Groundwater flow in crystalline rock: flow-log data evolution and predictive modeling

Liangchao Zou and Vladimir Cvetkovic

Department of Sustainable Development, Environmental Science and Engineering (SEED), KTH Royal Institute of Technology, Stockholm, Sweden, e-mail: lzo@kth.se

Abstract

Prediction of groundwater flow in crystalline rock remains a challenging task, which is important for many geoengineering applications, such as geological disposal of high-level radioactive waste, rock tunnelling, and geo-energy extraction and underground storage (e.g., Zou & Cvetkovic 2023). At present, many flow-logs and computational models have been developed to characterize and analyze hydraulic properties and groundwater flow processes in crystalline rocks. It is realized that groundwater flow pathways in crystalline rocks are dominated by the complex rock fracture networks, which essentially contains multiscale hydraulic heterogeneity, such as the network scale heterogeneity, fracture-to-fracture scale heterogeneity and internal heterogeneity due to fracture surface roughness. We analyzed the impact of multiscale heterogeneity on inference of fracture transmissivity based on flow-log measurements and prediction of groundwater flow in crystalline rocks using three-dimensional discrete fracture network and channel network models in our recent studies (i.e., Zou and Cvetkovic 2020, 2021; Zou et al., 2023; Frampton et al., 2019). The results generally show that the internal heterogeneity has relatively small impact on the inferred transmissivity distributions compared to the fracture-to-fracture scale heterogeneity. Comparison between the inferred and underlying input transmissivity distributions shows that interpreting hydraulic tests in crystalline rock using flow logs and the Thiem equation may underestimate the variation range of the underlying transmissivity. The ambient hydraulic gradient has limited impact on pumping test because the pumping flow is dominant compared to the ambient flow during pumping. The channel conductance can be statistically parameterized based on available hydrogeological characterization data. It is possible to compensate for the neglected heterogeneity in the channel network model by enhancing the variability of assigned channel conductance. The findings are useful for improvement of hydraulic characterization and simplification of predictive models for simulating groundwater flow in crystalline rock relevant to various applications.

References

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