally triggers slope hazards. In Japan, permafrost was discovered in the early 1970s on Mt. Fuji and the Daisetsu Mountains in Hokkaido. However, the thermal status of the permafrost was unclear until the 2000s because no boreholes had penetrated the seasonal thaw layer above the permafrost.

Thus, we began a research project to understand the permafrost on Mt. Fuji, to monitor its changes, and to evaluate the effects of climate change and volcanic activity on the surrounding environment from the summer of 2008.

2. Results and remarks

Permafrost temperatures in the 10-m-deep borehole dug in 2010 were monitored from the second year of the project (2011) to 2016; the data logger failed in the first winter because of lightning. This is the first continuous record of permafrost temperature on Mt. Fuji. The temperature near the bottom of the hole was stable at about −3 °C, which means that the permafrost can easily survive recent warming. In addition, we found that the maximum seasonal thaw layer (active layer) above the permafrost was 1.0-1.1 m thick at the site. The active layer is 10% thicker than in 1971 because of the warming, especially after the late 1990s.

Contrary to the assumption of previous studies, the absence of permafrost was also confirmed in several other boreholes dug in 2008 in the summit area. By using a portable ground infiltrometer, we found that the water permeability of the non-permafrost sites is higher than that of the permafrost sites. Highly conductive sandy sites with no permafrost showed an extreme thermal response to heavy rainfall events, whereas the silty site with the lowest conductivity had the thinnest active layer. Thus, we concluded that highly permeable debris allows heat transportation by rainwater infiltration, which prevents the ground from being frozen throughout the year.

However, the distribution of impermeable layers is difficult to evaluate because the degree of volcanic welding is heterogeneous. In contrast, the ground surface temperatures measured at 20 sites reflected the air temperature and solar radiation. This indicates that the permafrost maintained at only those locations less affected by rainwater infiltration responds mainly to long-term variation in air temperature. Thus, the 0.7 °C

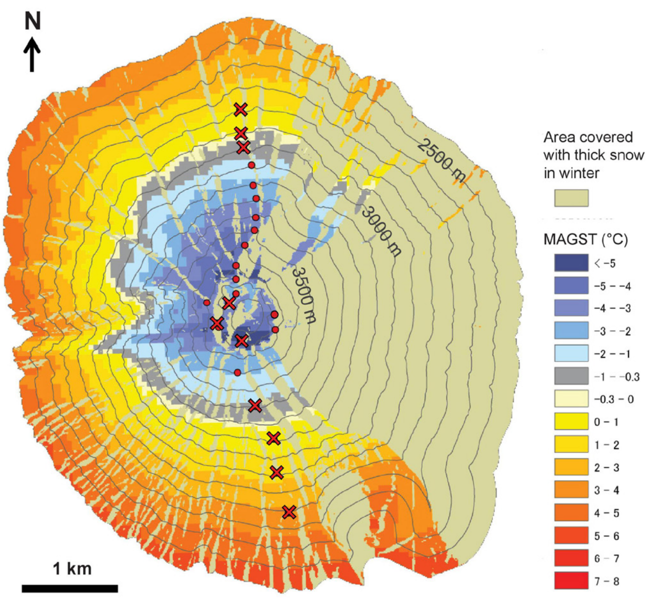

Fig. 4.8-1: Map of mean annual ground surface temperature (MAGST) roughly above the forest line on Mt. Fuji

warming from the 1970s to the 2000s recorded at the summit station could shift the lower boundary of the permafrost upward by 100 m. The effect of this shift on the slope stability should be studied because the debris flow source catchment (Osawa-kuzure) crosses this permafrost boundary.

According to the measured relations between the surface temperatures and altitudes on the north- and south-facing slopes, the monitored ground surface temperatures were spatially extrapolated for the whole Mt. Fuji area by using GIS software. For this calculation, the benchmark data were those of the permafrost monitoring site on the summit. The potential lower boundary of permafrost lies at 3050-3150 m above sea level on the north-facing slope and at 3450-3600 m on the south-facing slope (Fig. 4.8-1).

By comparing this map with sites with positive mean annual ground temperatures at a depth of 0.5 m (marked X in the figure), the lower limit of permafrost is estimated to be a MAGST of −1 to −2 °C. The increase in mean annual air temperature from the 1970s is 0.7 °C, which disturbs the permafrost in the gray area. The area covered with thick snow is also shown because thick snow prevents ground cooling and permafrost development.