Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-P01 Room:Convention Hall Time:May 24 14:00-16:30

Theoretical and experimental study on the combination of bullets of snow

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Combination of bullets is a kind of aggregation snow crystals constructed by single crystals of ice Ih; the stable phase of ice. The formation process of these crystals were considered as that ice Ic, which is the metastable phase of ice, was formed at first, and later the stable phase ice crystals (Ih) nucleated and grew on the surfaces of the preexisting metastable crystal (Takahashi, 1982; Takahashi and Kobayashi).

The phenomenon that the thermodynamically metastable phase is born at the beginning of crystallization and later the stable phase crystal nucleates and grows is called the Ostwald's step rule. The crystallization processes governed by the Ostwald's step rule has been observed in many experiments with various materials (Ostwald,1897; Barrer, 1988). However, in spite of the universality of the Ostwald's step rule, the mechanism has not been sufficiently elucidated so far. Most studies on the Ostwald's step rule are nothing but reports of the observed phenomenon with respect to specific materials, or the partial understanding of crystallization process governed by this rule.

In this study, for the purpose of the comprehensive understanding of crystallization process governed by the Ostwald's step rule, both theoretical and practical study were conducted.

I. Theoretical study

The fastest nucleation process against the values of the chemical potentials of the metastable and stable phase was derived from the comparison of the free energy barrier of all possible nucleation process (homogeneous 3D nucleation of the stable or the metastable phase, heterogeneous 2D nucleation of either phase on the other phase, and homogeneous 2D nucleation of the stable or metastable phase). Then, on the basis of the results, a diagram which shows the nucleation process against the condition of the system (nucleation mode diagram) was obtained. The path on this diagram which the actual system will trace enables to know the subsequent nucleation process, from beginning to end of the crystallization.

The necessary condition of the surface energy and driving force of the nucleation for crystallization governed by Ostwald's step rule will take place was revealed. It can be thought as that the metastable phase crystal was born under high supersaturated condition at first, and later the decrease of the degree of supersaturation due to the nucleation and the crystal growth made the stable phase crystals to nucleate on the surfaces of the existing metastable crystals.

II. Experimental study

On the basis of the present theoretical study, the experiments for artificial combination of bullets was conducted.

In the cold room at Nishiborieizaburo kinen Explorer Museum in Higashiomi, Shiga Prefecture, water droplet less than 1 micrometer in diameter were introduced into the vessel cooled with liquid nitrogen to be frozen and grew. After that, they were recovered for microscopic observation.

As a Result, combination of bullets in nature was recreated for the first time. This success is owe to the present theoretical study, thus the validity of the present theory was roughly confirmed.

Keywords: combination of bullets, Ostwald's step rule

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An attempt to estimate ice sheet flow rate and its temporal change over coastal region of east Antarctica by InSAR

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Development of a global digital elevation model (GDEM) from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data allowed us to detect surface displacements easily over ice sheet and ice stream in polar region by applying it in interferometric SAR processing. We applied the ASTER GDEM to interferograms obtained from two interferometric pair data in 2007 and 2008 observed by the Phased Array type L-band Synthetic Aperture Radar (PALSAR) boarded on Advanced Land Observing Satellite (ALOS) over an Antarctic ice sheet of the northern part of Enderby Land to remove topographic fringe and extract fringes induced by ice sheet surface displacements (Doi et al., 2011). The interferograms consisted of the extracted fringes were converted to maps of displacement along look vector. The observed maximum displacements of the both displacement maps for the recurrent period of 46 days were about 2 m. We also obtained a difference between the displacement maps, and found that complicated displacement pattern was canceled out in the differenced map. Small changes in displacements of less than 30 cm/46 days were also found along ice stream margins in the obtained differenced displacement map. Similar analysis will be applied to interferometric SAR pair data observing area along Soya Coast, where many ground truth data were obtained.

Keywords: InSAR, Antarctica ice sheet, ice sheet flow rate

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On detection of mountain permafrost boundary using ground-temperature lapse rate

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Ground-temperature lapse rates at 50cm depth in late summer had been used for detecting the lower boundary of permafrost distribution in a mountainous terrain (Fukui et al., 2006; Fujii and Higuchi, 1972). The aim of this study is to generalize this method to use ground temperature of certain depth, to validate and to check its limit.

The basic ideas behind this method are that (1) the shallow depth ground temperature is generally controlled by the balance of mean daily air temperature and ground heat flux, and that (2) this balance is then also affected by latent heat from permafrost within permafrost zone. This effect from permafrost is considered to cause a ”bend” in lapse-rate plot along the slope, which has been interpreted as the lower boundary of permafrost zone. The method is suitable for the field work in the areas with difficulties in logistics, especially for steep mountains or remote regions.

Although the method was used in some cases for its usefulness, it had not been theoretically validated. The method should have certain limits of application, because 50-cm ground temperature depends on the variation of ground heat flux, the amount of latent heat, etc. In this study, we verify this method quantitatively, as general ”ground-temperature lapse rate method”. The distributed 1-D ground temperature calculation was made in a idealized semi-infinite slope, assuming uniform atmosphere-land energy exchange. To evaluate the effectiveness of the method, temperature profile of equilibrium state for the ideal slope was calculated. As in the previous studies, ground temperature was plotted against the altitude for different time slice (i.e. corresponds to seasonality).

From the result, the correlation between the altitude of boundary and the altitude of ”bend” was partly confirmed, while it was suggested that some offset in the diagram should be considered for its altitude. Effect of variation in soil water content and soil thermal properties are examined to investigate its sensitivity. Further parameter studies are necessary toward the realistic application for specific site.

Keywords: permafrost, ground temperature, observational method, numerical experiment, mountain area

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Monitoring of 3 m-profiles of ground temperature on the summit area of Mt. Fuji (2008-2010): Toward elucidation of perm

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Permafrost occurrence on the summit of Mt. Fuji was reported at the beginning of 1970's. Public attention has been paid to possible changes in surface and underground conditions including the permafrost on the Mt. Fuji in relation to recent climate change.

The occurrence of permafrost have not confirmed during our 2-year monitoring of two soil temperature profiles down to 3m on the summit area of Mt. Fuji since 2008.

At the one site, we observed deep seasonal frost reaching over 3m depth. However, every summer heavy rain event triggered large increase in soil temperature and deeper 2-3m frozen layer was rapidly thawed by heavy rain events during autumn rainy season. At the other site, insulation effect of snow cover weakened frost penetration into the ground and heating by rain infiltration kept soil temperature relatively higher throughout the monitored period.

Our investigation suggested that soil temperature regime is highly various over years and the thermal status of frozen ground is unstable on the summit area of Mt. Fuji. It is difficult to evaluate the influence of recent climate change on the underground condition on the summit of Mt. Fuji using available information at this moment. This kind of evaluation of long-term change in soil temperature regime and frozen ground status should be done based on multipoint and long-term monitoring of ground to the deeper extent ,together with surface micrometeorological observation.

Keywords: Mt. Fuji, Permafrost, Rain infiltration, Monitoring, Soil temperature