

FROM ROCKS TO ROASTS: ADAPTING PORE-SCALE IMAGING AND MULTIPHASE FLOW PHYSICS TO OPTIMIZE COFFEE EXTRACTION

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Motivation

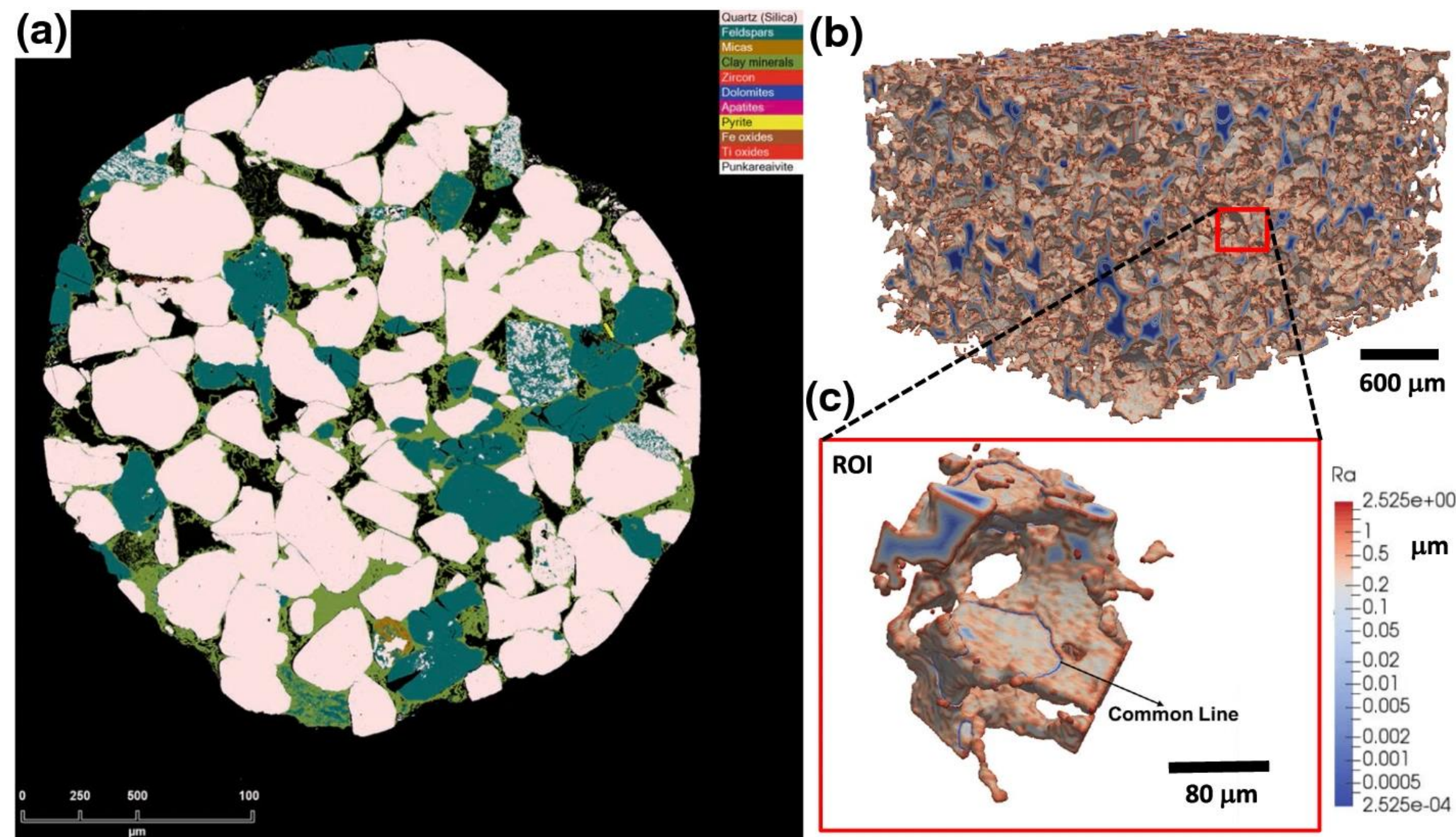
Problem. Extraction is driven by unseen pores; we mostly guess.

Gap. Macroscopic measurements miss channelling, CO₂ release and local dissolution.

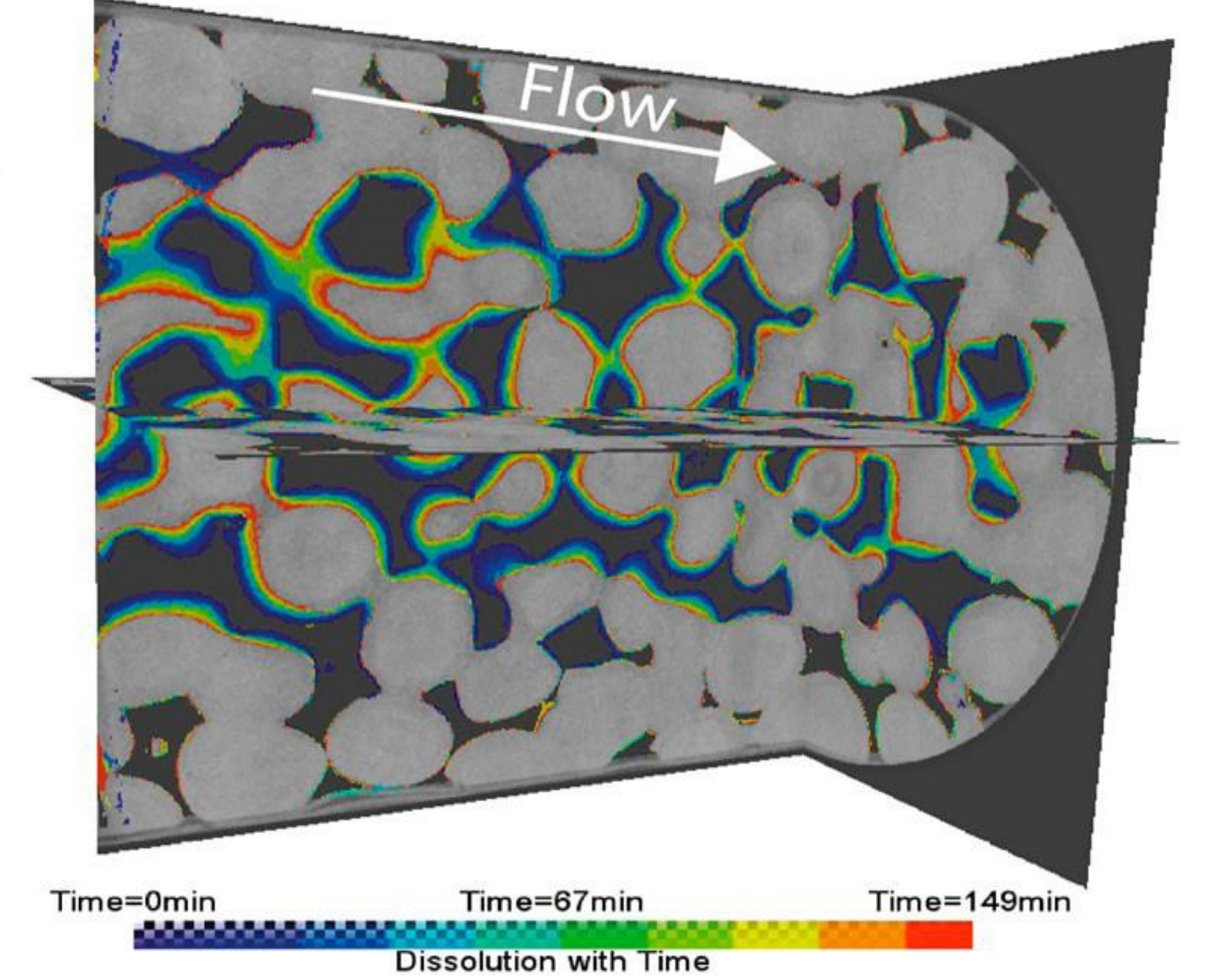
Opportunity. 4-D imaging + pore-scale flow models reveal what the puck is actually doing.

Impact. Optimise grind, puck prep and flow to maximise flavour and minimise waste/energy.

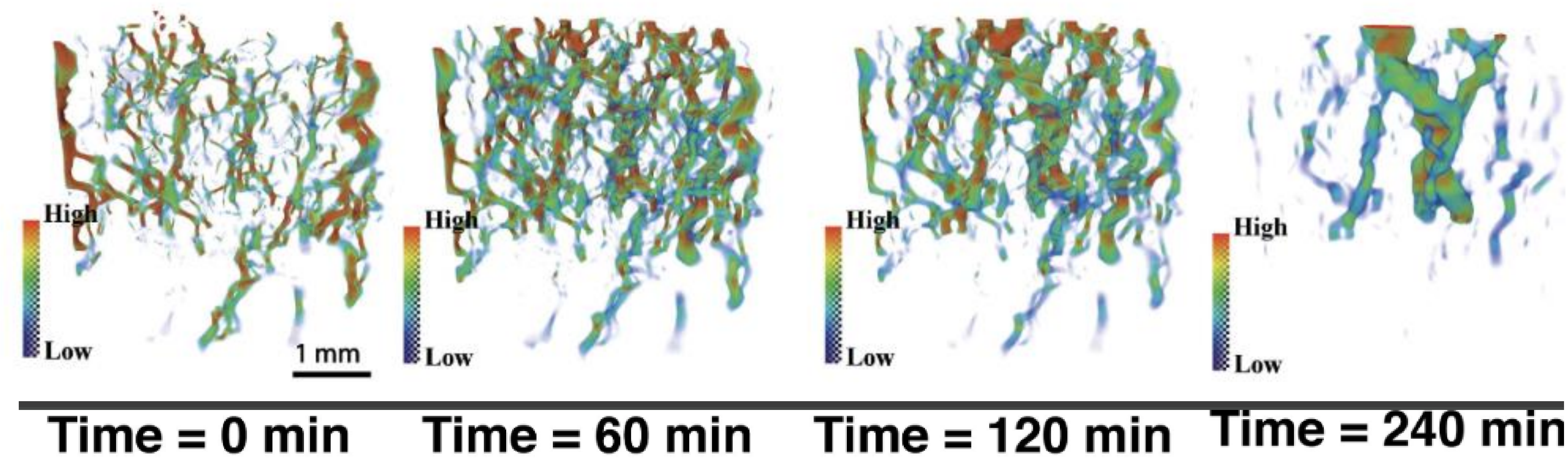
What is X-ray micro computed tomography and in situ imaging??



- *In situ* X-ray imaging lets us watch a porous microstructure and fluids in 3D, in real time, under high pressure and temperature non-destructively.
- We can directly measure porosity/packing, wetting fronts and channelling, CO₂ nucleation/release, and solute transport—non-destructively.
- These become actionable metrics (permeability, uniformity, dispersion) that link to grind distribution, puck density and flow waveform for more flavour with less waste.

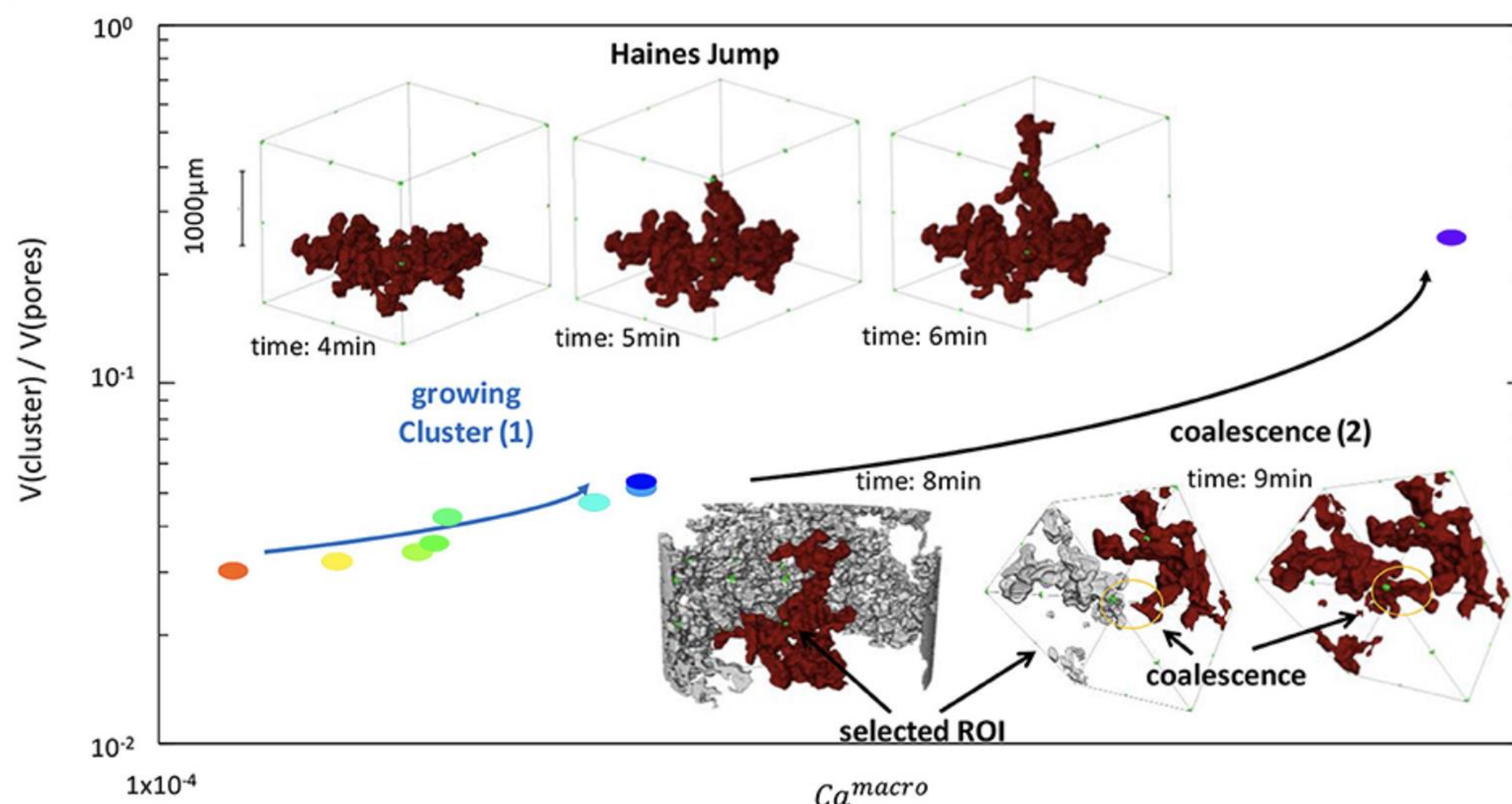


Time-resolved Imaging of solids dissolution



Take-away: small initial differences in flow lead to large pathways opening and reaction focussing (channelling!) at later times

Imaging of multiphase flow displacement events



Take-away: multiple phases in the pores can move, break apart, coalesce and block fluid pathways, changing overall flow behaviour.

Our Questions for YOU:

What should we image first?

- Which *extraction failure modes* hurt you most: channelling, uneven wetting, CO₂ bursts, fines migration?
- Beans, grounds, or puck *in situ*—where would imaging change decisions fastest?

When should we look?

- Pre-brew vs first 10 s vs peak flow—*when* does most damage/benefit happen?
- How does *post-roast age/degassing* alter pore structure and flow?

What outputs are useful?

- If we give you maps of “where water goes” and “where solubles stay,” what *dial* will you turn?
- Which single metric would you adopt tomorrow? (e.g., “channelling index,” “CO₂ release rate,” “wetting uniformity,” “in-bed dispersion length”)

Collaboration ask:

- How can we work with you to improve our understanding of coffee extraction?