This work presents a new fully-unstructured meshing scheme for generating simulation meshes, coupled with a novel simulation method for fluid flow models in porous media.

We use unstructured tetrahedral meshing algorithms to generate meshes that rigorously adhere to structural and depositional heterogeneity in geological reservoir models at multiple scales. Geological heterogeneity is represented using numerous surfaces, in contrast with traditional pixel- or grid-based methods. This approach allows the generation of meshes which capture heterogeneity more efficiently and accurately than structured or partially-structured grids.

The flow simulations are performed using a new hybrid discontinuous Galerkin/control volume based method which combines continuous pressure and discontinuous velocities. Our approach rigorously enforces material balance equations while ensuring crucial scalar fields such as pressure and saturation remain positive and bounded.

This research has direct application to aquifer flow systems. We report the results of single-phase flow simulations on unstructured meshes for complex geological systems. These simulations accurately model the spread of groundwater contaminants such as methyl tertiary butyl ether (MTBE) or metals such as arsenic that behave as tracers in aquifers.

Initially, simulations are run on simple anisotropic geological systems for two-dimensional flow to benchmark against analytical solutions and validate the accuracy of the simulator for simple flow problems. Next, simulations for tracer flow are performed on 3D channelized and fractured reservoir systems to demonstrate the robustness and accuracy of the new grids and simulator in complex reservoir geology.

We present numerical simulations of single-phase flow for a variety of geological systems of increasing complexity, culminating in systems which would be impossible to mesh and solve with structured meshes. This is also a first step towards a more complex multi-phase and multi-component implementation of the novel methods for flow through porous media.