Subflow - An Open-Source, Object-Oriented Application for Modeling Geologic Storage of CO$_2$

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Abstract

The capture of carbon dioxide for its subsequent storage in brine-saturated reservoirs or depleted oil fields has become a significant part of US energy policy. In this work, we focus on the design and development of a novel CCUS application to model carbon dioxide injection in brine-saturated reservoirs. SubFlow is written in C++ and uses a relational database to store user session and simulation parameters such as mineral, solute, kinetic reaction, lithology, formation, and injection water data. Subflow is capable of 3D real-time visualization, distributed-parallel execution on massively parallel processor (MPP) systems using OpenMP and MPI, and features an intuitive user interface developed using Qt. SubFlow uses a mimetic discretization method (MDM) for solving conservation of solute mass, energy, and fluid momentum, and the finite-element method for solving the pressure, rock stress, and fracture fields. SubFlow is implemented with the Mimetic Methods Toolkit (MTK), a C++ API which allows for an intuitive implementation of the Castillo-Grone based Mimetic Discretization Methods. The FVM is second order accurate while the MDM is capable of fourth order accuracy. OpenGL is used to render pressure, temperature, stress, velocity, and solute concentration fields on a 3D mesh that represents a reservoir. Results from selected simulations are compared with those produced by TOUGHREACT and STOMP.