

# MultiMaDDS – Implementing Magma dynamics with the commercial software COMSOL Multiphysics™

Laurent G. J. Montési, *University of Maryland, College Park, USA*

The Magma Dynamics Demonstration Suite (MaDDS), is a sequence of models defined for CIG by Spiegelman et al. [2007] as a guide to implement magma dynamics in a software platform. I have been implementing MaDDS in the commercial software COMSOL Multiphysics™ (MultiMaDDS project) used in my research group to model mantle flow, thermal evolution, shear zone formation, and elastic flexure. Implementing melt migration in COMSOL Multiphysics™ opens the door to new investigations of the various coupling in effect in the crust and upper mantle.

MultiMaDDS currently features MaDDS-1 (Stokes solver test), MaDDS-2 (Melt migration in a constant porosity background, Fig. 1) and MaDDS-4 (Solitary waves, Fig. 2). MaDDS-1 uses the predefined Navier-Stokes application and reveals the importance of using quadratic mixed-mode elements and unstructured meshes refined at the ridge's corner. MaDDS-2 was straightforward either as a post-processing step in Matlab or as a true multiphysics problem coupling the Navier-Stokes and Darcy application modes. For the Solitary Waves problem (MaDDS-4), it was necessary to use the PDE-general form mode coupled with a predefined Helmholtz equation mode.

As advertized, it is easy to couple various predefined modes (MaDDS-1, MaDDS-2) or even to define a custom mode from the PDE without the need to derive the weak form of the equation. However scaling is limited, as COMSOL cannot take advantage of DMM architectures. I find that advection is somewhat problematic: advection tests and solitary waves in a moving frame suffered from discretization artifacts. Nevertheless, the ease of use (including an intuitive GUI) and flexibility of mode coupling, mesh generation, and element choice make COMSOL a valuable tool for small geodynamics problem, exploratory studies, and student training. Inspired by this CIG activity, I developed simple geodynamics demonstration problems using COMSOL and posted them at <http://www.geology.umd.edu/~montesi/Geodynamics/ComsolModels.shtml>.

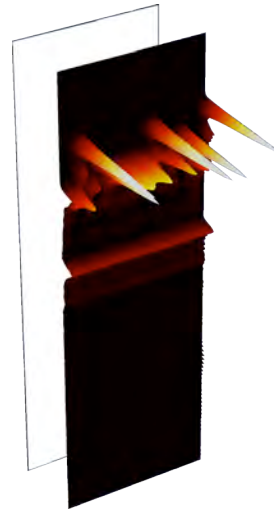


Figure 2: 2D Solitary wave (MaDDS-4) realized with COMSOL Multiphysics™. An initially “bar” of high porosity breaks down into circular waves that rise with minimal (although non-zero) interaction. The simulation is realized in a reference frame that with the expected motion of the waves.

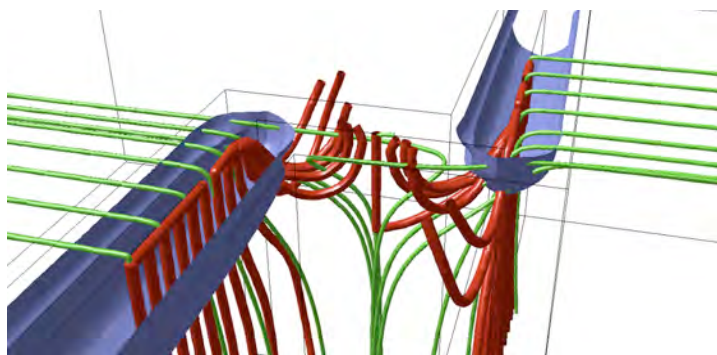


Figure 1: MaDDS-2 implemented with COMSOL Multiphysics™. Green lines represent mantle trajectories underneath a segment ridge axis, with the blue surface a pressure isosurface and red are trajectories of magma assuming constant porosity. The model reproduces 2D focusing far from the ridge offset and 3D effects near the offset, including melts that cross the transform fault