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Processes of stone displacement under freeze-thaw conditions on low mountain slopes

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This study presents new data on surface stone migration and temperature fluctuation in three winter seasons on a low mountain peak in the Goreibitsu pass (c. 900m a.s.l., 37.5N), northeastern Japan. Wind-beaten bare ground and patterned ground are very locally developed on the peaks near the Goreibitsu pass surrounded by forest. We observed air temperature, ground temperature, paint-line movement, soil water content and wind speed on ground surface on the wind-beaten bare ground sloping c. 10 to 20 degrees. Air and ground temperatures were recorded every 60 minutes throughout the 2004/2005, 2005/2006, 2006/2007, 2007/2008 and 2008/2009 winter seasons. The maximum downslope dislocation of stones in a winter season was 100cm. On this bare ground, we observed the development of needle ice, which lifted a stone 7cm in the case of 23 Nov. 2007. These observations suggest that mass-movement including frost creep, gelifluction and talus creep are operative on the slope lower than the general forest limit of this region.
In order to clarify the processes of stone displacements occurred in wind-beaten bare ground which is very locally developed below the forest line, a series of experiments, Ex1 to Ex23, was carried out under the controlled freeze-thaw cycles in a cold laboratory. Two boxes, Box A and Box B, were prepared. Both boxes were filled with soil 10 cm thick. Four flat and angular stones about 15cm across with point marks were placed on soil surface of each box. Box A and Box B are inclined 15 degrees and 10 degrees, respectively. The results of Ex3 under cooling to -10 degrees Celsius during 5 hours followed by warming to +5 degrees Celsius during 73 hours showed that frost heaving was occurred and the maximum horizontal stone movement, 1.1 cm, was recorded when a needle ice collapsed. The frost heaving (vertical movement of gravels) of the experiment slope began immediately after a freeze start and maximum value was recorded in about 21 September Frost heaving was end, and the maximum value of horizontal movement was recorded when a needle ice collapsed around 24 Sep. in the time. On the other hand, the ground temperature recorded the lowest at night of 22 Sep. The delay of time between the occurrence of maximum gravel movement and that of needle-ice development suggests that gravels were moved by frost creep which was caused by the needle ice. The average of frost heaving amount and that of gravel movement was 1.0cm and 1.1cm, respectively, at Box A, whereas 0.7cm and 0.1cm, respectively, at Box B. Both ice needles and ice lens were observed in the box in which frost heaving and movement occurred. Strong correlation was recognized between frost heaving amount and the maximum value of gravel movement. The difference of gravel movement at the two boxes seems to be caused by not only the slant of the box but also less-developed needle-ice and ice lens at Box B.

Keywords: stone displacement, freeze-thaw conditions, laboratory experiment, wind-beaten bare ground, Goreibitsu pass