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Roles of Transport Mechanisms and Model Parameters in Gas Flow Migration across low-permeability porous media

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Appropriate modeling approaches to quantify gas migration in low-permeability porous media can assist appraisal of sealing efficiency of caprocks, with key applications in sustainable use of underground energy resources. A variety of models depicting gas movement across low-permeability geomaterials are available (Wu et al., 2016; Sun et al., 2017, Rani et al., 2018). Some of these models represent gas migration in low-permeability media as a weighted sum of diverse mechanisms taking place across the porous system. Parameters associated with these models are envisioned to embed the chemical, mechanical, flow, and transport features governing feedbacks between gas and the host rock matrix. Such parameters cannot be easily and unambiguously evaluated via experimental investigations and are always affected by uncertainty. In this context, modern sensitivity analysis techniques enable us to diagnose the behavior of a given model through quantification of the importance and role of model parameter uncertainties onto a target model output.
Here, we rely on two global sensitivity analysis approaches and metrics (i.e., variance-based Sobol'indices and moment-based AMA indices) to assess the behavior of a recent interpretive model that conceptualizes gas migration as the sum of a surface diffusion mechanism and two weighted bulk flow components (i.e., Slip flow and Knudsen diffusion). We quantitatively investigate the impact of each uncertain model parameter on the evaluation of methane flow, which is, in turn, conceptualized as a random quantity. Considering the paucity of available information, we consider three diverse characterizations of the probability density function describing the uncertain model parameters: (**a**) all parameters are described by uniform distributions; (**b**) all parameters are represented through truncated normal distributions; and (**c**) the reference pore radius is described by a truncated log-normal distribution while the remaining parameters are associated with uniform distributions. We then derive analytically the structure of an effective diffusion coefficient embedding all complex mechanisms of the model considered and rely on the global sensitivity analysis results to quantify the relative contribution of each flow mechanism to the overall gas flow.
Our results suggest that, in decreasing order of importance, reference pore radius, reference porosity, pore pressure, tortuosity, and temperature are the model parameters driving the major features of the gas flow probability density function. These results remain essentially unaffected by the choice of probability density function characterizing model uncertain parameters.

Participation

In-Person

References

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