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A method to discretize fractures for 3D numerical simulations

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This paper presents a new method to discretize complex networks of inclined 2D fractures within a 3D rock matrix. Prior methods discretize 2D fractures first and fill the rock volume between fractures with 3D elements second (Method A). The disadvantage of method A is that degenerate elements are likely to exist if the angle between two fractures is small. In that case, the mesh quality is poor, which can lead to major numerical inaccuracies and significantly increased simulation time. To avoid these problems, method B has been developed here, where fracture networks are discretized, then degenerate elements are removed, and the 3D rock matrix is discretized last. The main steps of method B include: (i) discretization of the 2D fracture network, (ii) verification and removal of existing degenerate elements, (iii) re-connection of fractures at fracture-fracture intersections, (iv) discretization of the 3D rock matrix. Using the HydroGeoSphere modeling software, the new method is tested against existing analytical solutions of flow and solute transport in fractured rock. Applying the new method B and the existing method A to a two-fracture system, it is shown that simulated solute concentrations are significantly different. Even for very fine grids, method A considerably underestimates solute concentrations. The new method B is finally applied to discretize a complex network of multiple fractures, and it is demonstrated that method B (i) adequately represents the fractured domain by maintaining the geometric integrity of input surfaces and geologic data, (ii) provides numerically accurate results, and (iii) is less grid sensitive than method A.