Biological ice core dating in the glacier of Russian Altai mountains

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In central Asia, glaciers have experienced rapid shrinking, and the current trends suggest that this wastage will accelerate. Therefore, ice-core studies in central Asia are important in order to understand the response of glaciers to the recent warming in this region. However, in analyses of ice cores from lower-latitude regions such as central Asia, it can be difficult to use seasonal changes in Delta 18 O and chemical concentrations for ice core dating because initial patterns of stable isotopes and chemical ions are often disturbed by heavy melt water percolation in the glacial strata. To minimize melt distortion of Delta 18 O and chemical concentrations, samples should be collected at high elevations where summer melting is very low; however, drilling operations are more difficult and dangerous at such sites due to the severe conditions. Therefore, new dating methods that are applicable to ice cores from lower latitudes and lower-altitude glaciers must be developed.

Previous study suggest ice core analysis using biological particles (microorganisms and pollens) may provide information on past environmental conditions in lower latitudes and lower-altitude glaciers. However, biological ice core analyses have been conducted only in Himalaya and Patagonia, yet.

In this study, to establish the methods of ice core analysis using biological particles, we analysed microorganisms and pollen in the two ice cores from Russian Altai Mountains. Especially, we tried to use the biological particles for dating the ice core.

The ice cores are collected from Sofiyskiy glacier (3,435m a.s.l. : 25.01m length) and Belukha Glacier (4,120m a.s.l. : 171m length) in the Russian Altai mountains. We analyzed not only the snow algae and pollen but also cyanobacteria, bacteria and fungi by direct observation using fluorescence microscope.

In Sofiyskiy glacier, 6 types of photosynthetic microorganism (5 types of unicellular green algae and 1 types of unicellular cyanobacteria), 2 types of bacteria and 2 species of fungi reported from cold environment (Chionaster bicornis, Chionaster nivalis) are observed. In contrast, in Belukha glacier 700m higher than Sofiyskiy glacier, only 2 types of unicellular green algae and 2 types of yeast cells are observed. Total green algal biomass in an annual layer of Belukha ice core is 100 times smaller than that of Sofiyskiy ice core. In both ice cores, 3 types of pollen (Betulaceae, Pinaceae and Artemisia) are observed.

In the Sofiyskiy ice cores, layers with high algal biomass corresponded to the peaks in Delta 18 O profile. This suggests that algal layers were formed during warm periods. Very distinct peaks were observed in the pollen. Peaks of Pinaceae pollen, which was reported to disperse from late spring to early summer in this region, corresponded with the algal layers suggesting that the algal layers were formed during summer. These results suggest that snow algae and pollens are good marker for summer layers in Sofiyskiy ice core.

On the other hands, in the Belukha ice cores, no distinct algal layers were observed, probably due to the very limited amount of melt-water during summer. However, 3 types of pollen peaks which clearly kept the order of the deposition seasons, because of the little effect of the melt-water mixing. These results suggest that vertical profiles of pollens can be good markers for seasonal layers in Belukha ice core.

Based on these results on the two ice cores, we tried to date the ice cores. We estimated that Sofiyskiy 25.01m ice core included 17 summer layers from 1985 to 2001, and Belukha 48.245m ice core included 85 annual layers from 1917 to 2002. This dating of Belukha 48.245m ice core agreed very well with that from the layer of 1963 with high level of tritium, while dating from isotope and melt percentage did not agreed with the result from the tritium layer. This result verified the accuracy of biological ice core dating in the Belukha ice core.