Geophysical Research Abstracts
Vol. 20, EGU2018-18962, 2018
EGU General Assembly 2018

Computational methods for two-phase flow

Dave May, David Rees Jones, Richard F. Katz, and Meng Tian
University of Oxford, Department of Earth Sciences, United Kingdom (dave.mayhem23@gmail.com)

Subduction zones (SZs) are the crossroads of plate tectonics, where volatile-rich sediments, basalts, and lithosphere exchange mass and energy with the shallow and deep mantle. Solids descend while liquids ascend; temperatures vary by 800K; melting occurs by hydrous flux and decompression; liquids range from hydrous to silicic; energy is transported in every direction. This physical and chemical complexity means that our understanding of SZ magmatism lags behind other tectonic settings.

Progress in understanding such multi-phase, multi-component systems requires an accurate and efficient PDE modelling framework that consistently couples essential physics and allows for hypothesis testing and interpretation of observations. Developing such a framework for geodynamic processes presents a number of new technical challenges which have not been addressed by analysis or methodological developments arising from modelling single-phase, lithospheric dynamics. Specific issues unique to the two-phase problem are (but not limited to): devising formulations for the conservation of mass and momentum (mechanics) which permit accurate representations of the velocity and pressure for both phases, and which also maintain their accuracy in regions of zero and or nonzero porosity; accurate methods for transport processes which are conservative and strictly respect the physical bounds of the conserved variable; accurate methods to reconstruct the melting rate in multi-component systems.

In this presentation I'll discuss work aiming to address these technical issues. With respect to the mechanics, I'll show that with a particular choice of the pressure variable, together with a suitable regularization, high order and high accuracy solutions can be obtained via the finite element method applied over unstructured meshes for both the velocity and pressure fields in each phase, even in cases where the porosity is globally, or locally, identically equal to zero. Efficient solvers for this discrete formulation is achieved via a novel multilevel auxiliary space preconditioner. An accurate, bound preserving discretization of the hyperbolic system associated with the porosity / chemistry is achieved via a finite volume inspired conservative semi-Lagrangian method.

The above techniques are brought together in a framework being developed coined SubFUSc. The essential features of the framework required to enable multi-physics applications, together with representative demonstrators and examples of two-phase flow in an idealised subduction zone will also be presented.