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Cyclic steps formed by a hydrophobic fluid with water dispersed flowing on ice - an analogy with NPLD -

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A variety of characteristic landforms on Mars have been discovered since Mariner 9 spacecraft returned images of Martian surface in 1972 for the first time. Recently, in particular, spiral troughs on Martian north polar ice cap have been focused due to a possibility that characteristic landforms such as spiral troughs can reveal historical variation of climate on Mars. Though they are suspected to have some relation with katabatic wind blowing on the ice cap, it has been unclear how they are formed in detail. It has been observed that spiral troughs are formed perpendicularly to the direction of katabatic wind, so that they should be boundary waves formed between Mars atmosphere and ice rather than troughs excavated by flow. In addition, because internal structures of boundary waves clarified by radar show traces of upstream migration, these steps may possibly be cyclic steps formed by density airflow.

In this study, we have performed a series of analogue model experiments of the formation of cyclic steps on Martian polar ice cap. Experiments were conducted with the use of a low temperature chamber in the Institute of Low Temperature Science (ILTS), Hokkaido University. In order to simulate density airflow including water vapor blowing on Martian polar ice cap, we have used a hydrophobic fluid with water dispersed. We did not include temperature difference among ice, flowing fluid and ambient air, which is important for the formation of cyclic steps on Mars. It is found that cyclic steps were formed on ice even without the influence of temperature. It is suspected that the concentration of water in the hydrophobic fluid changes in space, and non-uniform freezing and melting take place on ice. This causes instability of a flat ice bed. By formulating freezing and melting rates of ice as functions of flow velocity and water concentration respectively, we found that the formation of cyclic steps on ice can be described by the equations similar to that for transportational cyclic steps formed on river beds composed of suspendable fine sand.

Keywords: Cyclic steps, Mars, Polar caps, Ice, Hydrophobic fluid