Ground penetrating radar survey on Qaanaaq Glacier in northwestern Greenland

Ken Sato[1], Shin Sugiyama[2]
[1] *Graduate school of Environmental Science, Hokkaido University*
[2] *Institute of Low Temperature Science, Hokkaido University*

To study changes in peripheral glaciers and ice caps in Greenland, we have been running field observations on Qaanaaq Ice Cap in northwestern Greenland (77º28' N, 69º14' W) under the projects of GRENE (2012–2016), ArCS (2016–2020) and ArCS II (2020–). Qaanaaq Ice Cap has an area of 289 km^2 with an elevation range of 30–1110 m. In the summer 2022, we performed a GPR (ground penetrating radar) survey on Qaanaaq Glacier (Figure 1), an outlet glacier of the ice cap. The GPR measurement was performed from 18th July to 12th August 2022, using a GPR system (SIR-4000, 3200 MFL) manufactured by GSSI, Inc. The system consists of a controller, transmitter, receiver and 2.4 m long antennae. The central frequency of the radar wave was 40 MHz. During the survey, reflection waves received within a time range of up to 2700 ns were recorded, which is equivalent to the ice depth up to 226 m. The measurement was performed along 14 survey routes, i.e. seven sections perpendicular to the ice flow direction, one long section along six mass balance stakes, and four additional sections along the side margins of the glacier (Figure 1). The total length of the survey routes was 21.13 km.

The reflection image obtained along the uppermost transverse section (Figure 1, section 1) is shown in Figure 2. Two-way travel time was converted to ice thickness by assuming a wave propagation velocity of 168 m s^{-1} in the glacier. The maximum depth along the section 1 was approximately 160 m. A clear v-shaped depression was observed on the bed at 1000 m from the eastern margin of the survey section (Figure 2). Results obtained at other transverse sections indicated that this depression continues downstream. In addition to reflections from the bed, strong reflections were recorded within the glacier from the surface to the bed at about 800 m from the eastern margin of the survey section (Figure 2). Based on our in-situ observation on the glacier, we attribute these englacial reflections to meltwater in a crevasse.

The GPR data provided information on ice thickness, bed geometry and englacial structures, which are crucial to study physical processes of the glacier as well as to quantify the volume of ice. Most importantly, these data help us to understand the englacial and basal hydrology in polythermal glaciers in the Arctic.

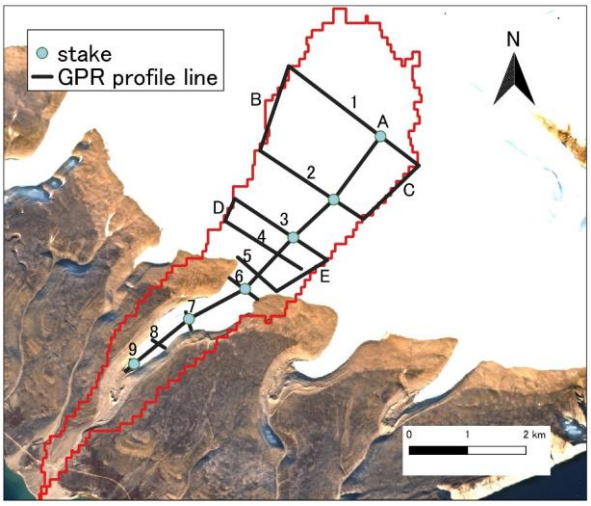

Figure 1. GPR survey routes and mass balance stake locations on Qaanaaq Glacier.
The background is a satellite image acquired on Sep. 17, 2022

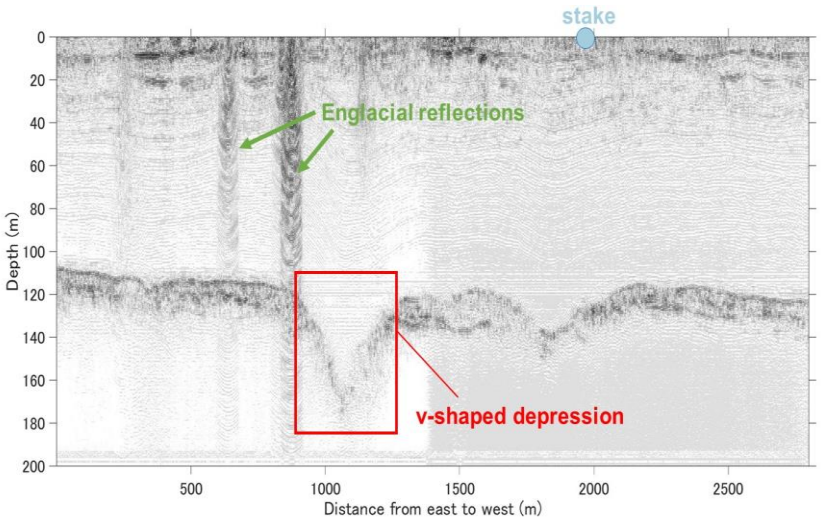

Figure 2. GPR profile along the section 1 in Figure 1.
Horizontal axis shows the distance from the eastern margin of the survey route.

References

Sugiyama, S., Sakakibara, D., Matsuno, S., Yamaguchi, S., Matoba, S. and Aoki, T., 2014. Initial field observations on Qaanaaq ice cap, northwestern Greenland, Annals of Glaciology, 55(66), 25-33.