Geophysical Research Abstracts
Vol. 13, EGU2011-509, 2011
EGU General Assembly 2011

Modelling of Supraglacial Spring Evolution Under Influences of Climate Change

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With increasing temperatures, coverage and extent of permafrost, and thickness of the active layer are changing. This fundamentally affects the groundwater system of the Arctic through an alteration in circulation, increase in temperature and enhancement of groundwater flow velocities. Increasing depth of groundwater circulation has the potential to better sustain winter base-flow in Arctic rivers, highlighting the importance of degrading permafrost on water resources. Little attention has been given to hydrogeology in permafrost areas. However, further research is needed to understand these complex, and strongly climate sensitive systems. Moreover, cold springs in the high Arctic may present terrestrial analogues for springs on Mars.

A supraglacial sulfur spring has been discovered at Borup Fiord Pass in the Eastern Krieger Mountains, on Ellesmere Island, Nuvavut, Canadian High Arctic. The spring location varies interannually at the convergence of two glacier tongues, flowing down from adjacent mountains. The spring deposits native sulphur, gypsum, calcite and vaterite. The surrounding area is covered by thick permafrost (>500 m), which is impermeable to groundwater flow. The springs occur near a reverse fault, which we hypothesise to conduit the groundwater through the frozen ground to the surface. We propose the recharge origin from subglacial meltwater under a warm based glacier. We suspect that the conduit was formed under unfrozen conditions. Transient modelling of these springs will show their climate dependence; their evolution under past climate condition, and adaptation under a warming climate. With climate change, the glacier may decrease in size and thickness and as a result become cold based in the ablation area. This will cut off the recharge and will impede the spring system. Paleo-spring channels in the pro-glacial area support this. With decreasing length, the springs may become periglacial and new permafrost will be formed at their location. Then, the springs may remain active if enough heat energy is provided from the discharging water to prevent freezing.