Living Micro-Plants in the Dirt Layer Dust of Yala Glacier, Nepal Himalaya

Shiro KOHSHIMA*

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**Department of Zoology, Faculty of Science, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606*

Abstract

Dust particles in the dirt layer of the ice core of the accumulation area and the surface dust of the ablation area of Yala Glacier were analyzed. Both contained not only airborne organic and inorganic materials but also living micro-plants such as aquatic blue-green algae and bacteria. These plants were most abundant in the melt water drainage of the ablation area and formed a simple ecosystem on the glacier ice which consists of these plants and a newly found insect feeding on them. The existence of these aquatic micro-plants in the dirt layer of the accumulation area shows that dust contents of dirt layers are formed on the surface of the accumulation area during the ablation period, when there is enough melt water for algal growth on the surface. So, dirt layers in the ice core represent the past ablation surfaces stable enough for algal growth. This study shows for the first time the photosynthetic formation of dirt layer dust on a glacier which has been believed to consist only of airborne materials.

1. Introduction

In many glaciers, it has been reported that visible dirt layers containing dust particles exist in the glacial strata. Several glaciological studies speculated on their origin (Grove, 1960; Orheim, 1975). However, the content of the dust particles in the dirt layer has never been analyzed from a biological viewpoint, and has unanimously been believed to be airborne accumulations. But, this time, by stimulation of the discovery of an insect which spend its entire life cycle on Yala Glacier and feed on surface dust on the glacier ice (Kohshima, unpublished), a biological analysis of dust contents was carried out.

2. Field description

The research was done on Yala Glacier (5,100–5,600 m in altitude) in the Langtang region of Nepal from September 14 to October 24, 1982 (from the end of the monsoon season to the beginning of winter). It is a very clean mountain glacier without debris cover and has several terrassed plateaus divided by ice cliffs and crevasses (Fig. 1). The research was mainly done on three plateaus named P1 (the lowest one, 5,130 m in altitude), P2 (5,200 m) and P3 (5,400 m). The equilibrium line is about 5,300 m in altitude, between P2 and P3.

3. Materials and method

Observations of the surface structure of the ablation area and sampling of surface dust were carried out on P1 and P2. Collected dust samples were preserved in 3% formalin or 70% alcohol solution.

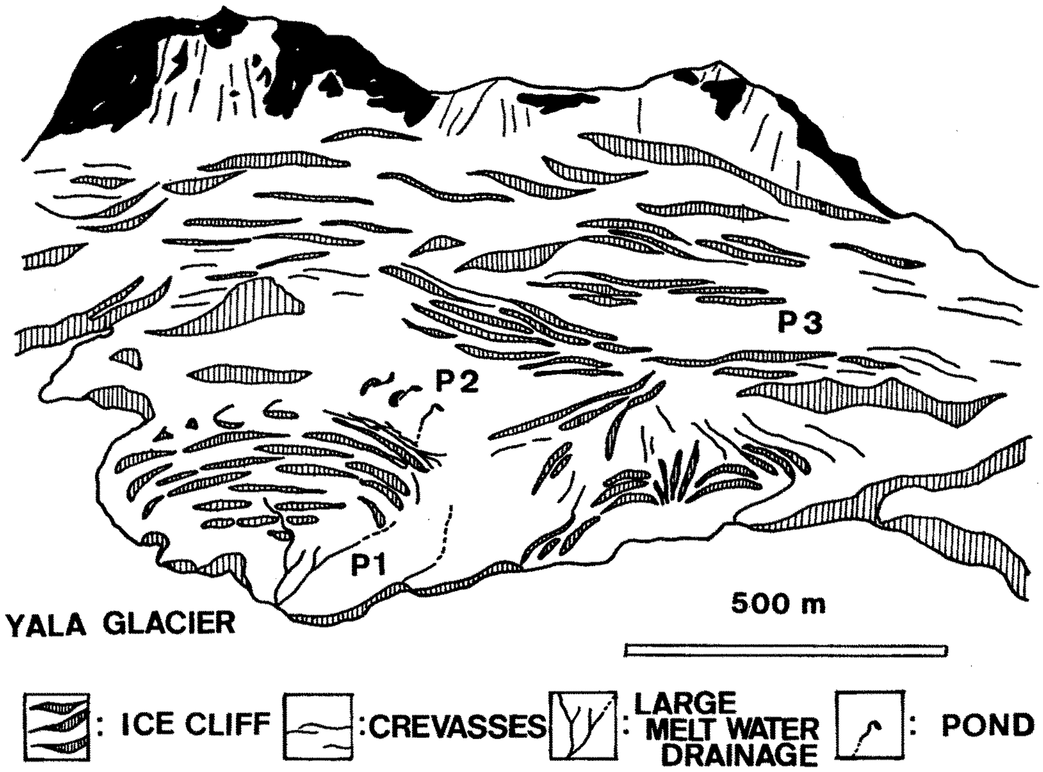

Fig. 1. Outline of Yala Glacier

Ice core sampling was done at P3 by mechanical drilling which reached to the bottom of the glacier about 60 m in depth (Takenaka et al., 1984). 75 dirt layers were identified in the ice core samples. And dust contents of 57 layers out of these samples were analyzed. The parts of the ice core containing dirt layers were melted in clean polyethylene bags and preserved in polyethylene bottles mixed with some formalin to form 3% formalin solution. Sediments of these dirt layer samples and the surface dust samples were analyzed by microscopic observation.

4. Results

4.1. Surface structure of the ablation area

At the beginning of the study period (Sept. 14), there was a snow cover (1.0–2.0 m in depth) on the glacier ice of P1 and P2. It decreased in depth with the advancing season and partly disappeared on P1 at the end of the study period (Oct. 24). In the study period, there was much melt water flow on P1 and P2 during the daytime. It created many tunnellike melt water drainages running along the boundary of the glacier ice and the snow cover (Fig. 2). And at the low places on P2, there were small ponds on the glacier ice gathering water from many melt water drainages.

The most characteristic feature of the ablation surface (surface of the glacier ice) of this region was a small pit structure (Fig. 3). Each pit had some granular dust at the bottom.

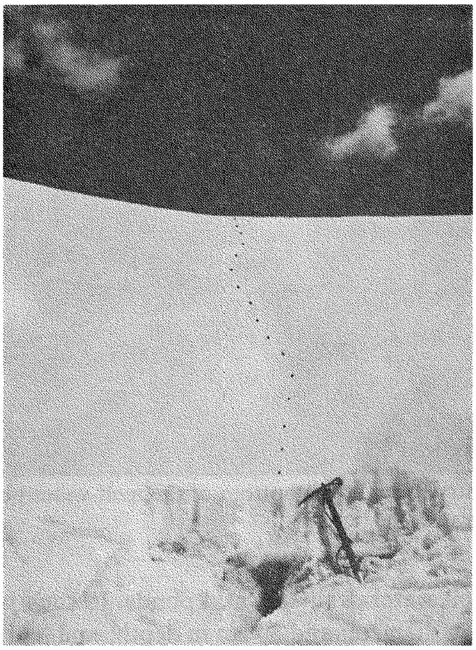

Fig. 2. Under-snow melt-water drainage on P2.

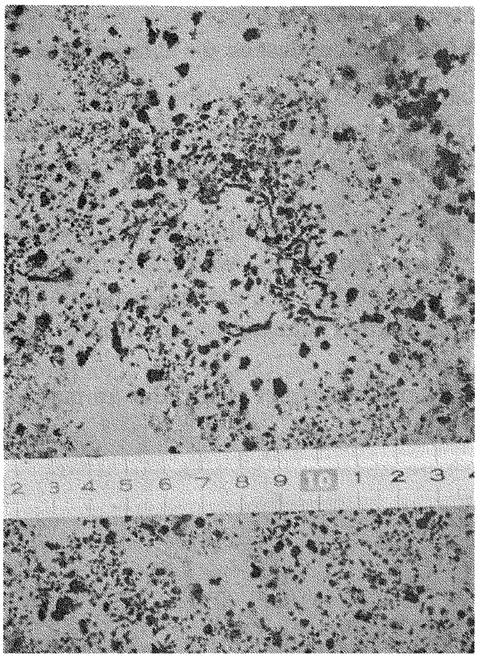

Fig. 3. Ablation surface under the snow cover (P2). There are many granular dust particles in the small pits on the glacier ice.

This structure seemed to be formed when blackish dust granules sank into the glacier ice by melting the ice by absorption of solar radiation by dust. This structure developed very well

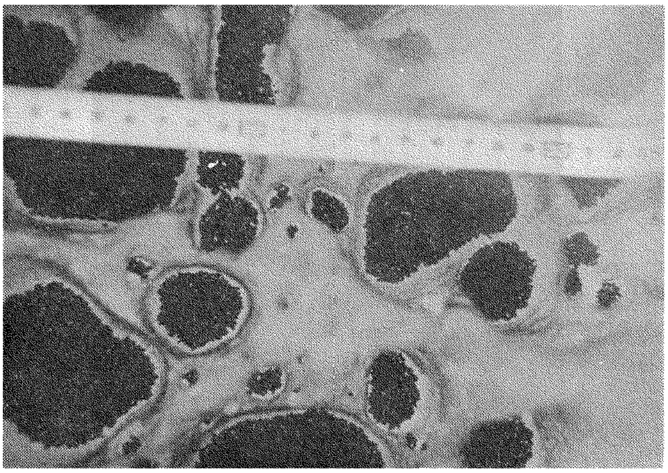

Fig. 4. Well developed pit structures at the bottom of the melt-water pond on P2. There were many dust granules and insect larvae at the bottom.

at the bottom of large melt water drainages and ponds. In such places these pits eventually became as large as 10 cm in diameter and 30 cm in depth, and had many dust granules at the bottom (Fig. 4). This suggests that there is a relation between development of this structure and the amount of melt water on the glacier ice.

4.2 Structure and contents of the surface dust on the ablation area

Almost all dust collected from the bottom of the pit took small granular forms, 0.2–3.0 mm in diameter (Fig. 4). By microscopic observation, it was shown that these granules were made of organic and inorganic materials gathered by filamentous blue-green algae (*Phormidium* sp.) and bacteria (Figs. 5, 6).

As living algae, *Phormidium* 2 spp. (Cyanophyceae) and *Mesotaenium* sp. (Chlorophyceae) were identified. However, *Phormidium* 2 spp. were far more abundant than *Mesotaenium* sp. These algae were so abundant that the 70% alcohol solution in which dust granules were preserved became green. This colored solution was showed to contain chrolophyll a by absorption spectrum analysis.

Organic materials, pollen, small parts of plant and animal tissues and dead bodies of

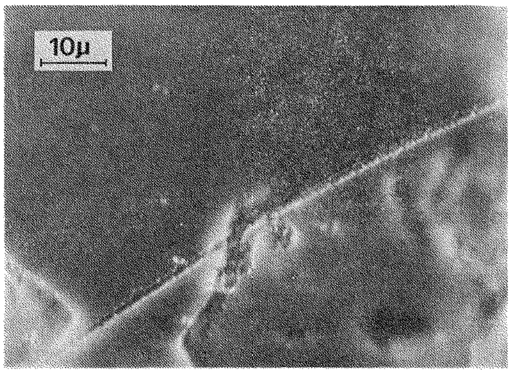

Fig. 5. Filamentous blue-green algae (Phormidium sp.) in dust granules from P2.

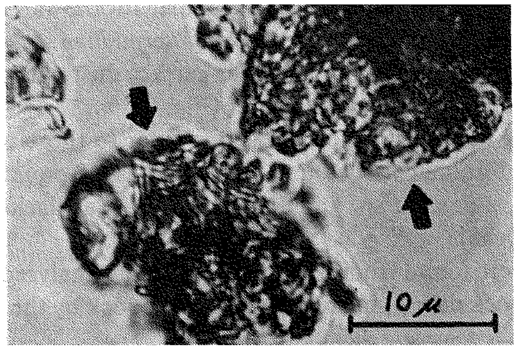

Fig. 6. Bacteria colonies in dust granules of P2 (arrows).

aquatic phytoplankton: *Hantzschia* sp., *Nitzschia* sp., *Pinnularia* sp., *Navicula* sp., *Synedra* sp. (Bacillariophyceae) and *Trachelomonas* sp. (Euglenophyceae) were identified. These phytoplanktons are thought to live in the melt water system in the ablation area.

As inorganic materials, rock forming minerals such as pyroxene, hornblende etc. were identified. These inorganic materials as well as pollen and small plant tissues are thought to be airborne.

4.3 Insect life on the glacier

Insect larvae feeding on the surface dust of the ablation area were discovered at the bottom of melt water drainages and ponds on P1 and P2. They are the larvae of a new species of Chironomid (*Diamesa* sp.) with reduced wings, the first insect which was shown to spend its entire life cycle on a glacier (Kohshima, unpublished). Adult of this insect cannot fly and only walk on the surface of the glacier and in the small cavities of the snow and ice. Males spend their all lives under the snow cover. However, adult females make a sun oriented migration by walking on the snow surface toward the upper part of the glacier, probably to keep their distribution area unchanged in spite of the downstream flow of their eggs and larvae in the melt-water drainages (Kohshima, unpublished).

4.4 Structure and content of the dirt layer dust in the ice core

Structure and content of the dust in the dirt layers was not so different from that of the

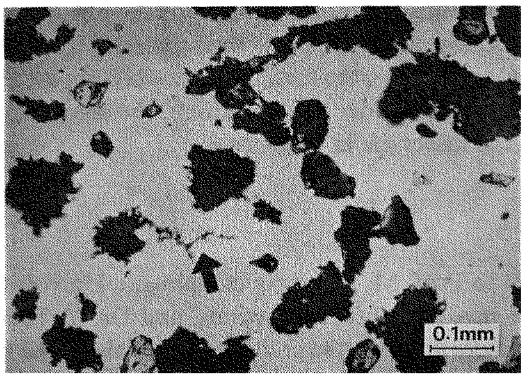

Fig. 7. Dust particles in a dirt layer of the ice core. The arrow shows filamentous blue-green algae (*Phormidium* sp.).

surface dust of the ablation area. It also takes granular forms, and consists of organic and inorganic materials gathered by filamentous algae (*Phormidium* sp.) and bacteria. However, the sizes of granules were smaller than those of the surface dust particles in the ablation area. They ranged from 0.1 mm to 0.5 mm in diameter (Fig. 7).

The following organic materials which are very similar to those of ablation area, pollen, small parts of plant and animal tissues and dead bodies of aquatic phytoplankton were identified: *Melosira* sp., *Nitzschia* sp. and *Pinnularia* sp. (Bacillariophyceae) and *Trachelomonas* sp. (Euglenophyceae).

These dust granules were found from almost all dirt layers analyzed except the lowest three layers which contained rock debris sheared from the base rock by the glacier ice.

5. Discussion

5.1 Origin of the dirt layer dust in the ice core

Living aquatic algae and dead bodies of aquatic phytoplankton in the surface dust on P1 and P2 clearly shows that such dust in the ice core was formed at the bottom of the melt-water drainages and ponds on the glacier ice. And, the similar content of the dirt layer dust strongly suggests that the dust is also formed in the melt water layer, which may be on the ablation surface of the accumulation area during summer.

The tritium content analysis of the ice core suggests that the dirt layer tends to be formed two times every year (Watanabe et al., 1984) just as on the Western Cwm of the Khumbu Glacier (Khumbu region, Nepal) at an altitude of 6,160 m where two strata, winter snow layer and monsoon snow layer, are deposited annually (Miller, M. M., Leventhal, J. S. and Libby, W. F. 1965). So, the dirt layer of this glacier should be formed two times in a summer, probably at the beginning and the end of the monsoon season when enough melt water for algae growth exists on the stable ablation surface of the accumulation area.

5.2 An ecological system on the glacier

These algae and bacteria in dust granules form a simple ecological system on the glacier which has been unknown to science.

On the accumulation area, organic and inorganic airborne particles are accumulated on the melting surface and nourish photosynthetic aquatic algae and bacteria growing on the ablation surface, which become components of the dirt layer dust afterward. These dust particles accumulated in the dirt layers are carried by the glacier movement toward the lower part of the glacier and concentrated on the surface of the ablation area as surface ablation proceeds. And melt-water flow also transports dust particles from the accumulation area to the ablation area. By these processes, the surface of the ablation area should be enriched with organic and inorganic nutrient. Under this condition, the growth of micro-plants could be large enough to sustain the insect life in this area.

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