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Subsurface Xenon Migration by Atmospheric Pumping Using an Implicit Non-Iterative Algorithm for a Locally 1D Dual-Porosity Model

R. Annewandter and M.B. Kalinowksi

Carl Friedrich von Weizsäcker Centre for Science and Peace Research, University of Hamburg, Germany
(rannewan@physnet.uni-hamburg.de)

An underground nuclear explosion injects radionuclids in the surrounding host rock creating an initial radionuclid distribution. In the case of fractured permeable media, cyclical changes in atmospheric pressure can draw gaseous species upwards to the surface, establishing a ratcheting pump effect. The resulting advective transport is orders of magnitude more significant than transport by molecular diffusion.

In the 1990s the US Department of Energy funded the socalled Non-Proliferation Experiment conducted by the Lawrence Livermore National Laboratory to investigate this barometric pumping effect for verifying compliance with respect to the Comprehensive Nuclear Test Ban Treaty. A chemical explosive of approximately 1 kt TNT-equivalent has been detonated in a cavity located 390 m deep in the Rainier Mesa (Nevada Test Site) in which two tracer gases were emplaced. Within this experiment SF_6 was first detected in soil gas samples taken near fault zones after 50 days and ^3He after 325 days.

For this paper a locally one-dimensional dual-porosity model for flow along the fracture and within the permeable matrix was used after Nilson and Lie (1990). Seepage of gases and diffusion of tracers between fracture and matrix are accounted. The advective flow along the fracture and within the matrix block is based on the FRAM filtering remedy and methodology of Chapman. The resulting system of equations is solved by an implicit non-iterative algorithm.

Results on time of arrival and subsurface concentration levels for the CTBT-relevant xenons will be presented.