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Editorial

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Editorial: Gas transport in clay materials

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Owing to their excellent properties for the confinement of contaminants, clays are considered as potential host formations for the geological disposal of radioactive waste in several countries across the world. Clay-based materials are also expected to be used in engineered barriers in most geological repository concepts under development.

Understanding the transport of gas produced by metal corrosion, microbial degradation, and water radiolysis within the clayey materials is essential for assessing the performance and long-term evolution of geological repositories for radioactive waste. To this end, innovative experiments and numerical developments are necessary to provide data and process-based models that support a mechanistic understanding of transport processes in natural and engineered clayey materials, their coupling with the mechanical behaviour, and their impact on the properties of these materials.

This special issue, dedicated to *Gas transport in clay materials*, aims to provide an overview of recent developments, key findings, and insights gained worldwide over the past years through various international projects, and in particular within the framework of the Work Package GAS of the European Joint Programme on Radioactive Waste Management, EURAD (2019–2024), funded by the European Union's Horizon 2020 research and innovation programme under grant agreement no. 847593.

Starting with a general overview of the state of knowledge on gas transport processes in clayey materials collected within the EURAD-GAS project (Levasseur *et al*., 2026), the contributions in this issue further explore, in greater detail, topics related to gas transport from both experimental and numerical perspectives.

The experimental studies presented in this special issue specifically highlight the importance of initial sample conditions and preparation protocols on the characterisation of gas transport properties of clayey materials, including clay host rocks such as Boom Clay, Opalinus Clay, Callovo-Oxfordian claystone, or Toarcian argillite, as well as various bentonites used in engineering barrier systems (Gonzalez-Blanco *et al*., 2026; Harrington *et al*., 2026; Liu *et al*., 2026). When conditions are well-controlled and appropriate protocols are used, the experimental results obtained from both lab and in situ tests demonstrated that the response of these materials subjected to a gas phase is strongly influenced by the interaction between the gas phase and the liquid phase, mainly governed by local stresses, gas pressure build-up rate and permeability (Cuss *et al*., 2026a, 2026b; Gonzalez-Blanco *et al*., 2026). Importantly, when a gas pathway is formed in clay host rocks or bentonites, the self-sealing capacity of these materials is sufficient to ensure that such pathways remain transient and do not compromise their long-term integrity, thereby preserving their effectiveness as geological and engineering barriers for radioactive waste disposal.

Harrington *et al*. (2026) also confirmed the usefulness of synthetic samples for exploring complex processes and generating data relevant to natural clay systems. More specifically, they demonstrated that knowledge of intrinsic permeability can be used to estimate diffusivity which is considerably more difficult to accurately measure at laboratory scale. However, the reverse is not true, as diffusivity is relatively insensitive to large variations in permeability. Regarding the upscaling mechanisms, Jacops *et al*. (2026) assessed the validity of diffusion laboratory experiments under in situ conditions by developing a new in situ experiment in Boom Clay mimicking the laboratory conditions. This experiment is still ongoing. However, the first results are very promising in the perspective of bridging the gap between laboratory-scale findings and large-scale behaviour.

In addition to experimental investigations, numerical simulations provide valuable tools for analysing the processes controlling gas transport in clay materials. The studies presented in this special issue illustrate how gas transport modelling framework has been refined during the GAS project using advanced hydromechanical models. Dymitrowska *et al*. (2026) have demonstrated the capability of the smoothed particle hydrodynamics method to simulate damage initiation and propagation during gas injection tests. Toprak *et al*. (2026) developed a three-dimensional coupled hydro-mechanical and gas transport model for FEBEX bentonite, showing the importance of material heterogeneity and localised dilatant pathways in reproducing experimental gas breakthrough behaviour. Huang *et al*. (2026) investigated the influence of heterogeneity on gas transport in natural clays through stochastic modelling, underlining the importance of accounting for spatial variability and uncertainty beyond deterministic approaches when analysing gas migration in clay formations.

Collectively, the articles in this special issue illustrate how the knowledge gained through the EURAD-GAS project can be used at the geological repository scale to assess gas transport in clay formations and in clay-based engineered barrier systems. Beyond the scientific results themselves, this special issue also reflects the value of sustained international collaboration in addressing one of the most demanding societal and environmental challenges of our time. The progress achieved through the EURAD-GAS project demonstrates how shared expertise, experimental infrastructures, and interdisciplinary approaches can significantly advance our understanding of complex coupled processes in clays. We hope that the contributions gathered here will inspire further research, foster new collaborations, and support the next generation of scientists and engineers working towards safe and sustainable solutions for radioactive waste management.

REFERENCES

Cuss RJ, Harrington JF and Sellin P (2026a) Evolution of gas migration properties in a field-scale bentonite engineered barrier system. *Environmental Geotechnics* **13(7)**: 637–656, 10.1680/jenge.25.00025.

Cuss RJ, Harrington JF, Sellin P and Nord M (2026b) The role of gas volume on the advective movement of gas through an engineered barrier system. *Environmental Geotechnics* **13(7)**: 657–672, 10.1680/jenge.25.00026.

Dymitrowska M, Amrofel N, Letourneux C *et al.* (2026) Modelling damage propagation and coupling of fluid flow and elasto-damage using smoothed particle hydrodynamics (SPH) method. *Environmental Geotechnics* **13(7)**: 687–703, 10.1680/jenge.24.00198.

Gonzalez-Blanco L, Llabjani Q, Romero E *et al.* (2026) Comparative study of gas testing protocols in clayey rocks for nuclear waste repositories. *Environmental Geotechnics* **13(7)**: 625–636, 10.1680/jenge.24.00185.

Harrington JF, Tamayo-Mas E, Fletcher CM *et al.* (2026) Gas diffusion measurements in natural and synthetic rocks: correlations and key relationships. *Environmental Geotechnics* **13(7)**: 590–611, 10.1680/jenge.25.00089.

Huang Z, Hoedemaker R, Liaudat J *et al.* (2026) Influence of heterogeneity on gas transport in natural clays: a stochastic analysis. *Environmental Geotechnics* **13(7)**: 725–745, 10.1680/jenge.25.00049.

Jacops E, Chen G, Yu L *et al.* (2026) In situ experimental investigation of neon diffusion in the Boom Clay in HADES URL. *Belgium. Environmental Geotechnics* **13(7)**: 673–686, 10.1680/jenge.24.00193.

Levasseur S, Talandier J and Marschall P (2026) Understanding of gas transport in clays for geological disposal of radioactive waste. *Environmental Geotechnics* **13(7)**: 579–589, 10.1680/jenge.24.00186.

Liu K, Dymitrowska M, Mokni N *et al.* (2026) Synchrotron imaging of pore structure and drying behaviour in Toarcian argillite. *Environmental Geotechnics* **13(7)**: 612–624, 10.1680/jenge.24.00179.

Toprak E, Olivella S, Gutierrez-Rodrigo V, Martin PL and Villar MV (2026) 3D modelling of gas injection tests on FEBEX material: incorporating heterogeneity effects. *Environmental Geotechnics* **13(7)**: 704–724, 10.1680/jenge.24.00180.