Glacier tremors revealed by Ocean Bottom Seismometer in Greenland

*Evgeny A. Podolskiy[1], Yoshio Murai[2], Naoya Kanna[1], Shin Sugiyama[3]

1. Arctic Research Center, Hokkaido University, 2. Institute of Seismology and Volcanology, Hokkaido University, 3. Institute of Low Temperature Science, Hokkaido University

On the one hand, our understanding of glacier basal sliding is currently one of the least certain aspects in models used to predict the future evolution of glaciers and, therefore, the rates of global sea level rise. On the other hand, less than 20 years ago careful attention to weak seismic tremor led to a discovery of a nonvolcanic episodic tremor and slip (ETS), which has revolutionized our understanding of subduction zones. Glacier basal sliding is at least three orders of magnitude faster (~500 m per year vs. 0.1 m per year), making it reasonable to suggest that a family of similar seismological phenomena could be expected and analogies with tectonic subduction established.

However, *in situ* observations in remote polar regions are limited, difficult, and challenging due to harsh and extremely noisy conditions. For example, seismic sensors installed directly on ice surface are subjected to intense cracking noise, can melt out, loose level or simply be destroyed due to crevassing and mechanical loss of ice (known as iceberg calving). Moreover, on-rock installations have to be positioned aside from the glacier of interest and require significant technical preparations for protecting the stations from polar conditions and animals, which are usually difficult due to limited resources and lack of any infrastructure.

In summer 2019, for elucidating co-seismic glacial processes, we overcame these fundamental limitations by conducting the first Ocean Bottom Seismometer (OBS) experiment for cryospheric research in Greenland. Specifically, we manually deployed an OBS system (i.e., 3D geophone, hydrophone, and thermometer) to ~250 m depth at about 600 m from the calving front of a Greenlandic marine-terminating glacier (Bowdoin Glacier). Such configuration implied that the receiver was coupled directly to the sliding interface of the glacier. This unique campaign was integrated into a comprehensive international expedition to Bowdoin Glacier, with various geophysical observations simultaneously made directly on ice, in the fjord, and rock outcrops nearby (e.g., GPS and seismic arrays, time-lapse photography, UAV mapping, and etc).

Our analysis shows very intense seismic activity, encompasses a major calving event with iceberg disintegration above the OBS, and suggests a presence of a distinct diurnal tremor signal which is apparently correlated with a horizontal ice speed of the glacier (~1 m per day). In this truly inter-disciplinary contribution, we present the experiment, provide our preliminary interpretation of the continuous tremor as evidence of sliding at the ice-rock interface, and discuss possible alternatives, which could be of interest to a vast community of geoscientists.

Keywords: Ocean Bottom Seismometer, seismic tremor, cryoseismology, Greenland, Arctic, Hydroacoustics