

Simulation of Radionuclide Transport in Fractured Porous Media

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Date: 2023/11/10

Abstract

Deep geological disposal with multi-barrier system is a generic and international idea for the final disposal of high-level radioactive waste (HLW). Moreover, radionuclide transport in fractured porous media is important for the safety assessment. The huge difference of hydraulic properties between fractures and matrix has made the simulations challenging. In the past, discrete fracture network (DFN) and equivalent continuum porous medium (ECPM) are two common approaches to simulate the flow and transport in fractured media. Due to rapid advances in computer computing performance, it is feasible to consider fractures and matrix in a simulation domain, which is called hybrid domain.

One hybrid approaches has been proposed by Lee *et al.*, (2019) and Yu *et al.*, (2021). The developed hybrid domain (HD) model uses 2D triangular mesh for fractures and 3D tetrahedron mesh for the rock matrix, and allows the system of equations to be solved simultaneously. Comparison based on the results of flow and particle tracking between HD method, DFN method and ECPM method has been proposed by Yu *et al.*, (2021). The result shows that the HD model is flexible in considering the concepts of DFN, ECPM, or both. The HD model could be developed further to solve the simulation the radionuclide transport in fractured porous media.

Keywords: Radionuclide transport, Fractured porous media, Numerical simulation analysis, Hybrid domain.

裂隙-孔隙介質內的放射性核種傳輸模擬

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報告日期：2023/11/10

摘要

深層地質處置搭配多重障壁系統，是國際間認為最適合用來作為高放射性廢棄物最終處置的方法。也因此，裂隙-孔隙介質(fractured porous media)中的放射性核種傳輸模擬對於安全評估至關重要。然而，裂隙和基質之間的水力特性往往有著極大的差異，使得同時考慮兩種材質的數值模擬方法不易進行。離散裂隙網路(discrete fracture network, DFN)和等效連續多孔介質(equivalent continuum porous medium, ECPM)是模擬裂隙岩體中水流與傳輸的兩種常用方法。近年來，由於電腦運算效能快速進步，也使得在模擬範圍同時考慮裂隙與基質(又稱為混合域)愈加可行。

Lee *et al.*, (2019) 和 Yu *et al.*, (2021)提出了一種混合方法。他們所開發的混合域(hybrid domain, HD)模型，使用二維的三角形網格來處理裂隙，三維的四面體網格來處理岩石基質，並允許同時求解方程組。在 Yu *et al.*, (2021)的文章中，分別以 HD 方法、DFN 方法和 ECPM 方法進行水流與粒子追蹤模型，並將結果相互比較。結果顯示，HD 模型可以靈活地代表 DFN、ECPM，甚至於包含兩者的概念。HD 模型可以進一步發展，以解決裂隙多孔介質中放射性核種傳輸模擬的問題。

關鍵字：放射性核種傳輸、裂隙-孔隙介質、數值模擬、混合域