Influence of rock permeability on subglacial hydrology and glacier motion

Zebre, Manja; Egholm, David L.; Glasser, Neil

Published in:
Geophysical Research Abstracts

Publication date:
2019

Citation for published version (APA):
Zebre, M., Egholm, D. L., & Glasser, N. (2019). Influence of rock permeability on subglacial hydrology and glacier motion. In *Geophysical Research Abstracts: EGU General Assembly 2019* Article X4.24

Geophysical Research Abstracts
Vol. 21, EGU2019-10733, 2019
EGU General Assembly 2019

Influence of rock permeability on subglacial hydrology and glacier motion

Manja Žebre (1), David L. Egholm (2), and Neil F. Glasser (1)

(1) Department of Geography & Earth Sciences, Aberystwyth University, United Kingdom, (2) Department of Geoscience, Aarhus University, Denmark

Understanding subglacial systems is essential for making predictions of glacier motion and the contribution of glacier melt to stream runoff in the context of overall glacier response to climate change. Several studies have shown that subglacial hydrology is one of the key controls on basal sliding, but how the ice bed geology influences the subglacial drainage system and therefore the basal sliding, is still poorly understood. The drainage system at the base of a glacier usually consists of two main components with complex interactions: 1) a distributed system of linked cavities and 2) a channelized system that depends on the development of Röthlisberger channels into the basal ice. Both systems are expected to evolve during the melt season in response to variable water flux, effective pressure, and sliding speed. In this study, we use a two-dimensional finite element model to simulate the seasonal evolution of a hydrological system at the base of a glacier. The sliding velocity of the ice is allowed to vary as a function of the contact area between the ice and its bed.

Our computational experiments consider a range of groundwater transmissivities in order to explore the effect of groundwater flow on the seasonal variability of sliding velocity. Using low groundwater transmissivities ($< 10^{-5}$ m^2 s^{-1}), typical of non-carbonate rocks, a subglacial drainage system evolves from an inefficient drainage system in winter with relatively slow sliding, a high contact area, and moderate effective pressure, followed by the spring event with enhanced sliding as the capability of the drainage system is exceeded by the increasing surface melt. In summer, channels gradually develop as the subglacial system adapts to the increased water flux. The development of channels cause cavities to shrink and sliding consequently slows towards the winter level. On the other hand, by applying groundwater transmissivities typical of carbonate rocks ($> 10^{-5}$ m^2 s^{-1}), the water discharge through bedrock prevails over the entire year, leaving the channelized system largely undeveloped. As a result, the sliding velocity remains low and stable throughout a year.

Warm-based glaciers typically exhibit a distinct seasonal variation in sliding velocity, with spring-summer sliding velocities sometimes two or three times faster than winter averages. However, glaciers resting on carbonate rocks, where the meltwater discharge through bedrock accounts for more than 90% of the total meltwater flux, are, at least in some cases known to show reduced seasonality. Our results demonstrate how groundwater flow can effectively remove the seasonal variation of glaciers flowing on carbonate rocks such as well-karstified limestone.