Verification of the Numerical Simulation of Permafrost Using COMSOL Multiphysics® Software

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Abstract

Introduction:
The thaw potential of warm uranium tailings disposed in an in-pit tailings management facility (TMF) and constructed in continuous permafrost could potentially influence future long-term contaminant migration. An understanding of the coupled processes of heat transfer (conduction and convection) with phase change and groundwater flow is needed to assess the changing thermal regime of a TMF and surrounding geological formations, as well as to determine the potential thaw effects which may lead to permafrost degradation and talik development beneath a TMF. Different modeling tools, including COMSOL Multiphysics® finite element method (FEM) simulation software can be used in understanding these complex thermal and hydrogeological effects. However, in order to assess whether COMSOL software could adequately model the coupled multiphysics problem in the application to uranium tailings disposal, verification of a simple model was performed. This simple model is based on that of Ling and Zhang (2003) for the numerical simulation of the permafrost thermal regime and talik development under shallow thaw lakes on the Alaskan arctic coastal plain.

Use of COMSOL Multiphysics®:
COMSOL software was used to simulate the conductive heat transfer with phase change in the geological formations encompassed in permafrost surrounding a shallow thaw lake. The purpose of the simulation was to verify the adequacy of COMSOL to model such phenomena by comparing the results to those obtained by another FEM model (Ling and Zhang, 2003).

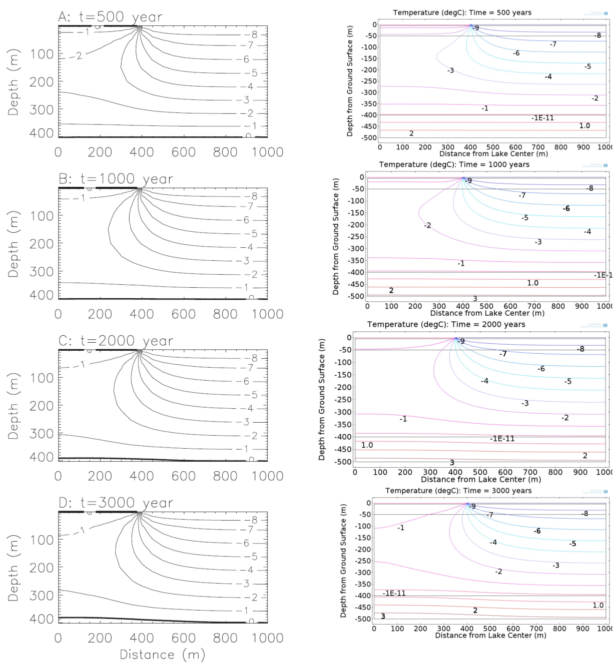
Results:
The simulation results are illustrated in Figure 1. The graphical comparison of the simulation results show that they are in agreement with those published by Ling and Zhang (2003).

Conclusion:
In light of the obtained results, COMSOL software can be used to adequately model the time-dependent conductive heat transfer with phase change and assess the thaw effects due to a shallow thaw lake over continuous permafrost. The verification of this study provides evidence that the COMSOL code can be applied to more complex multiphysics problems. This includes the modeling of coupled heat transfer (conduction and convection with phase change) and groundwater flow in order to determine the thaw effects surrounding a uranium in-pit TMF in continuous permafrost.

Reference

1. Ling, F., and Zhang, T. 2003. Numerical Simulation of Permafrost Thermal Regime and Talik Development Under Shallow Thaw Lakes on the Alaskan Arctic Coastal Plain. Journal of Geophysical Research, 108(D16), 4511.

Figures used in the abstract



Case C4 Results
(Ling and Zhang 2003)

Verification Results in
COMSOL

Figure 1: Comparison of Results of Ling and Zhang and Model Verification in COMSOL Multiphysics® Software.