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-to-End Numerical Simulation of Explosion Cavity Creation, Cavity Circulation Processes, Subsurface Gas Transport, and Prompt Atmospheric Releases

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A numerical study of conjugate flow, heat and mass transfer by natural convection of noble gases within an underground cavity partially filled with molten rock is presented. The molten rock is initially considered at rest at an initial temperature and concentration. The molten rock is viscous and possesses strength that is temperature- and crystal fraction-dependent. Under natural conditions, convection cells are developed within the molten rock leading to circulation, mixing and degassing of the initially trapped gases. Furthermore, the molten rock as well as the degassing enhances the conjugate convection flow in the air gap within the cavity. We illustrate the onset of the different regimes and their combined effect of flow, heat and mass transport of different gas species, the fraction of molten rock and their impact on the noble gas fractionation. We also present a sensitivity analysis of the effect of the outer cavity boundary condition on the heat loss and cooling to the adjacent rock formation and its eventual release to the atmosphere. We demonstrate several scenarios of underground prompt releases to the atmosphere using a first-ever fully coupled prompt subsurface-to-atmospheric transport without ad hoc boundary conditions between physics-based domains or handshakes between different numerical codes.

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Promotional text

We demonstrate a high resolution, first-ever, fully coupled numerical model of transport of nuclear explosion byproduct gases from source to atmospheric releases. It is a unique scientific capability to improve of nuclear test simulation fidelity, monitoring and verification.

Oral preference format

in-person

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