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Numerical Modeling of Acid Fracturing in Carbonate Geothermal Reservoir: A Case Study of the Well D22 in Xiong'an City, China

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In the development and utilization of carbonate rock geothermal reservoirs, acid fracturing is an effective technique for enhancing production and addressing issues such as poor reservoir permeability and long-term decline in productivity. However, a complete technical system for acid fracturing in the field of geothermal energy development has not yet been established, and the specific effects on geothermal reservoirs require targeted study. In this study, the mechanical behavior module of fractured rock and the reactive transport module were overlapped based on the fully coupled framework of fluid flow and heat transfer in TOUGH2. A multi-field coupling model considering the evolution process of reservoir permeability under mechanical and chemical coupling effects was established based on drilling data from Xiong'an Well D22 and measured data from acid fracturing engineering to explore the temporal and spatial evolution of reservoir characteristics during the acid fracturing process. The results indicate that the stimulation process significantly improved the treated zone, with a notable anisotropy in permeability enhancement due to fracture characteristics. The largest scale of permeability enhancement and fracture damage occurred during Phase 2, with permeability increases resulting from fracture dilation and extension under high fluid pressure and acid etching. Permeability increases due to fracture expansion gradually diminished as fluid pressure recovered, while those due to fracture propagation were maintained after injection ceased. Acid injection only enhanced the permeability of the reservoir proximal to the wellbore, yet it failed to significantly affect the expansion of the treatment area or increase the permeability of more distant reservoir sections.