Modeling carbonate microfractures with the lattice Boltzmann method

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Abstract. The presence of fractures in an oil-bearing reservoir can have a significant impact on production. Therefore, understanding and predicting the effect of fractures on overall reservoir performance is an important endeavor. In this work, we apply the lattice Boltzmann method to high-resolution images of Indiana Limestone to investigate the effect of microfractures on fluid flow in carbonates. High-resolution imaging is used to build 3D models of pore space in the Indiana Limestone. In the original images, no fractures were observed. Microfractures of varying size and shape were then digitally overlaid on the unfractured image. By analyzing images with and without microfractures, we can study the impact of their presence on flow behavior. Both single-phase and multiphase lattice Boltzmann flow simulations are performed. Single-phase analyses show the relationship between permeability and fracture properties, such as aperture size and shape. This allows us to emulate specific features, such as the role of variable confining stress and subsequent fracture closure. Modeled trends compare favorably to laboratory measurements. In multiphase analyses, properties such capillary pressure, relative permeability, and residual oil saturation are computed for varying fracture conditions. Special attention is paid to the interaction between matrix and fracture, particularly oil production from the matrix into the fracture.