Numerical modelling of heat and mass fluxes at the magma-hydrothermal interface

challenges and unknowns

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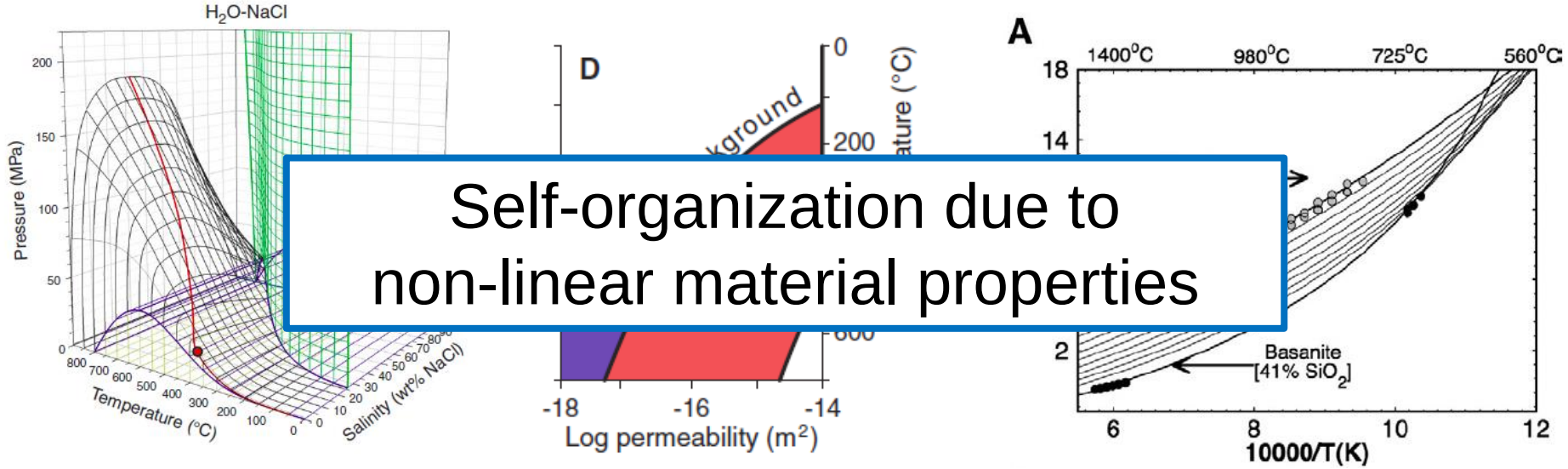
GFZ Potsdam

KMT@GFZ Workshop 28.4.2022

Numerical modelling of multi-phase fluids, dynamic permeability and melts

- CSMP++ Group at GFZ (Section 3.1): hydrothermal ore deposits
  - C. Andersen, M. Codeço, A. Glerum, A. Gruzdeva, M. Korges, A. Rodríguez, M. Stoltnow, P. Weis
- Collaboration on geothermal systems
  - University of Icleand (S. Scott), ETH Zurich (A. Yapparova)

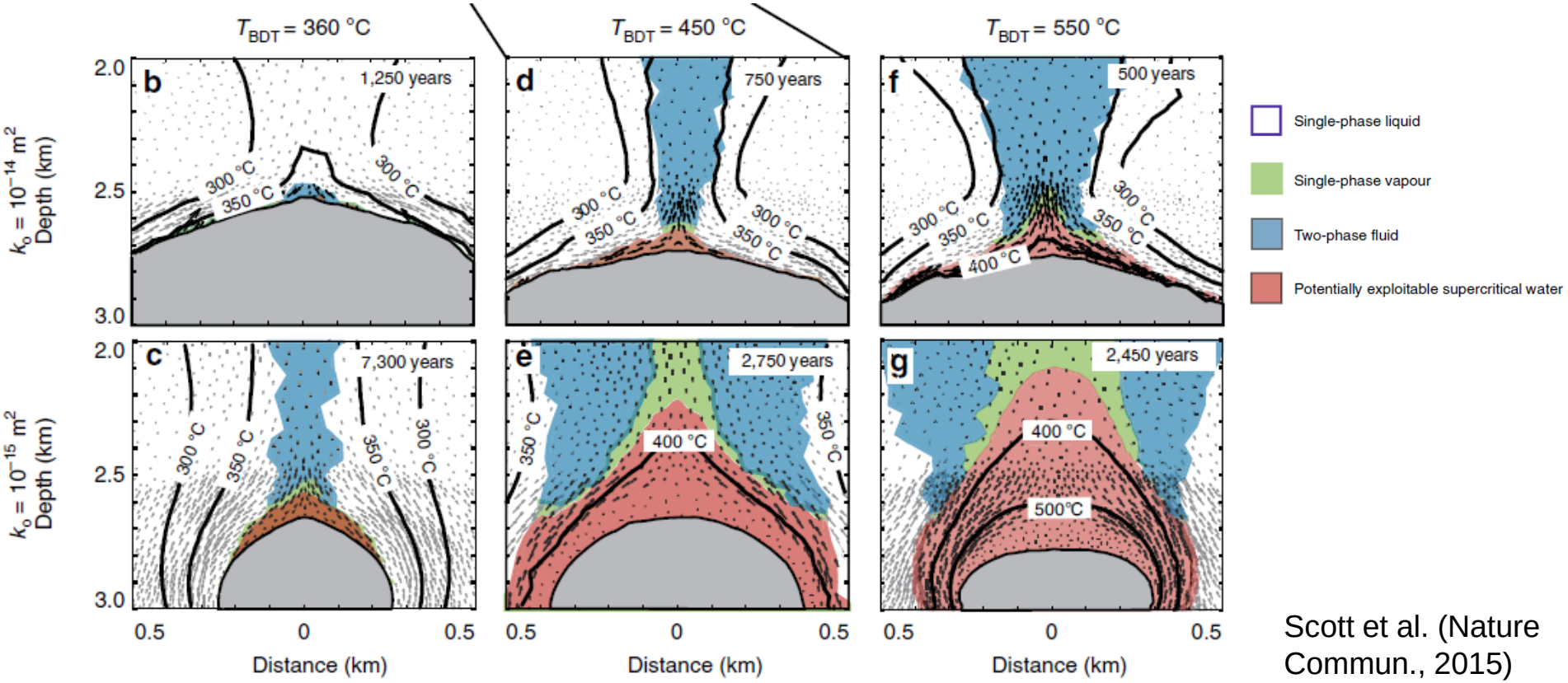


Self-organization due to non-linear material properties

Driesner & Heinrich (2007), Weis et al. (2012), Giordano et al.. (2008)

Supercritical geothermal systems

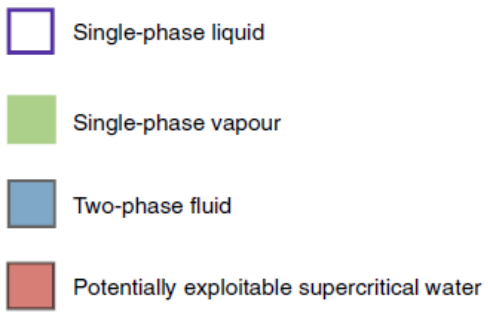
- High brittle-ductile transition temperatures increase potential
- High host-rock permeabilities reduce potential

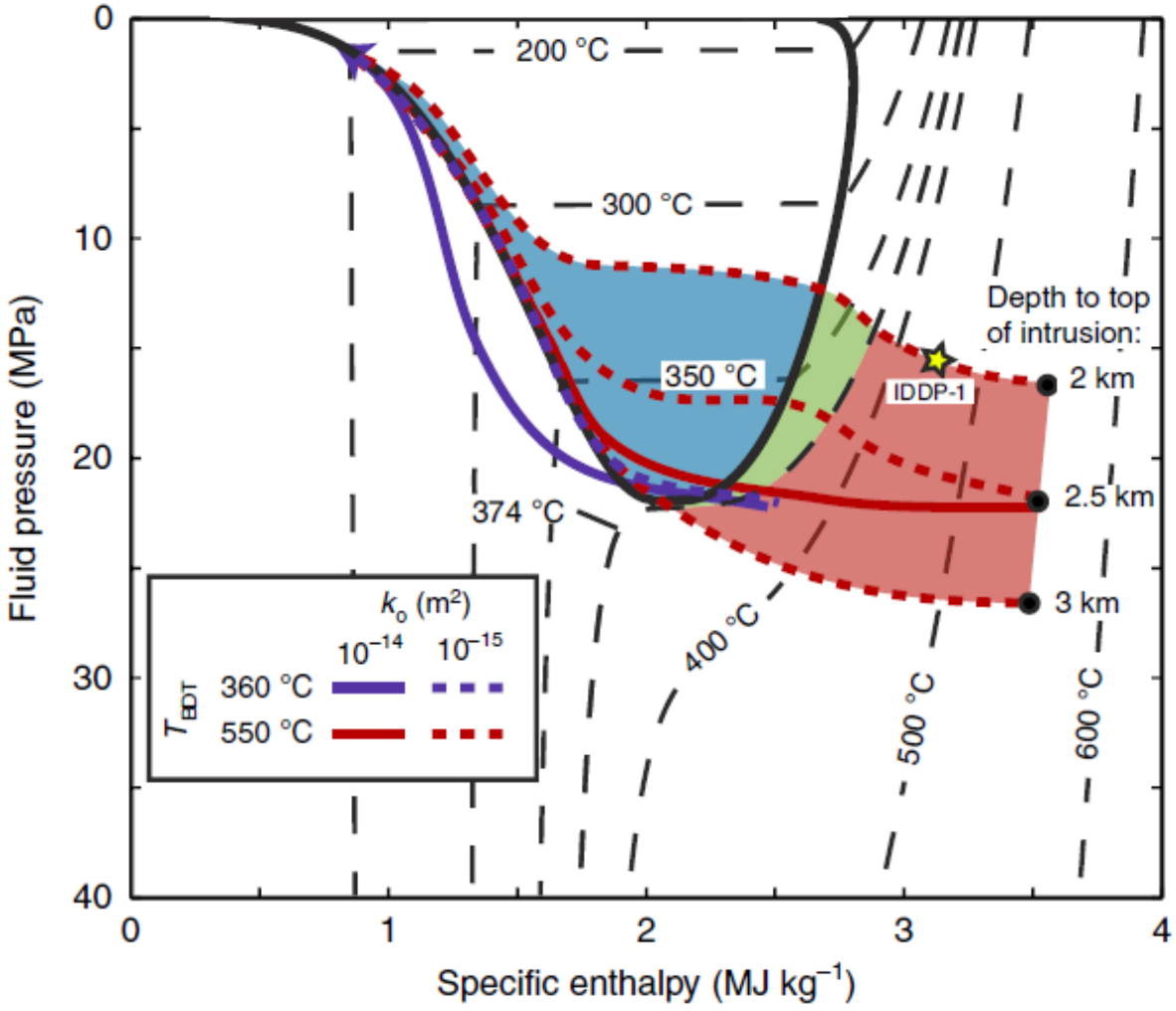


Scott et al. (Nature Commun., 2015)

Supercritical geothermal systems

- Pure water (IDDP-1): shallow systems make better resource
- Reduction of enthalpies due to fluid mixing in the upflow zone

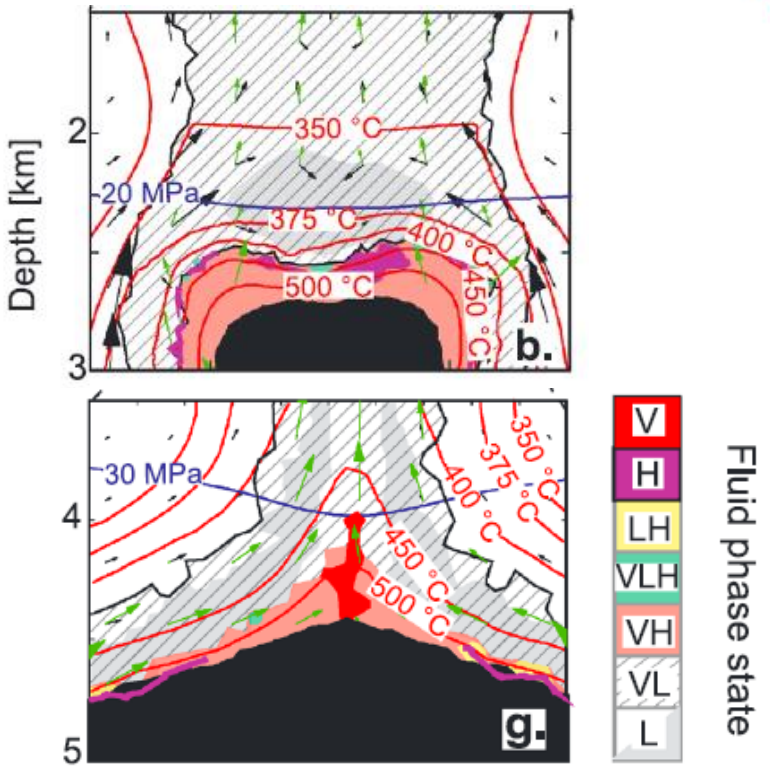


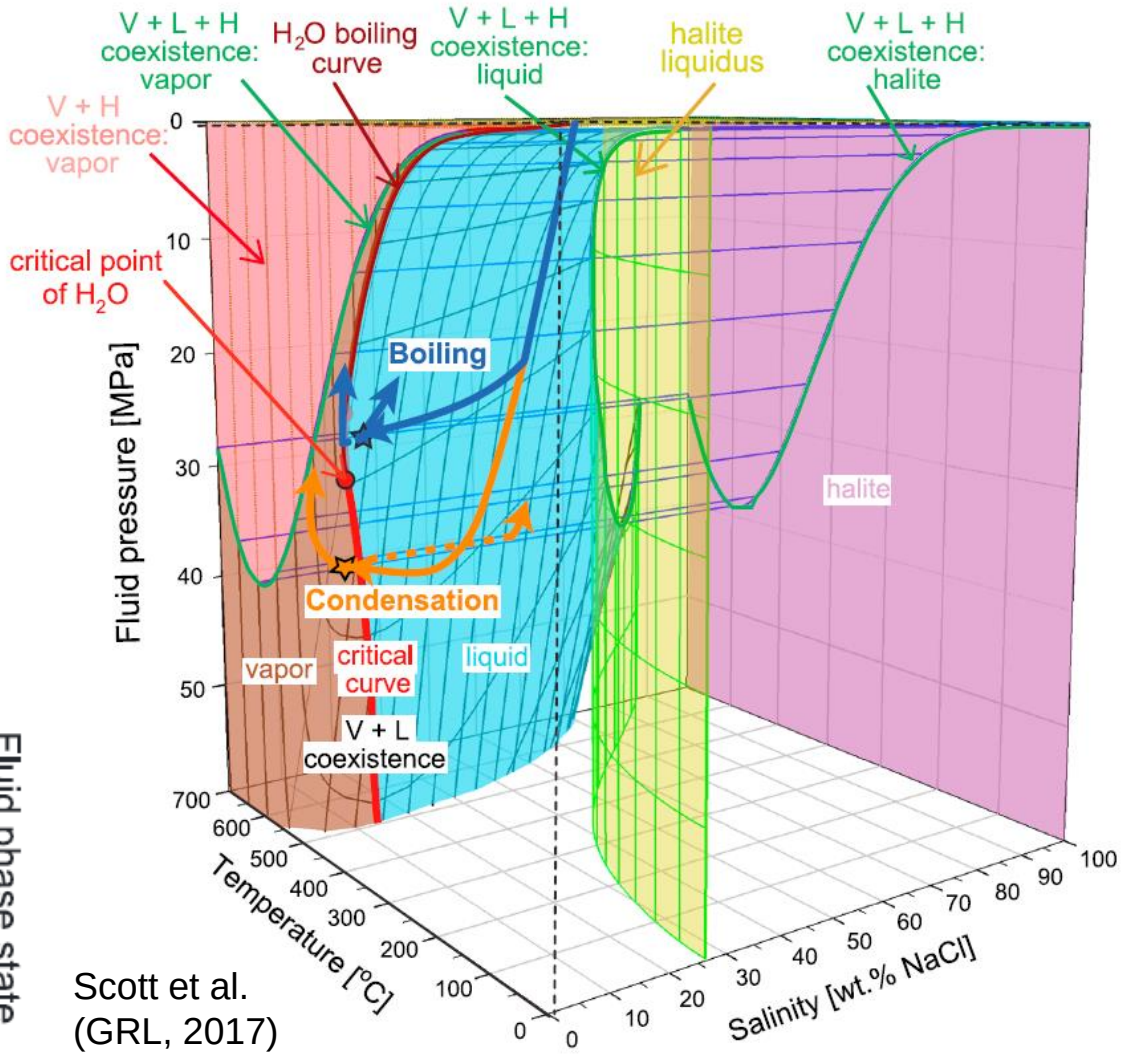


Scott et al. (Nature Commun., 2015)

Saline geothermal systems

- Salt water (IDDP-2): deep systems make better resource

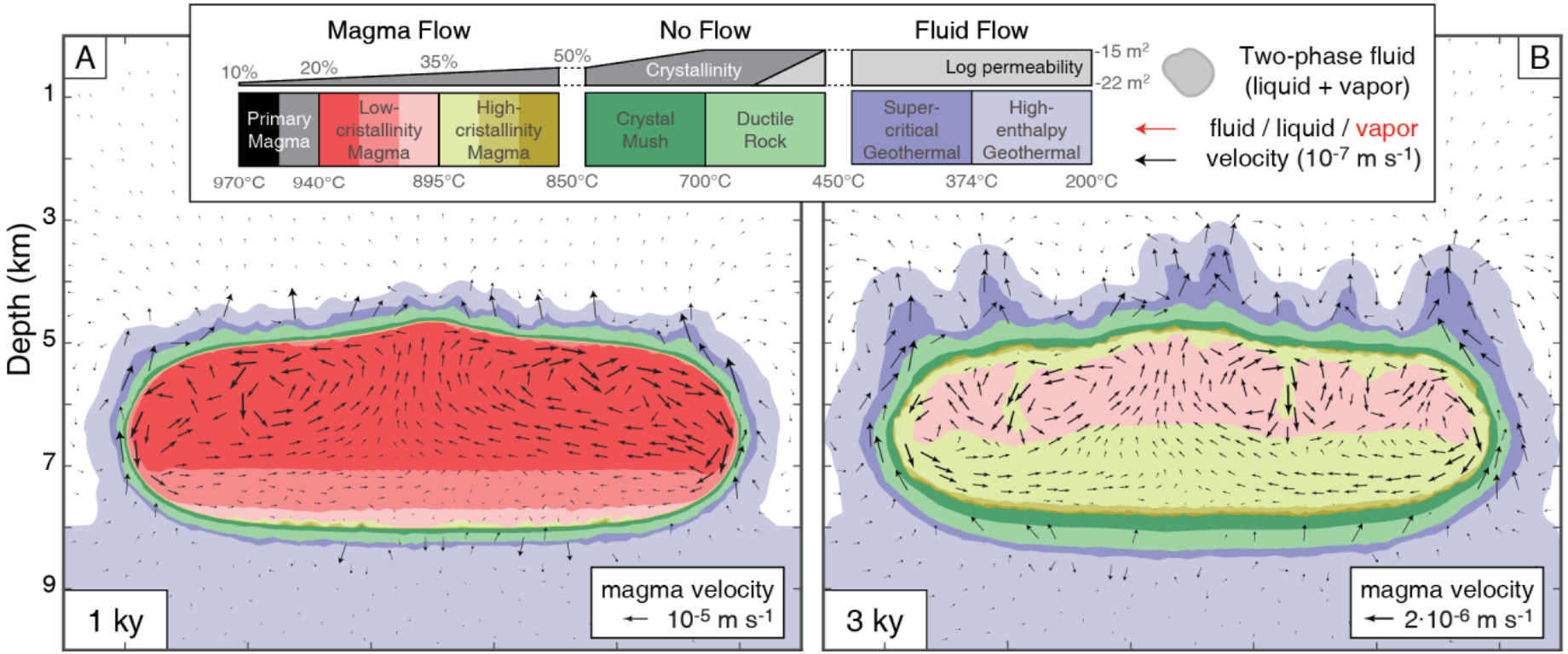




Scott et al. (GRL, 2017)

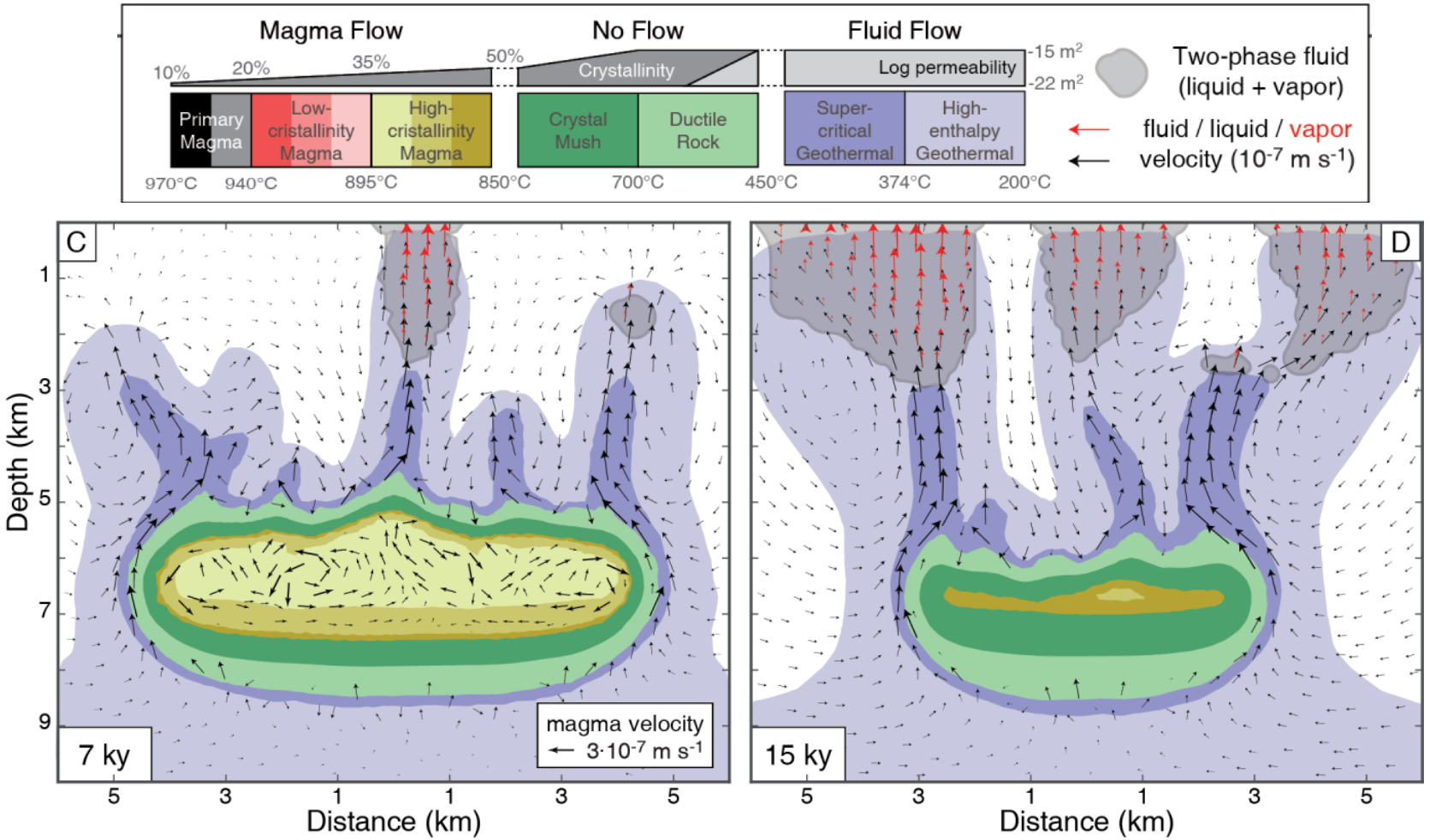
Heat transfer by magma and fluid flow

- Cooling of hot-dry rhyolitic magma



Andersen & Weis (*GRL*, 2020)

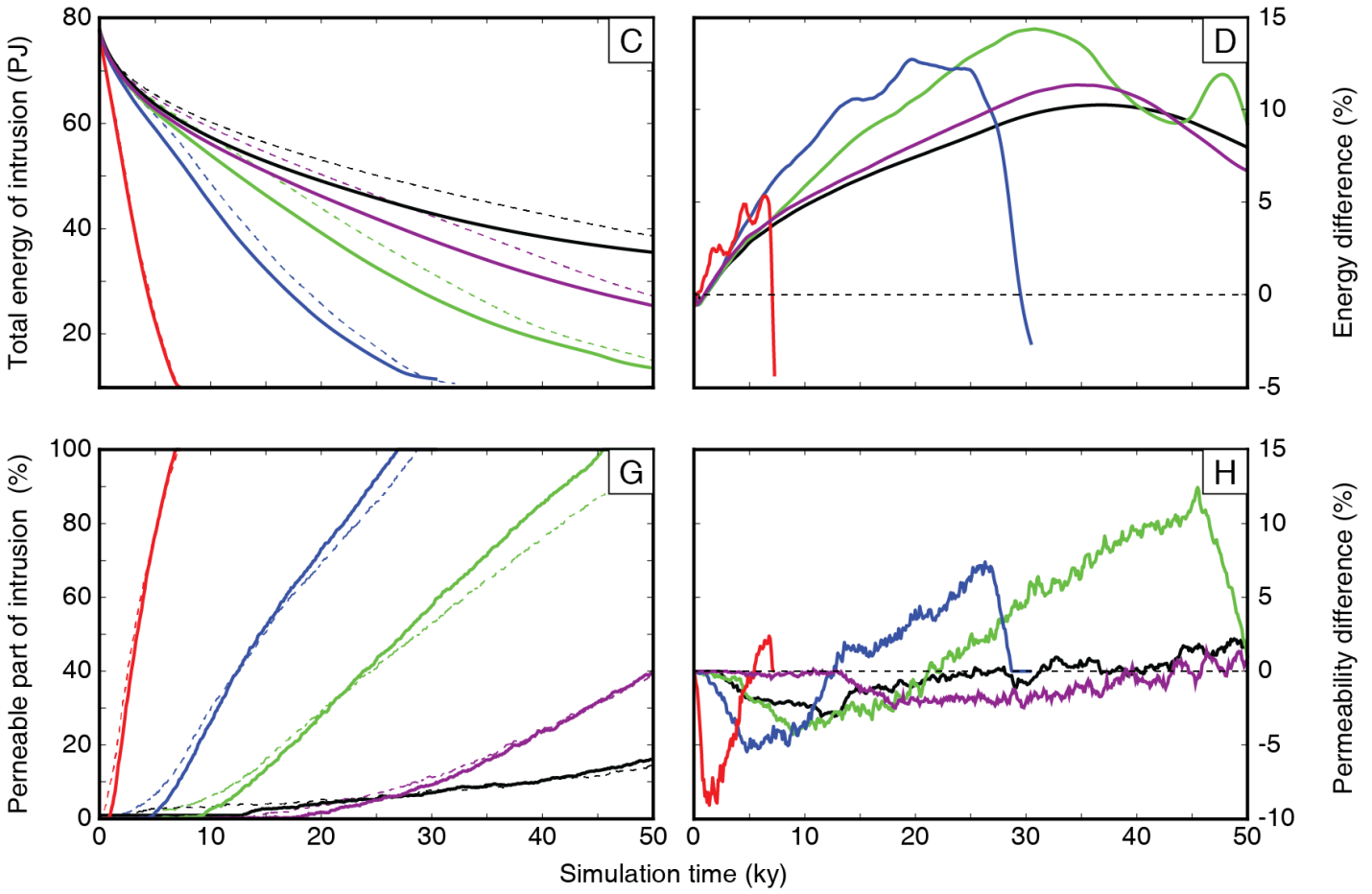
Heat transfer by magma and fluid flow



Andersen & Weis (*GRL*, 2020)

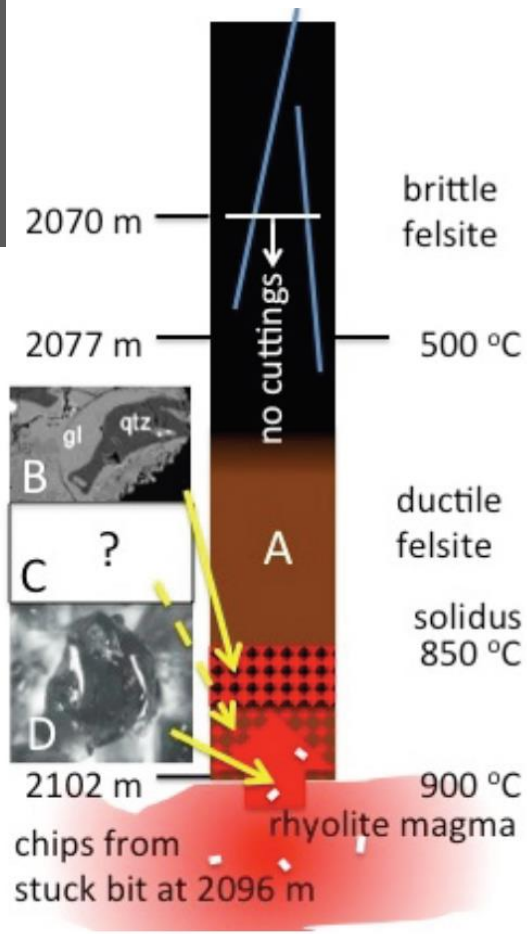
Heat transfer by magma and fluid flow

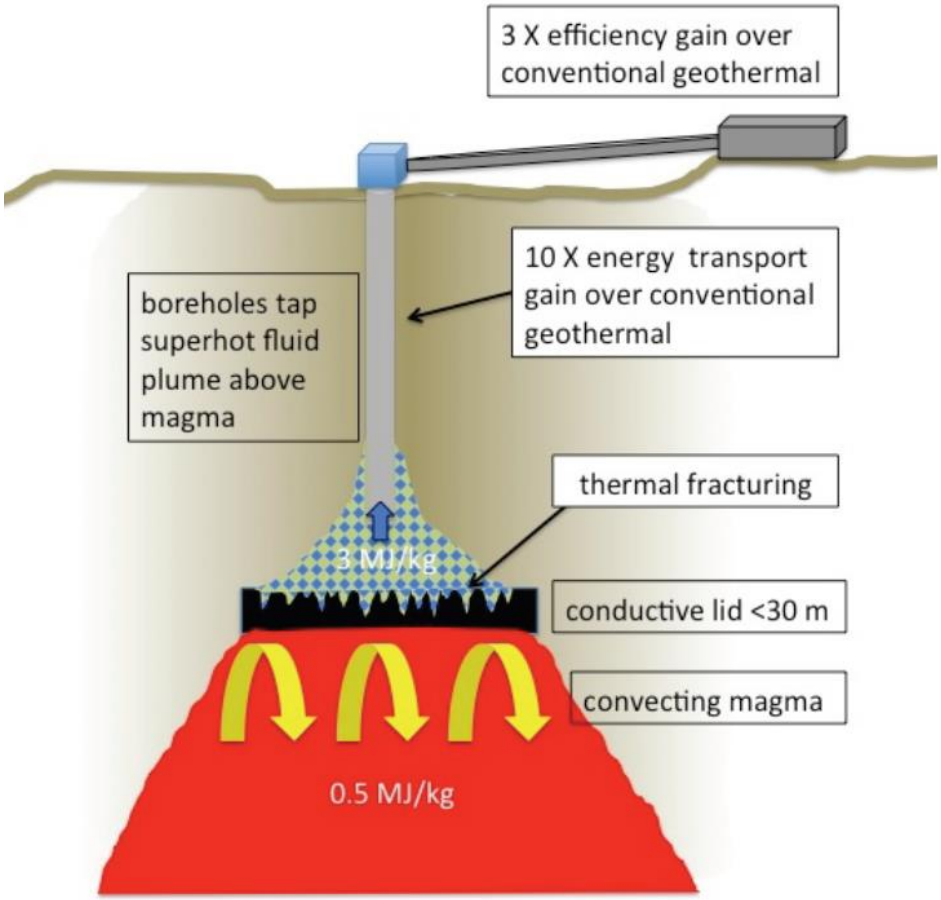
- Permeability controls heat transfer rates
- 15% faster cooling with magma flow
- Delayed permeability creation



Andersen & Weis (*GRL*, 2020)

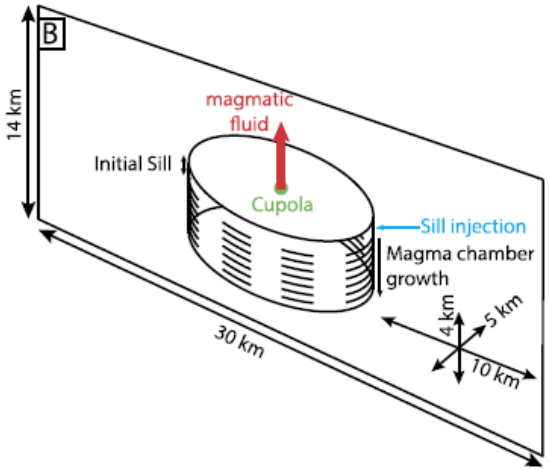
Potential application to Krafla Magma Testbed

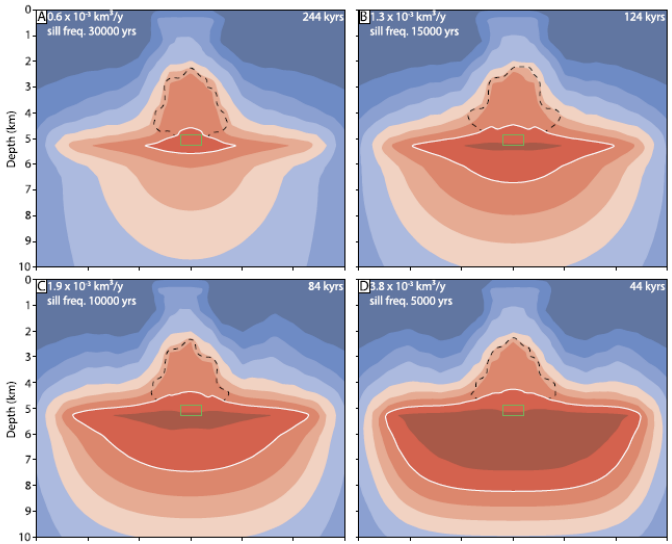


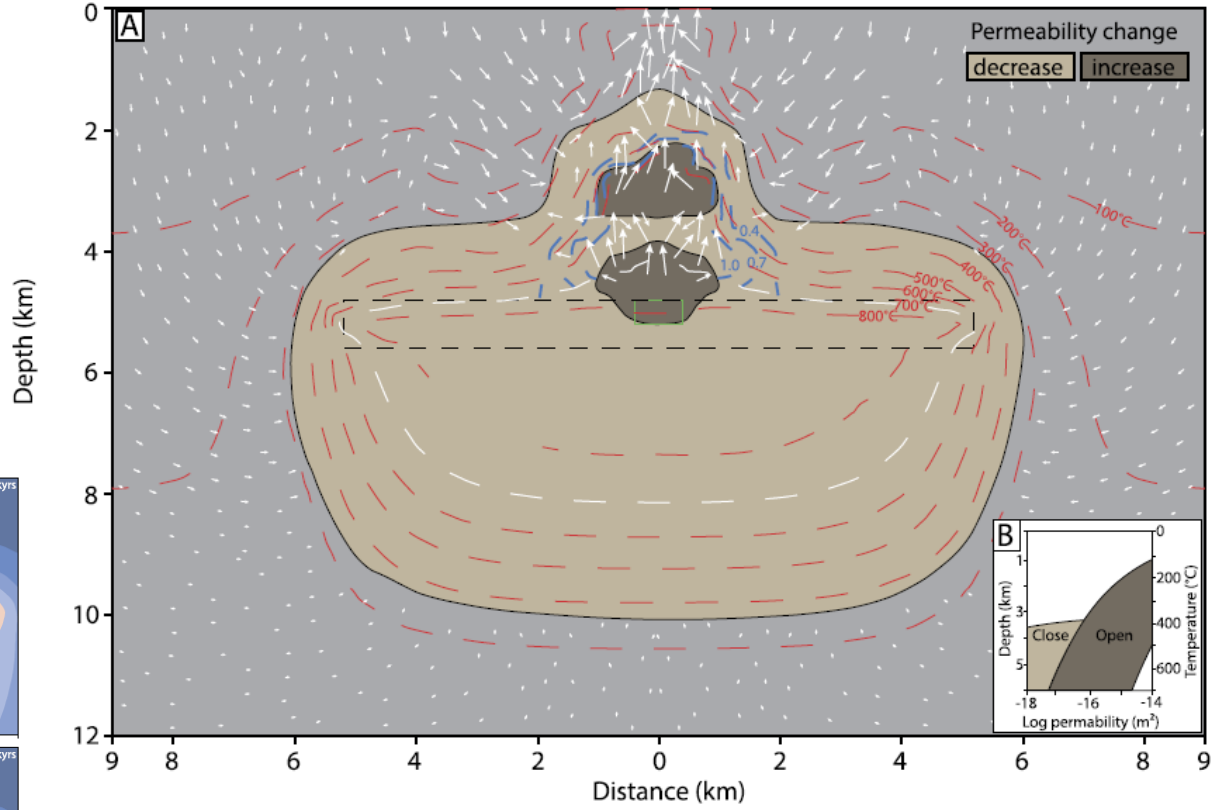


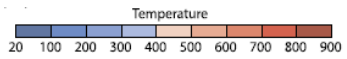
Eichelberger et al. (2018)

Incremental magma growth





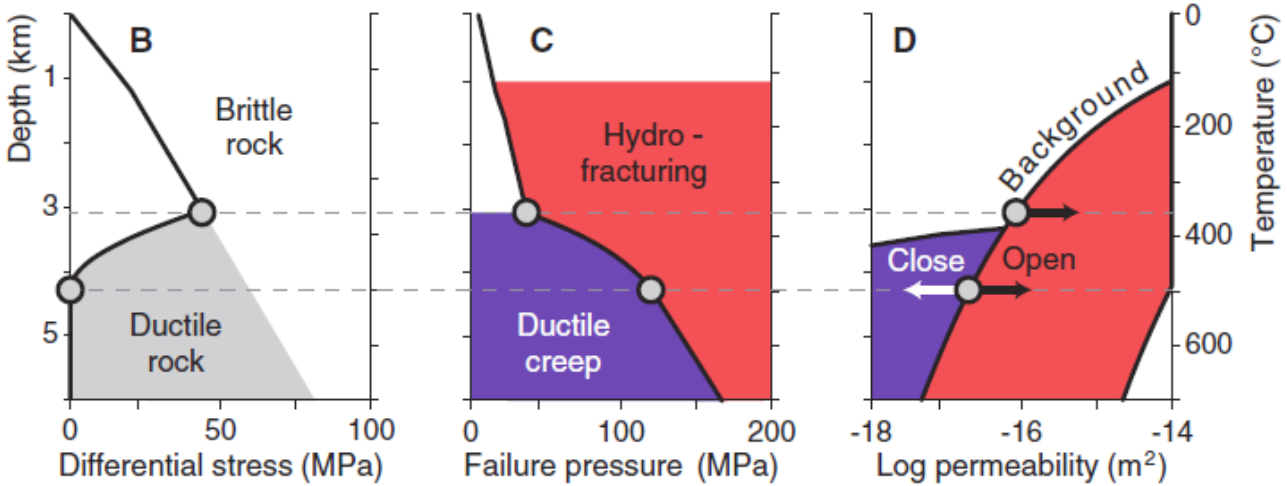


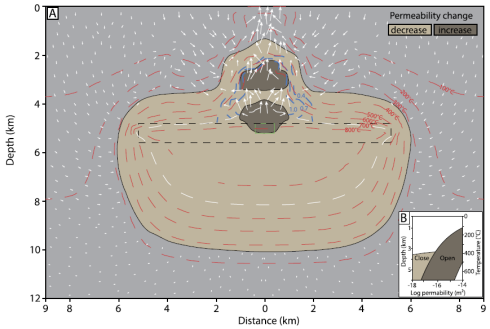


Korges et al. (*EPSL*, 2020)

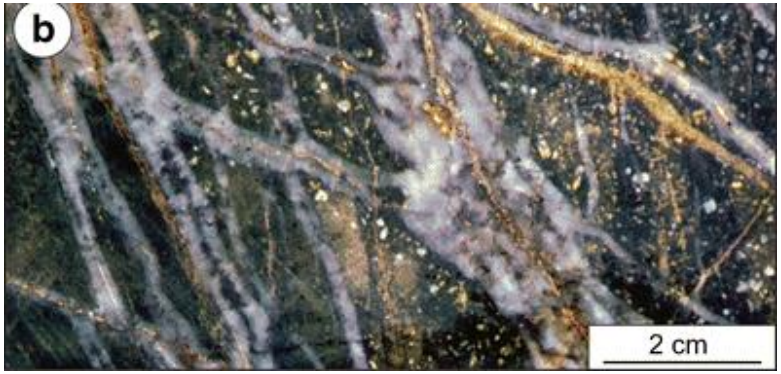
Injection into nominally ductile rocks

- Dynamic permeability creation by hydraulic fracturing





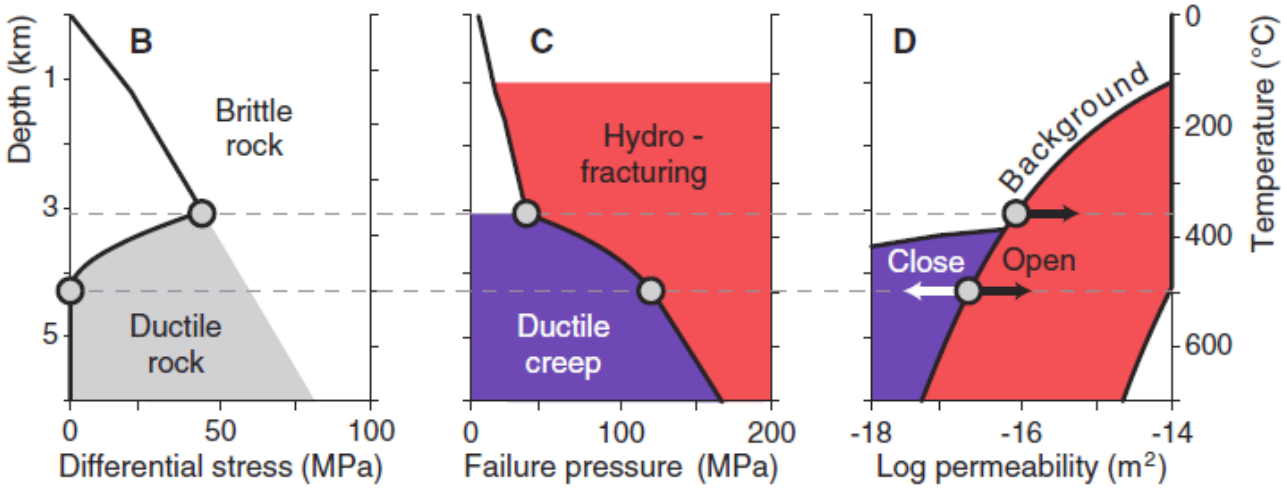
vein generations in porphyry Cu deposits

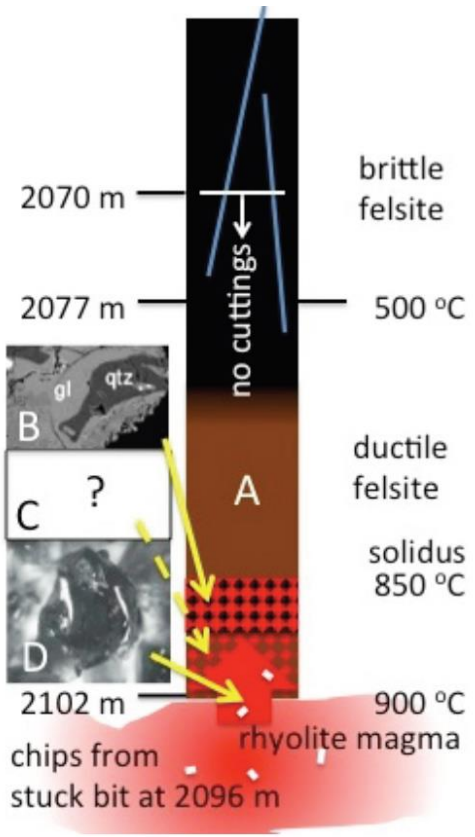


Weis et al. (*Science*, 2012),
Müller et al. (*Min. Dep.*, 2010)

Injection into nominally ductile rocks

- Dynamic permeability creation by hydraulic fracturing





Collaboration with S. Scott (Uni Iceland) and A. Yapparova (ETH)

- Revise permeability model for deep geothermal applications
- Add well model functionality
- Potential future application to KMT

Challenges and unknowns

- Existing modelling functionalities
  - magma flow and injection
  - fluid flow and injection
  - dynamic permeability evolution (BDT, hydrofracturing)

- Challenges and unknowns
  - Realistic material properties and behavior (magma, fluid, rock)
  - Realistic geological setting in time and space (magma reservoir, permeability structure, stresses and strains)
  - Improve functionality for fluid-rock interactions (physical, chemical) and magma evolution

- Research questions
  - Understand permeability evolution at brittle-ductile transition
  - Understand mass and heat fluxes at magma-hydrothermal interface
  - Understand how magma reservoirs form and evolve

Thank you