

Magma dynamics working group(s)

- ▶ Working group
 - **Marc Spiegelman (Columbia U.)**
 - Ritske Huisman (Bergen U.)
 - Garrett Ito (U. of Hawaii)
 - Richard Katz (Oxford U.)
 - Boris Kaus (ETH Zurich)
 - Laurent Montési (U. Maryland)
 - Benjamin Phillips (Los Alamos)
 - ▶ CIG Development:
 - Marc Spiegelman: PETSc, StG
 - Dave Lee (VPAC): StG
 - Wolfgang Bangerth: deal.ii
 - Laurent Montési: COMSOL
 - ▶ OCE Proposal team
 - Marc Spiegelman
 - Paul Asimow
 - Michael Gurnis
 - Garrett Ito
 - Laurent Montési
 - Peter van Keken
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Magma dynamics goals

- ▶ Short-term
 - Implementation and testing of McKenzie equation, at least using StGermain
 - MADDS benchmark 1-4, at least with StGermain
- ▶ Long-term
 - Coupling of magma dynamics with other software
 - MADDS benchmark 5-6
 - Coupling with computational thermodynamics software (e.g. MELTS) and geochemical databases
- ▶ Other
 - Submitted proposal to OCE in February 08: coupling with thermodynamics



MADDS: Magma Dynamics Demonstration Suite

- ▶ Demonstration suite, not software
 - 6 benchmarking exercises of increasing complexity, building up to couple Mid-Ocean Ridge models using the "McKenzie Equations"
 - Definition in "An Introduction and Tutorial to the "McKenzie Equations" for Magma Migration", written by Marc Spiegelman and students, available on CIG website
 - Implementation on various software platforms
 - CIG sponsors Dave Lee at VPAC for main effort
 - Other community effort (slower)



Benchmarks

- ▶ 1: 2D ridge / 3D segmented ridge, Stokes only (test pressure solution)
- ▶ 2: Test advection (ridge or other deformation)
- ▶ 3: Constant porosity ridge (post-processing)
- ▶ 4: Solitary wave (Darcy flow+compaction)
- ▶ 5: Shear bands
- ▶ 6: Coupled ridge, forced melting



MADDS status

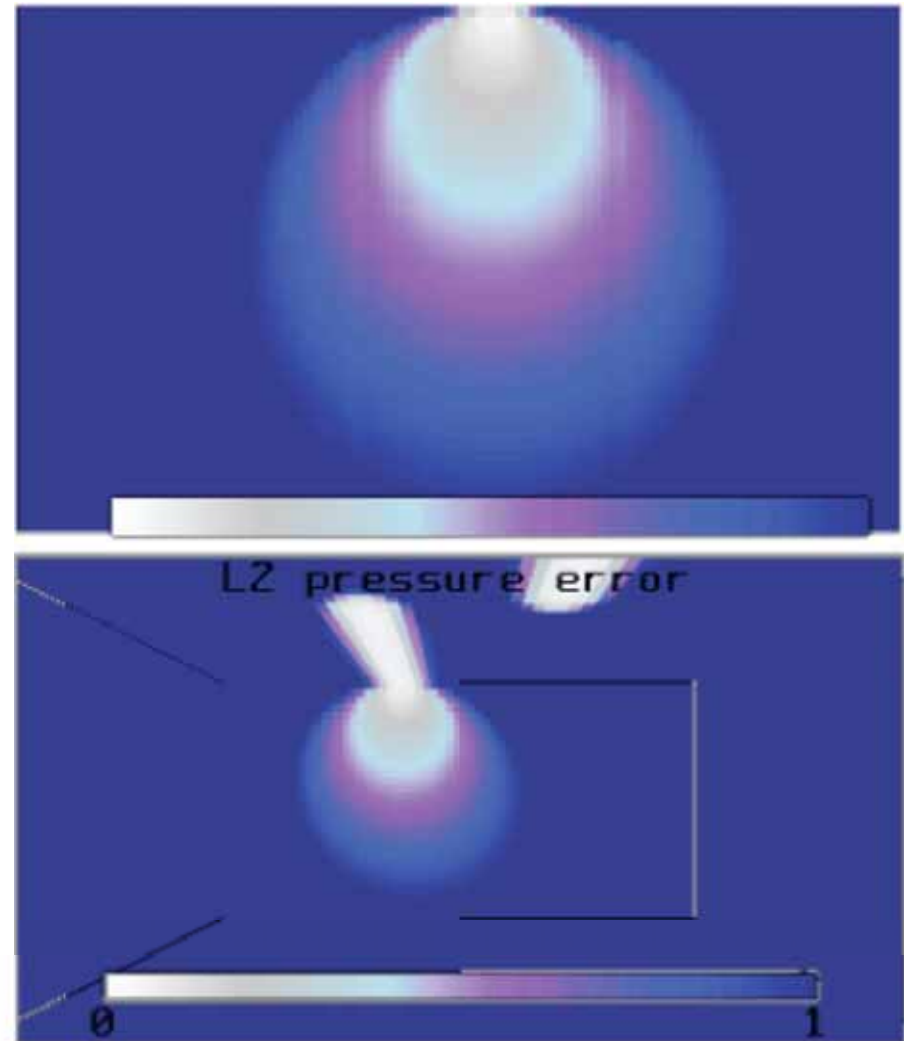
Software	Who?	Benchmark					
		1	2	3	4	5	6
StGMADDS	Dave Lee	X	X	X	X		✓
PETSC-based	Marc Spiegelman				X	X	
COMSOL	Laurent Montési	X	✓	✓			
Deal.II	Wolfgang Bangerth	X					

- ▶ X: Essentially done
- ▶ ✓: in progress



StG MADDs BM1

- ▶ Benchmark 1 necessitated implementation of higher-order elements
 - Quadratic in velocity
 - Linear in pressure
 - Pressure on internal nodes or at vertices
- ▶ Problems interpolating a reference solution: solved!

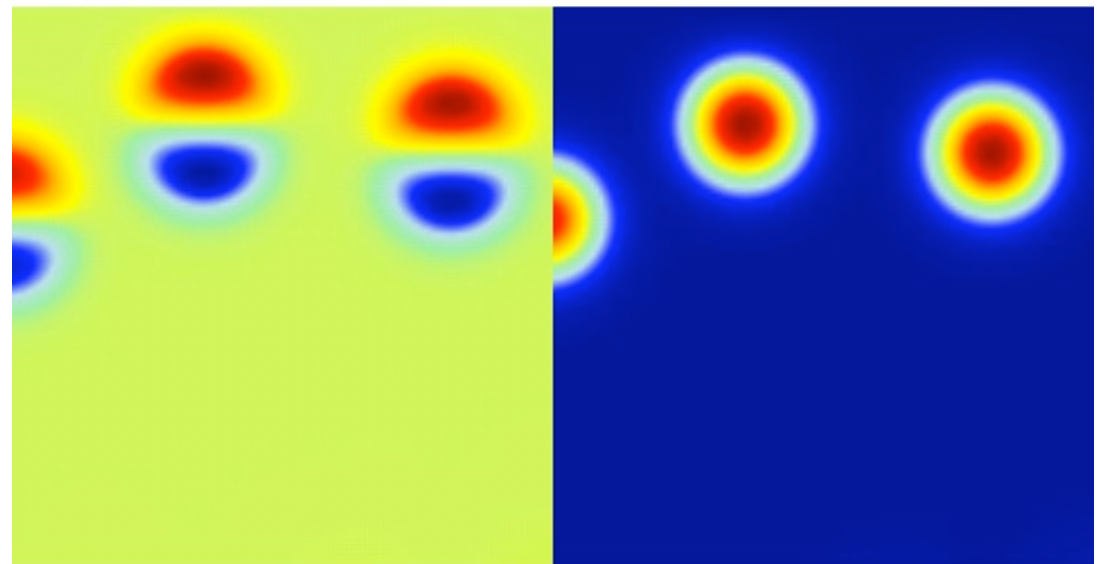


STG MADDS BM4

- ▶ First time coupled McKenzie description of two phase flow in open-source code!

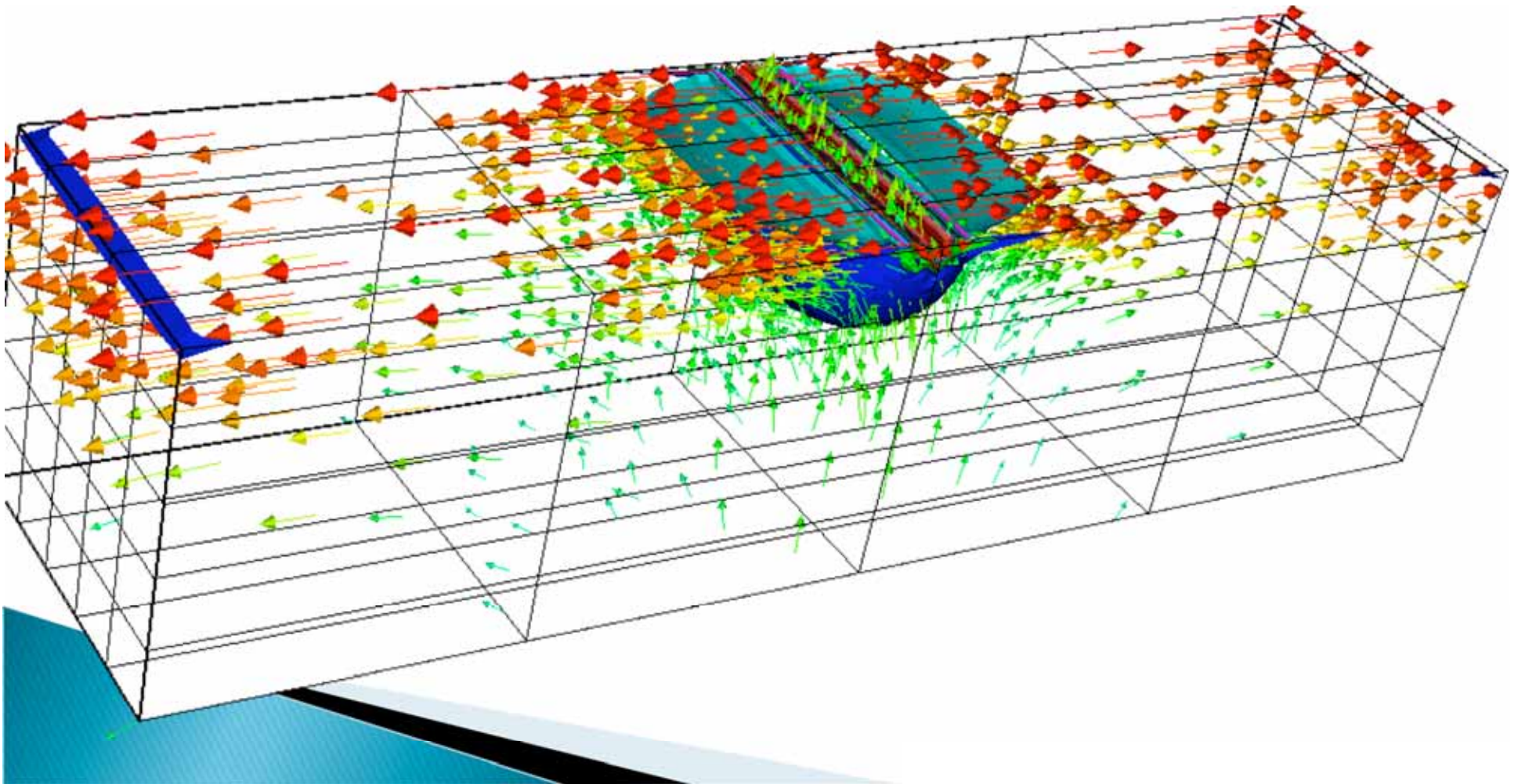
pressure

porosity as field



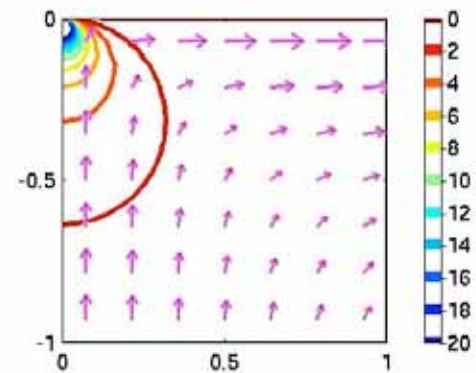
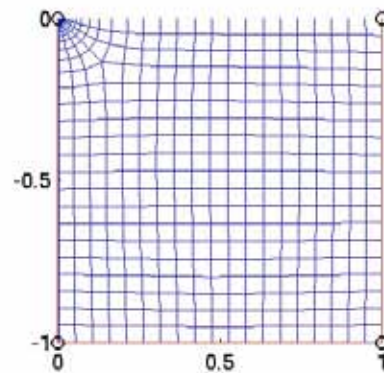
Deal II

- ▶ Stokes solver

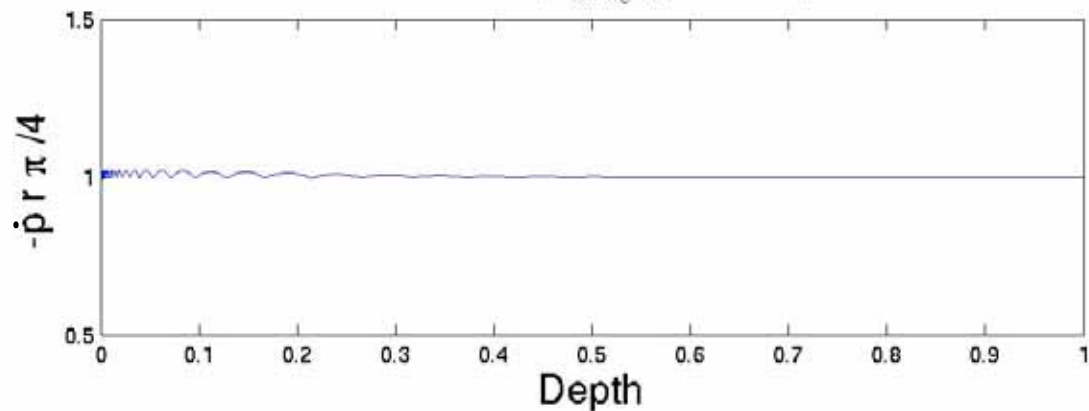


MADDS in COMSOL

- ▶ All set for BM1
 - Good pressure
 - Refined mesh
- ▶ BM2 and beyond:
 - Trouble with advection
 - No tracers, custom solver ...



Time to solution: 7.56902s; $\text{int}((p/p_c - 1)^2) = 0.000443751$; 5048 dof



Evaluation

- ▶ StG MADDS
 - Software works; Should be compatible with other StGermain-based software), including Gale
 - Slow performance
- ▶ COMSOL
 - Easy to use; Ready applications
 - Advection so-so (to be tested further)
 - Shared memory parallelization only
- ▶ deal.ii
 - Too early to tell but promising
- ▶ Marc's PETSc solitary wave code
 - Works, efficient, parallel
 - Caution: meant as benchmarking code only



What's next?

- ▶ Go on with MADDs
 - Continue with StG MADDs and build up with deal.ii and PETSc
 - Coordinate with other WGs for compatibility/coupling
- ▶ Multiphysics/thermodynamics coupling
 - Waiting to hear about OCE proposal
 - Coupling between regional and global mantle flow
- ▶ Community training
 - Define benchmark specifics
 - Publish cookbooks for in StG MADDs, COMSOL, deal.ii, other?

