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Isotopic Composition of Release Scenarios Based on Realistic Models of Underground Nuclear Explosion Cavity Evolution and Subsurface Gas Transport

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Isotopic ratios of radioxenons can be used to verify the occurrence of an underground nuclear explosion (UNE). Simplified analytical models and closed-form solutions using Bateman equations simulate a idealized radioactive decay/ingrowth chain in a closed and well mixed system. The partitioning of the radionuclide inventory between a gas phase and rock melt created by the detonation and the gas transport from the cavity to host rock or ground surface are not addressed properly. Either subsurface transport or prompt release that is principally responsible for gas signatures are inconsistent with the simple closed-system assumption. In this study, a realistic model about post-detonation cavity processes were developed. A closed-form solution representing time dependent source term activities is extended by considering the cavity partitioning process, slow seepage, and/or prompt release of gases from the cavity and applied to realistic systems, influencing the evolution of isotopic ratios over the course of UNE histories. A library of radioxenon composition in the cavity and host rock can be simulated with different parameters, which is used for event discrimination and further for estimation of the detonation time with respect to noble gas measurements at International Monitoring System stations. It can also be used for the event discrimination based on machine learning.

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Promotional text

Simulation models about the nuclear explosion and release scenarios is one of main aspects in characterization of CTBT-relevant nuclear events based on isotopic ratios detected at IMS stations.

Oral preference format

in-person

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