Progress toward an integrated computational model of magma genesis and transport in subduction zones

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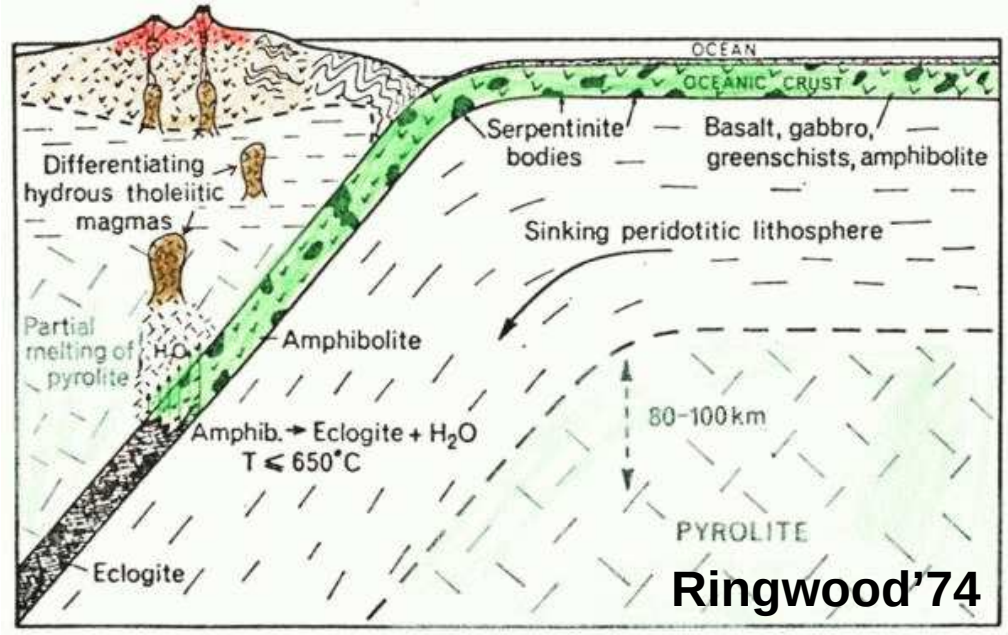
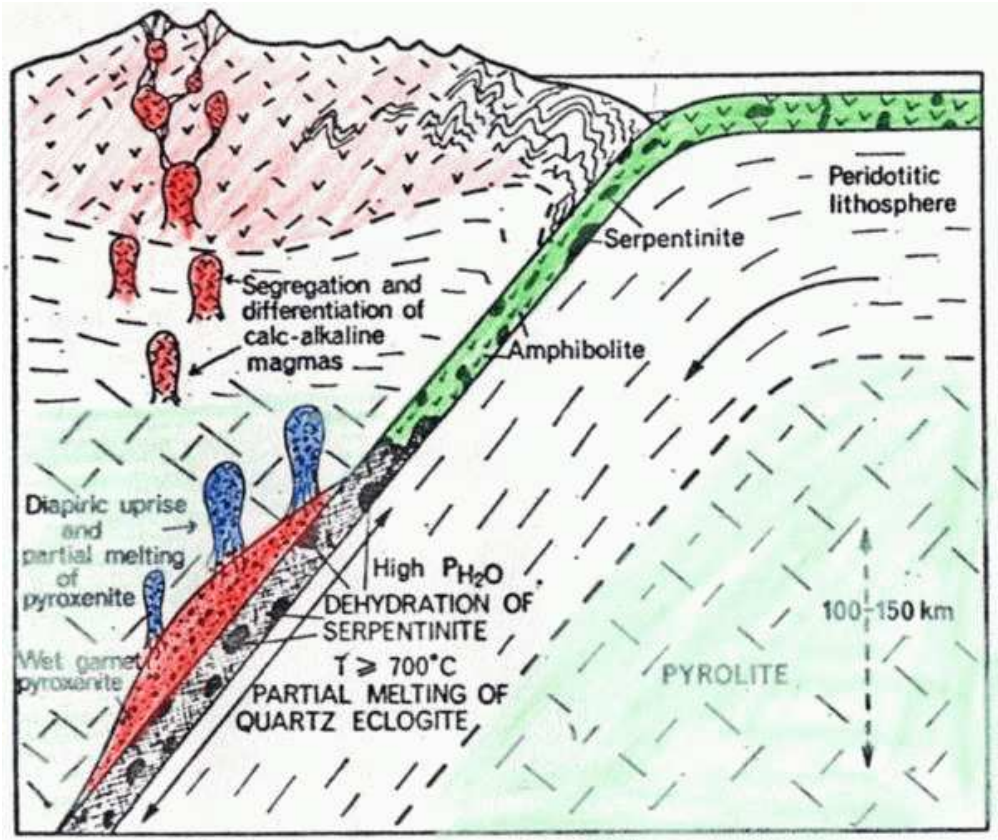
An OPEN question

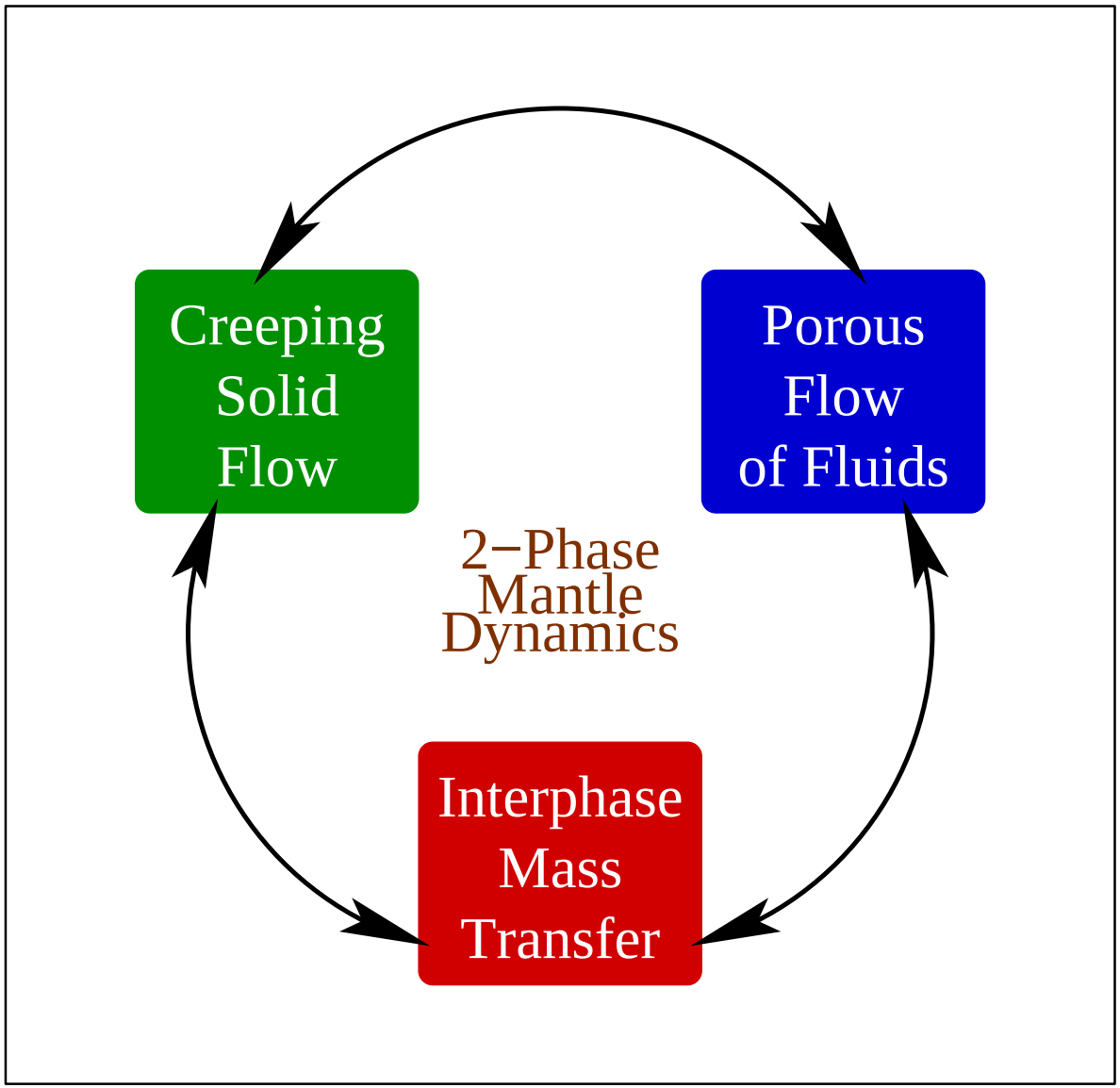


Porous flow of aqueous fluid

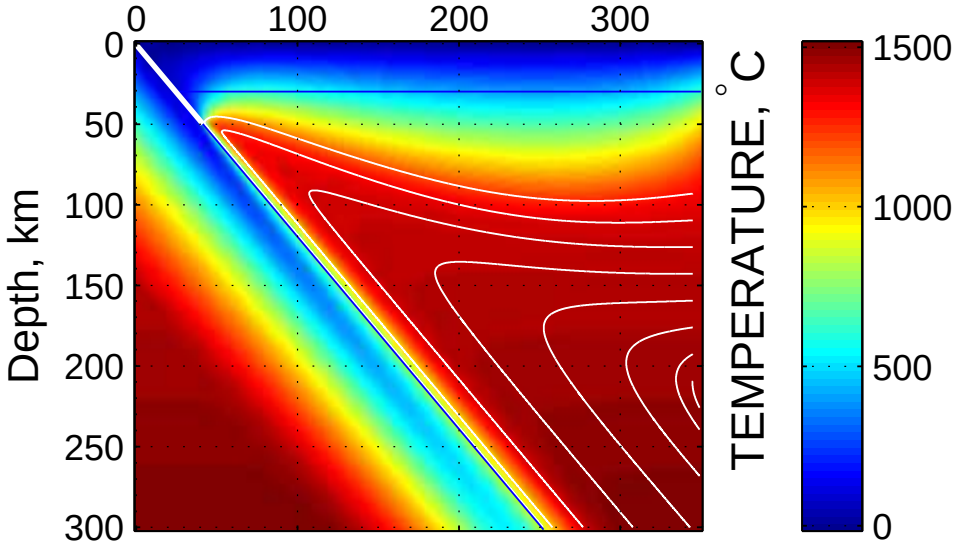


Diapiric solid upwelling

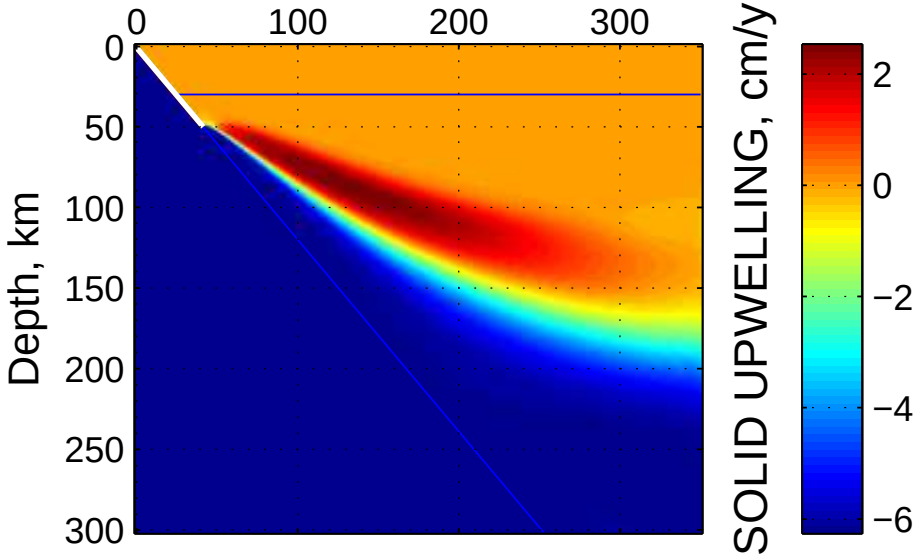
Open system subduction models: key components



Solid flow & thermal structure



- $\eta = f(P, T, \sigma)$
- Warmer wedge & slab



- Upwelling $\approx 1/4U_0$

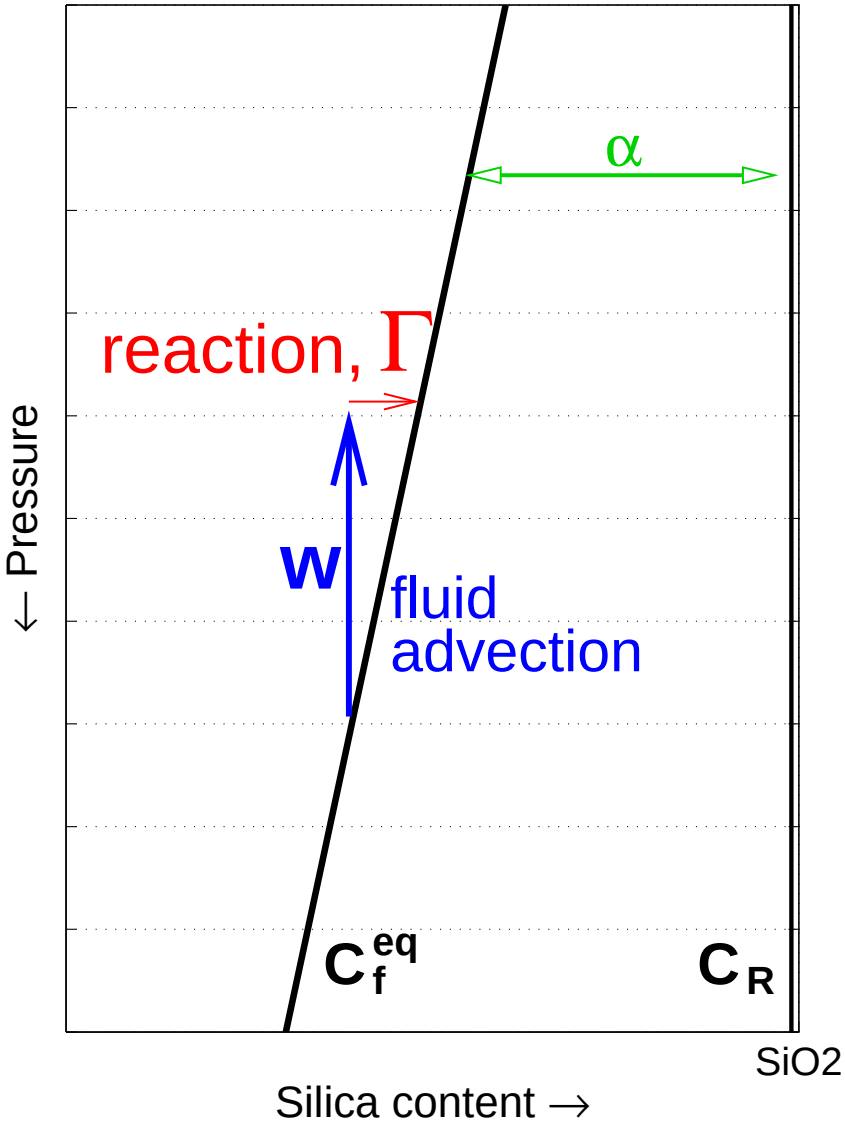
Fluid flow & melting

Building on past work

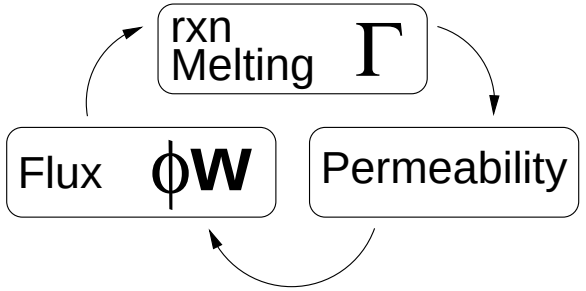
Spiegelman *et al.*, Causes and consequences of flow organization during melt transport: The reaction infiltration instability in compactible media, *JGR*, 2001.

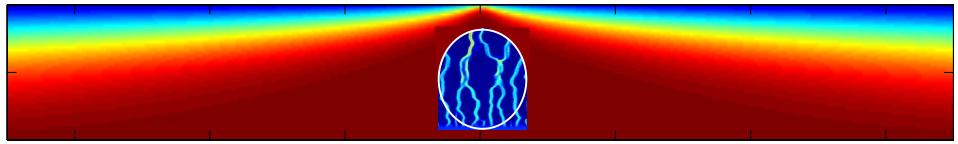
Yanming Fang, poster 595, V21A (tomorrow!) level 1

Reactive open-system melting



$$\Gamma \propto \frac{\phi \mathbf{w}}{\alpha} \frac{\partial C_f^{eq}}{\partial P}$$



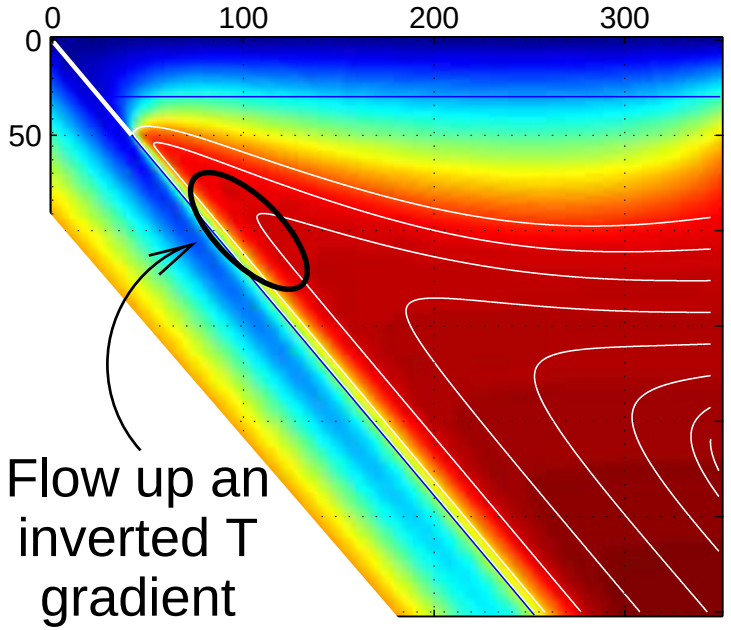


Fluid flow down a pressure gradient

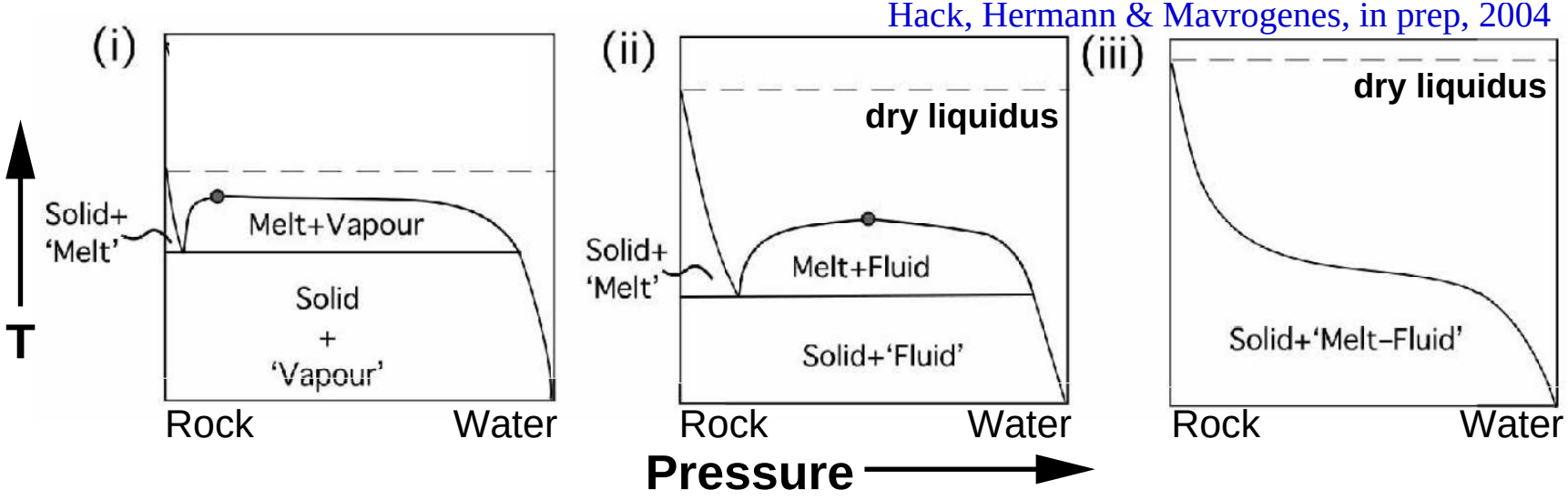
Hydrous reactive melting in arcs

Two phases: solid & fluid

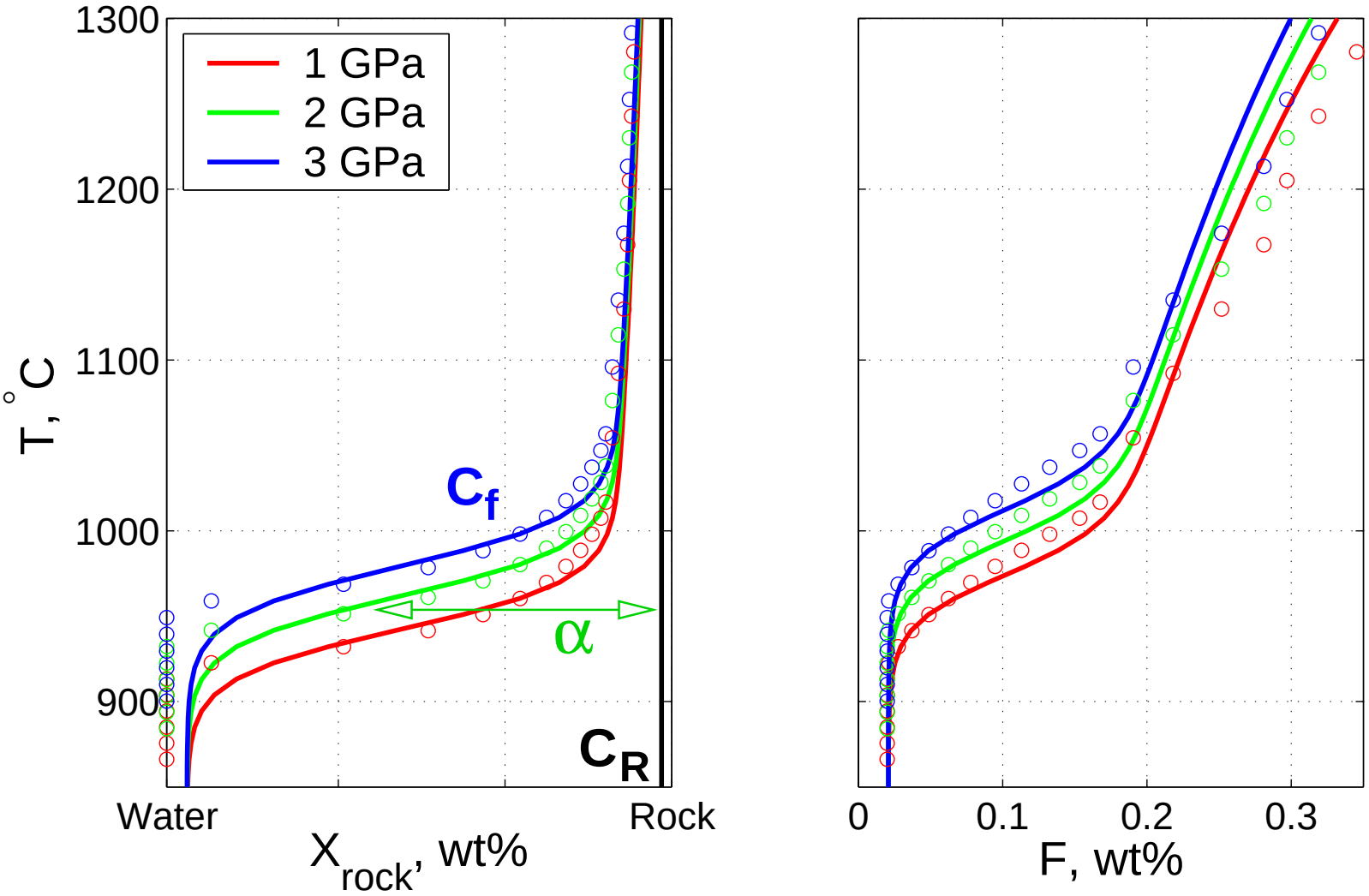
Two components: rock & water



Hack, Hermann & Mavrogenes, in prep, 2004

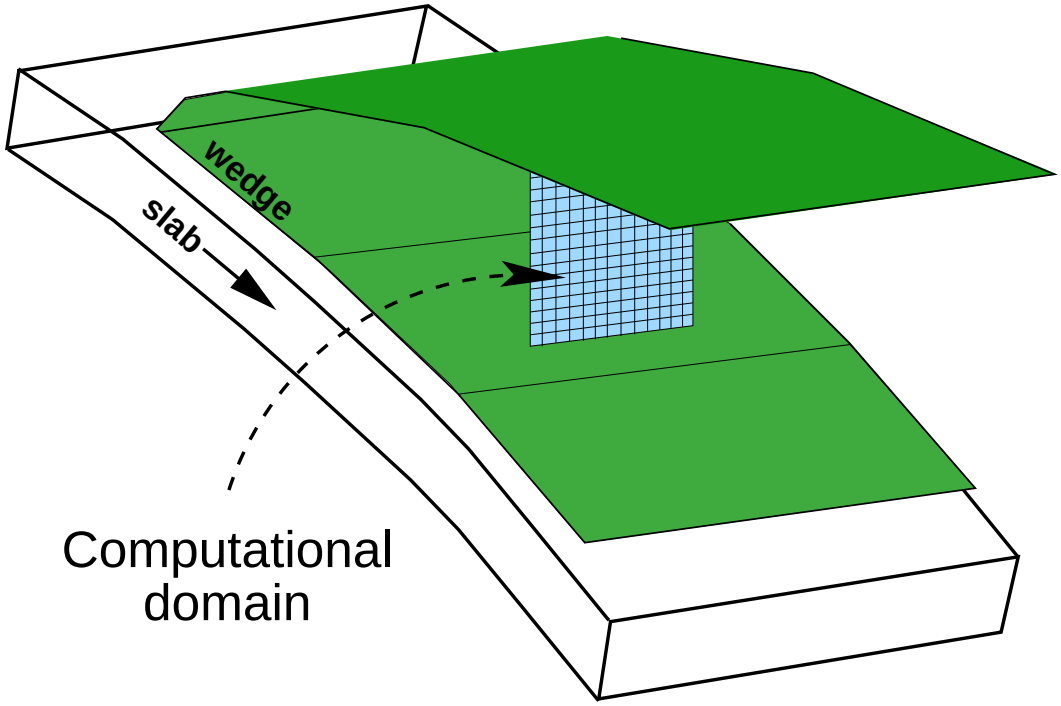


A parameterization of C_f^{eq} at 2 wt% bulk water



Points: A new parameterization of hydrous mantle melting, Katz *et al.* G^3, 2003

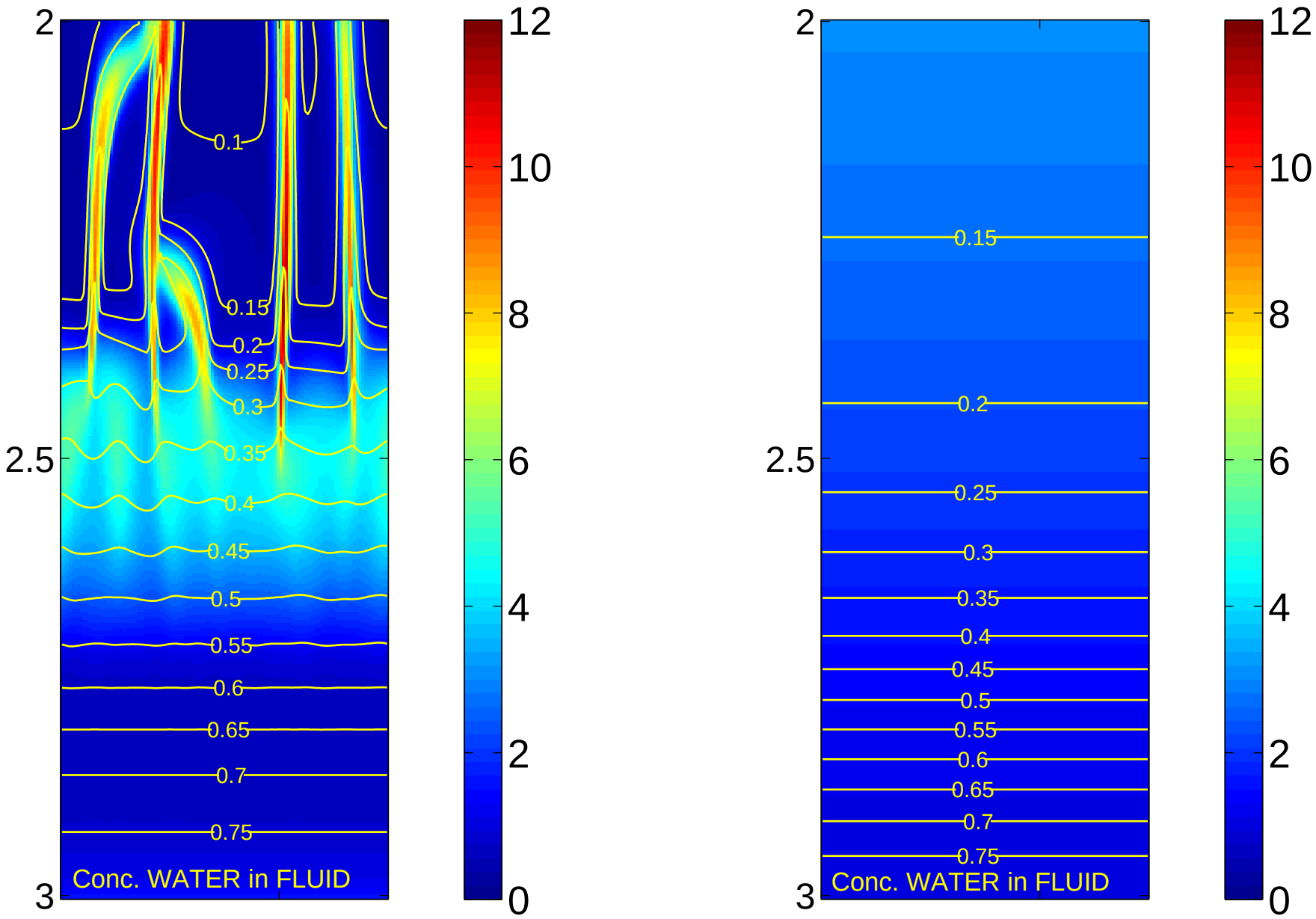
Reactive hydrous melting with conservation of energy



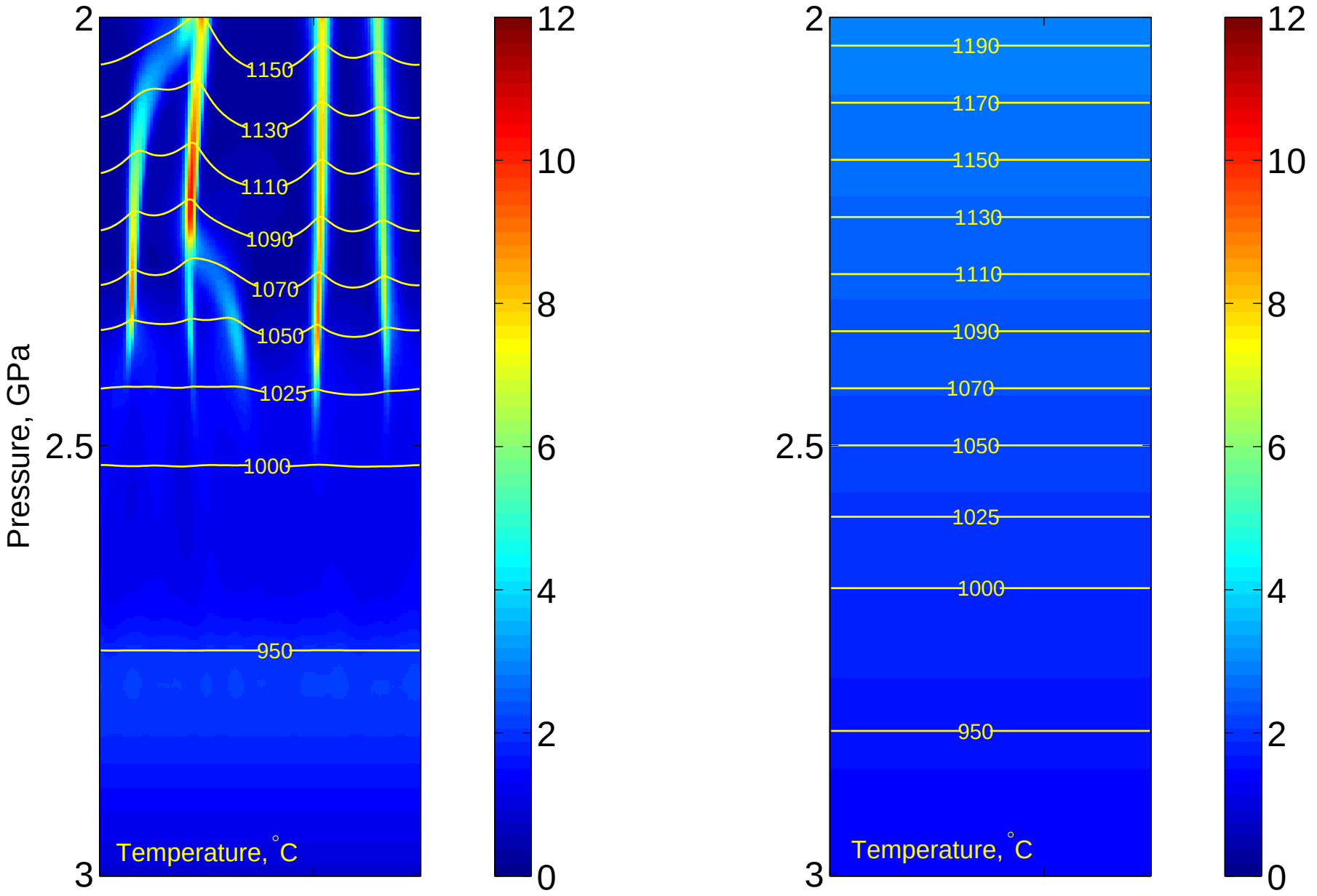
$$\frac{\partial T}{\partial t} + \frac{\rho_f \phi}{\bar{\rho}} \mathbf{v} \cdot \boldsymbol{\nabla} T = \frac{-T\Delta S}{\bar{\rho} c_P} \Gamma + \kappa \nabla^2 T + (1-\phi) S(T, \mathbf{x})$$

Solve system of equations using PETSc

Porosity, ϕ, vol%



Vertical fluid velocity, w, m/yr



Conclusions & Speculations

- A quantitative understanding of melt generation and transport in subduction zones requires calculating reactive fluid flow
- Channelized flow a natural consequence of magmatic reactive porous ascent up a solubility gradient.
- Differences between channelized flow and diffuse flow:
  - 10x difference in porosity.
  - 2x difference in water content of melt.
  - 10x difference in fluid velocity. $t_{slab \rightarrow moho} = \mathcal{O}(10^3 \, \mathrm{yrs})$
  - $50^{\circ}C$ temperature difference.
- These differences have important observable consequences.

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www.mcs.anl.gov/petsc

DOE CSGF Department of Energy Computational Science Graduate Fellowship

For more information:

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