

A grayscale micrograph of dolostone showing a complex network of fractures and porosity. The image displays a dense, interconnected pattern of mineral grains with various shapes and sizes, some appearing as bright, angular fragments. A prominent, dark, irregular fracture system cuts through the mineral grains, creating a network of interconnected voids and channels. The overall texture is highly porous and fractured.

Predicting Fracture and Porosity Evolution in Dolostone

Julia F. W. Gale¹, Robert H. Lander² & Robert M. Reed¹

1 Bureau of Economic Geology, Jackson School of Geosciences

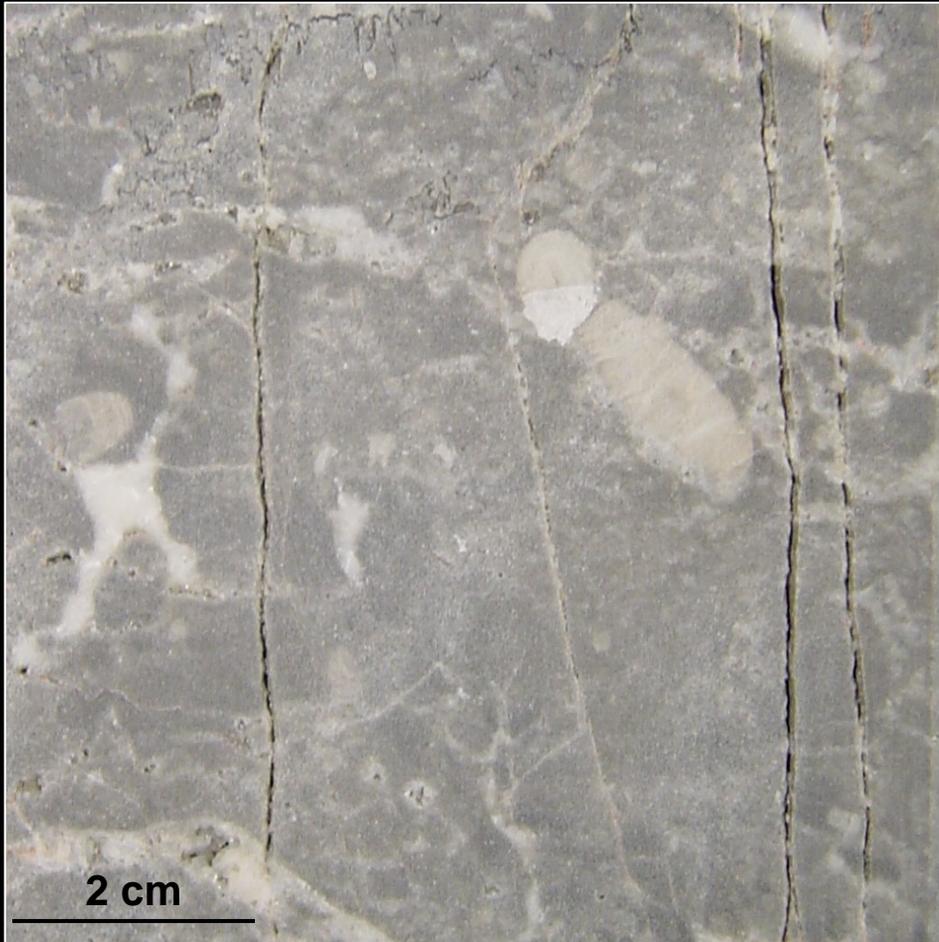
2 Geocosm LLC

200 μm

Outline

- Motivation
- Background
 - Fracture sealing and fluid flow
 - Hypothesis
- Modeling fracture sealing in dolostones
- Comparison of model with natural fracture examples (SEM-CL imagery)
- Application
- Conclusions

Motivation



Core sample, Pennsylvanian dolostone, NM

Understanding fluid flow
in carbonate reservoirs

Fractures important

How do fractures seal?

**How does sealing affect
fluid flow?**

Are Fractures Open?

Two processes seal fractures

1. During fracture opening



Crack-seal in synkinematic cement

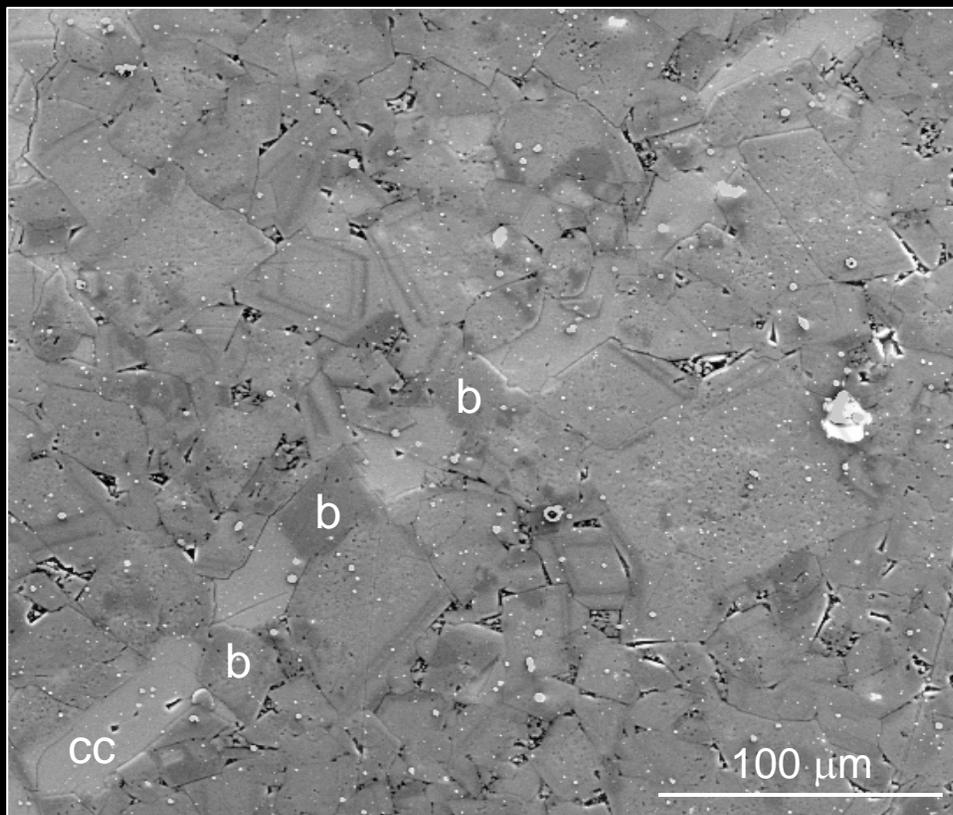
2. After fracture opening



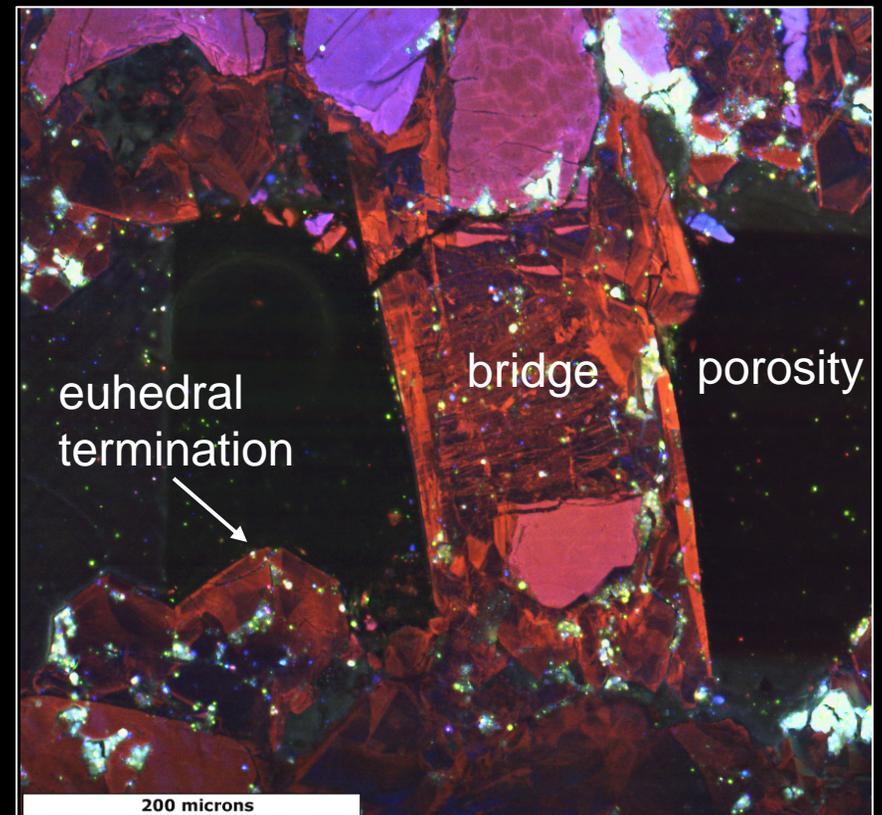
Postkinematic cement

Hypothesis

Dolomite and quartz cement structures in fractures form due to equivalent processes



Ordovician Knox Group dolostone



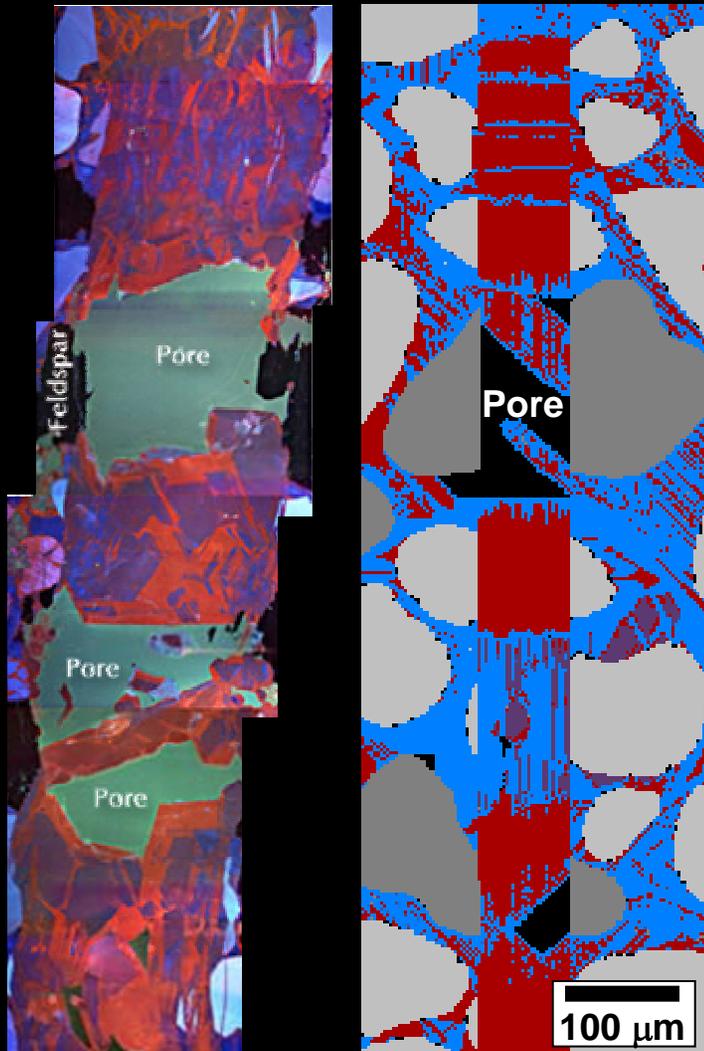
Cretaceous Travis Peak sandstone

Testing the hypothesis

Modeling and Observation

- Model dolomite growth in fractured dolostones using same approach as for fractured sandstones
- Characterize dolomite cement structures in fractures with:
 - Scanning Electron Microscope Cathodoluminescence (SEM-CL),
 - Backscattered Electron (BSE),
 - Secondary Electron images (SEI).

Comparison of Color CL and Modeled Textures in Quartz “PRISM”



Controls on pore occurrence

- Grains in wall rock
- Rate of opening vs rate of cement growth
- Cement growth rate is faster on broken non-euhedral surfaces
 - Creation of non-euhedral surfaces through crack-seal
- Crystallographic orientation of wall-rock grains

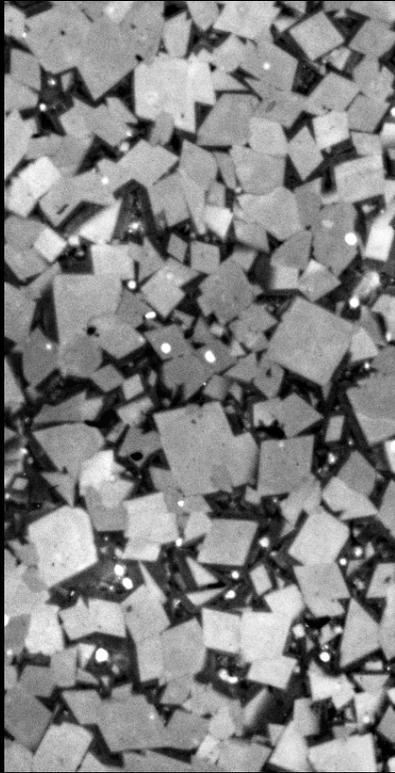
Modeling Approach

- Modification of cellular automaton PRISM model for dolomite (RHOMBO)
- Use template of dolostone
- Use crystal and growth rate modes to extract insights into growth patterns

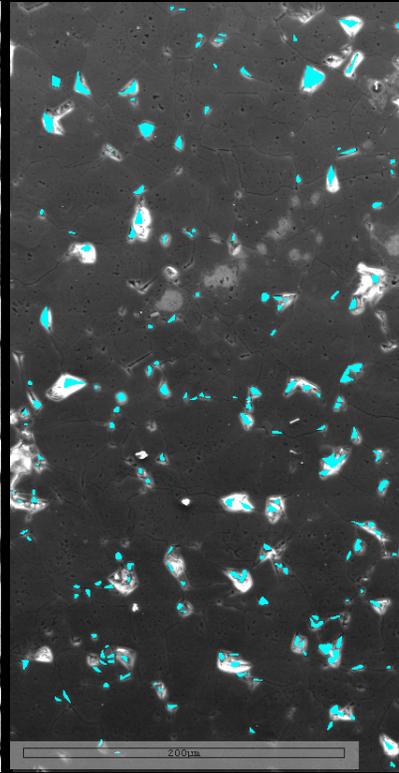
Assumptions in Model

- Dolomite grains in host assigned crystallographic orientations
- Dolomite cement grows in crystallographic continuity with grains in wall rock
- Equivalent growth rates along rhomb faces
- 20× precipitation rate reduction after formation of euhedral crystal surface
- No change in temperature or degree of supersaturation during course of simulation (assume supersaturated with respect to dolomite)

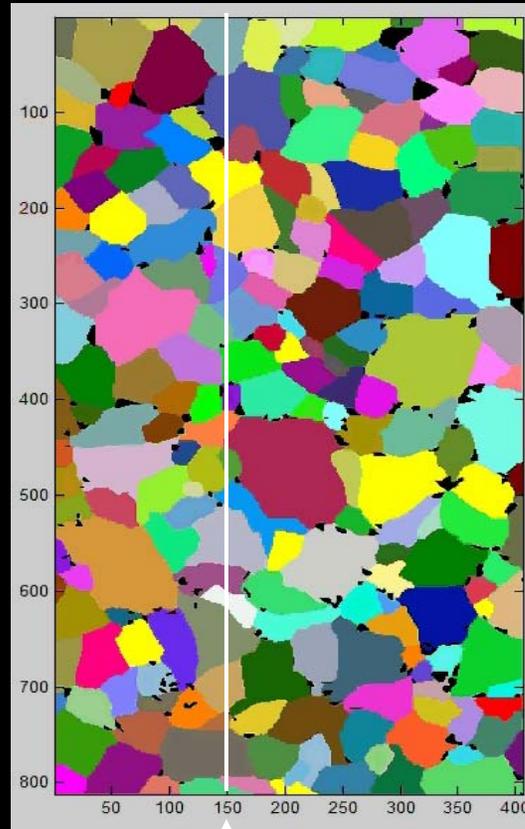
Making the Model Template



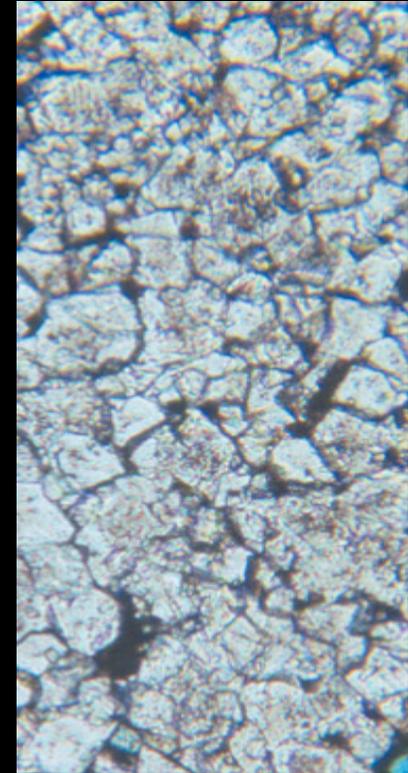
SEM-CL



SEI
Porosity



Model template
Fracture introduced



Grain
boundaries
SEI & PPL

Model Run

Slow opening rate

Fracture every 10 steps

400 steps

Fracturing during steps 1-300

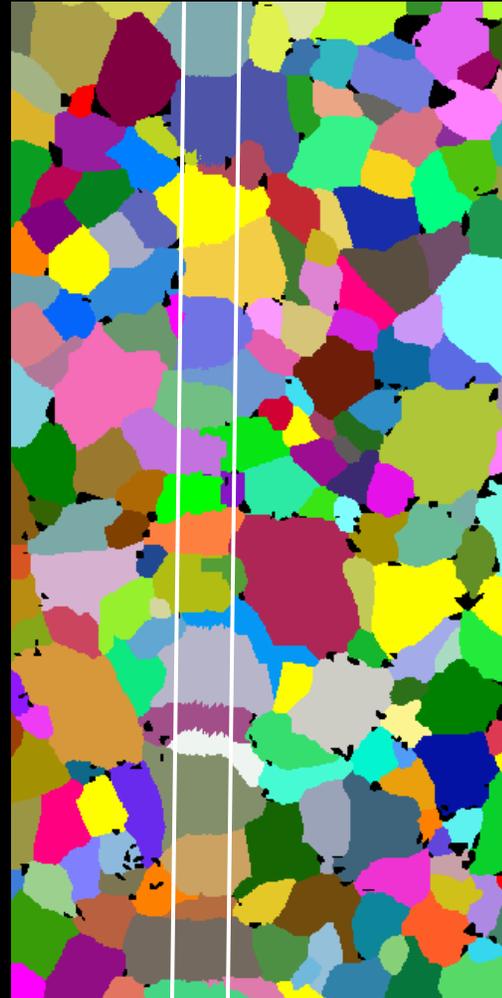
Fracture initiates in model column 150

Result

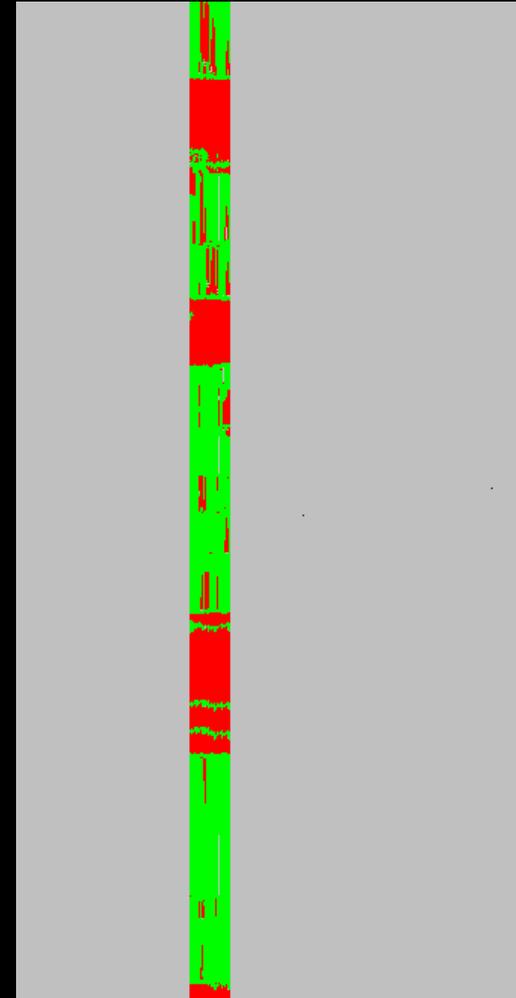
Fracture completely seals

Hard to see

Bands of fast growth



Crystal growth

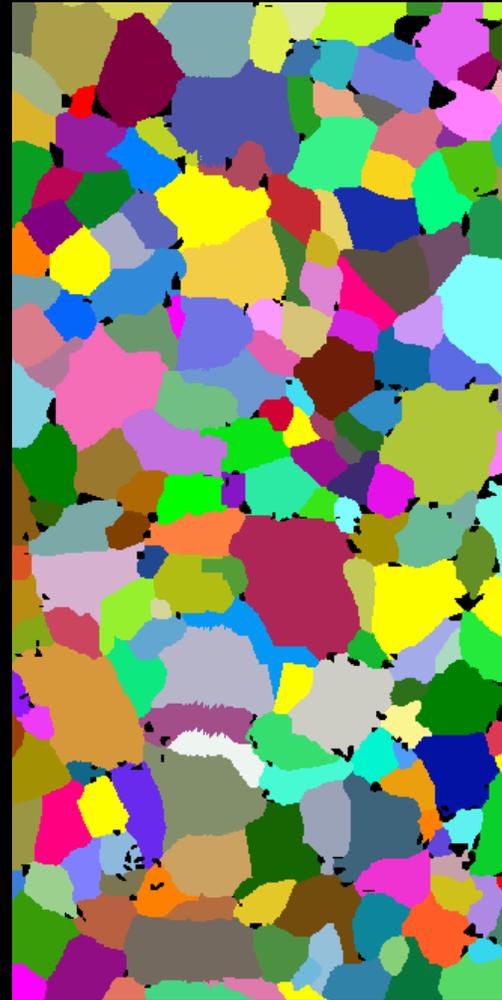


Growth rate

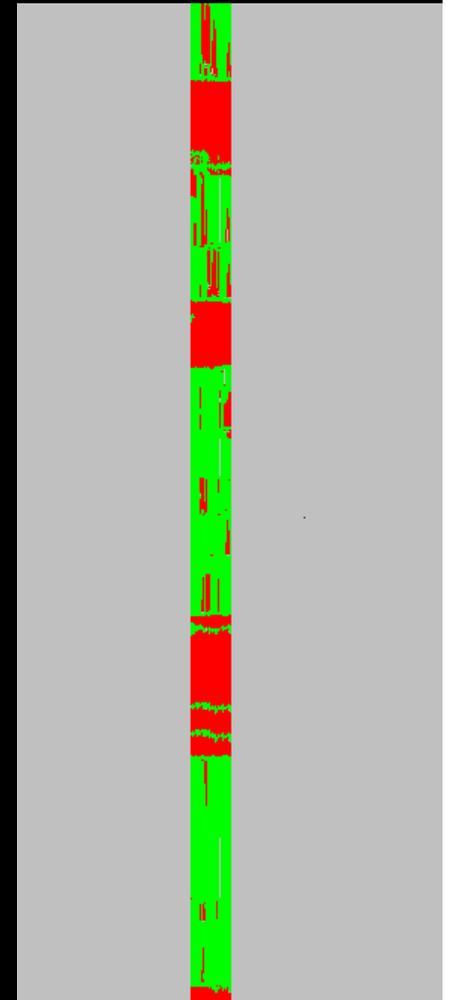
Sealed Fractures



Example, Ellenburger



Crystal growth



Growth rate

Model Run

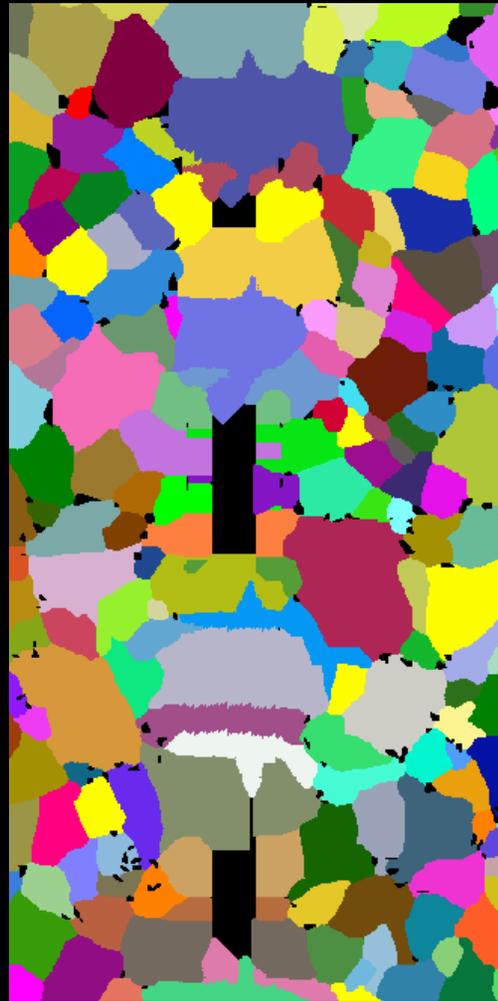
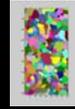
Moderate
fracture opening rate

Fracture every 4 steps

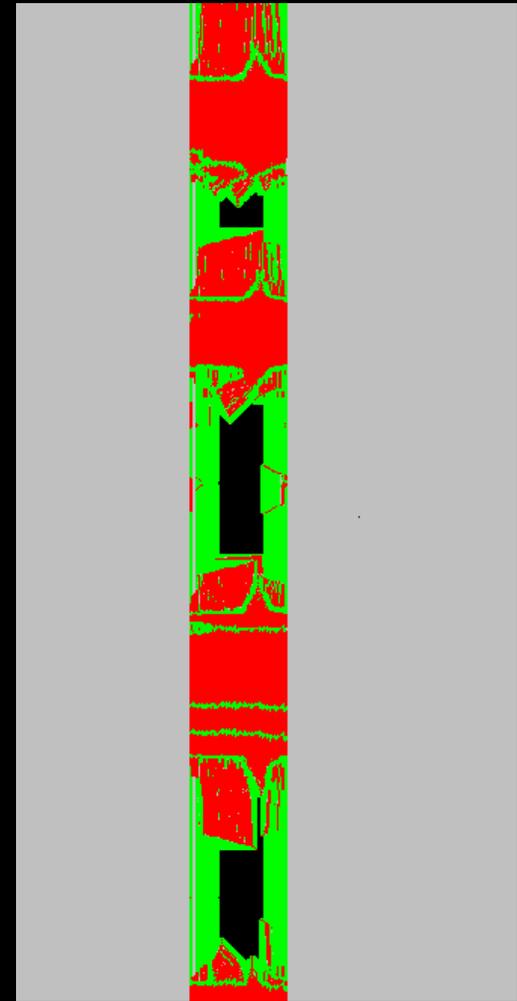
Result

Multiple-grain bridges
(fast growth)

Fracture linings
(slow growth)



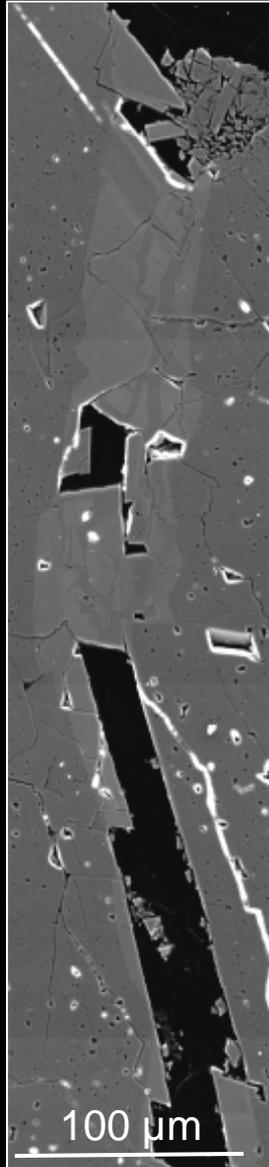
Fracture growth



Growth rate

Bridges and Pore Space

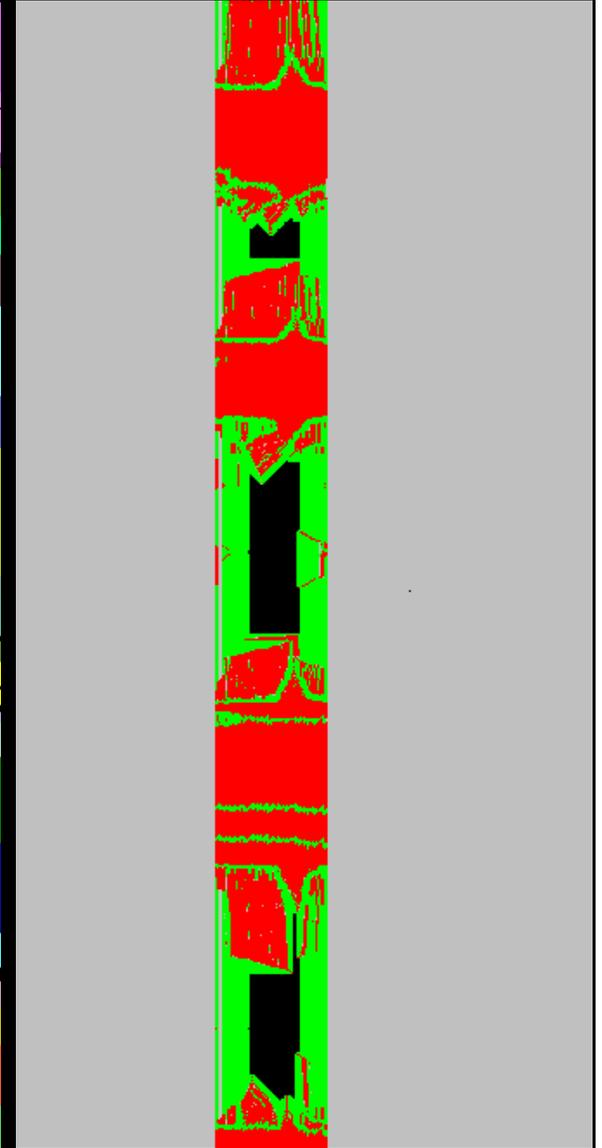
Grain orientation control



SEI



CL



Model Run

Fast opening rate

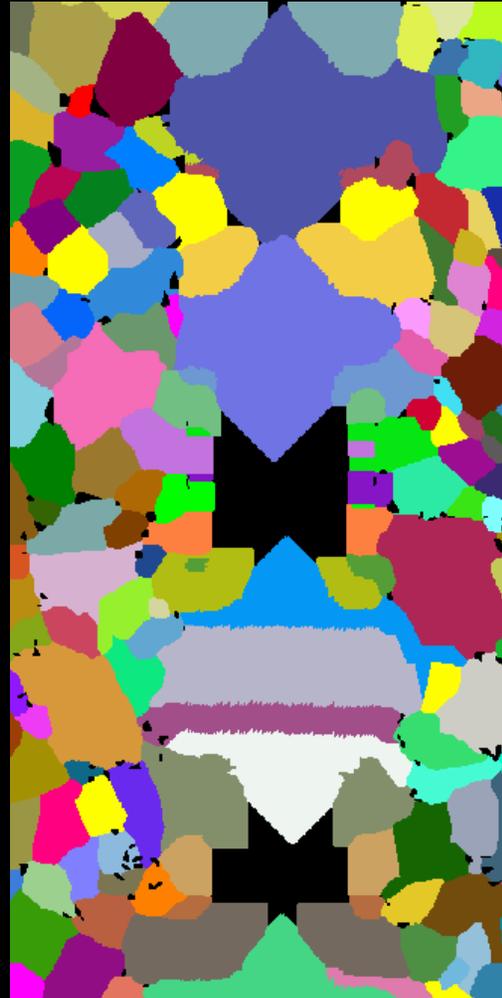
Fracture every other step

Result

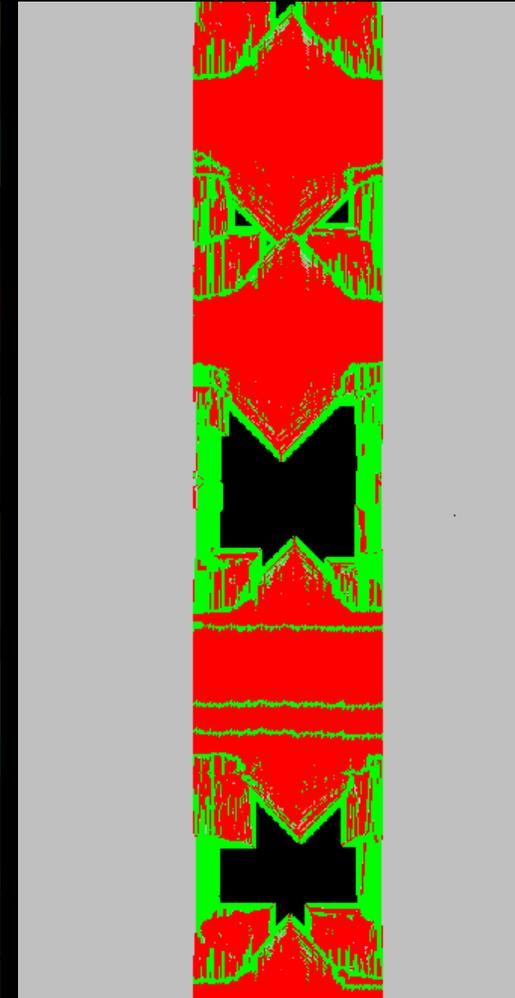
Multiple grain bridges with rhombic geometry

Fracture linings

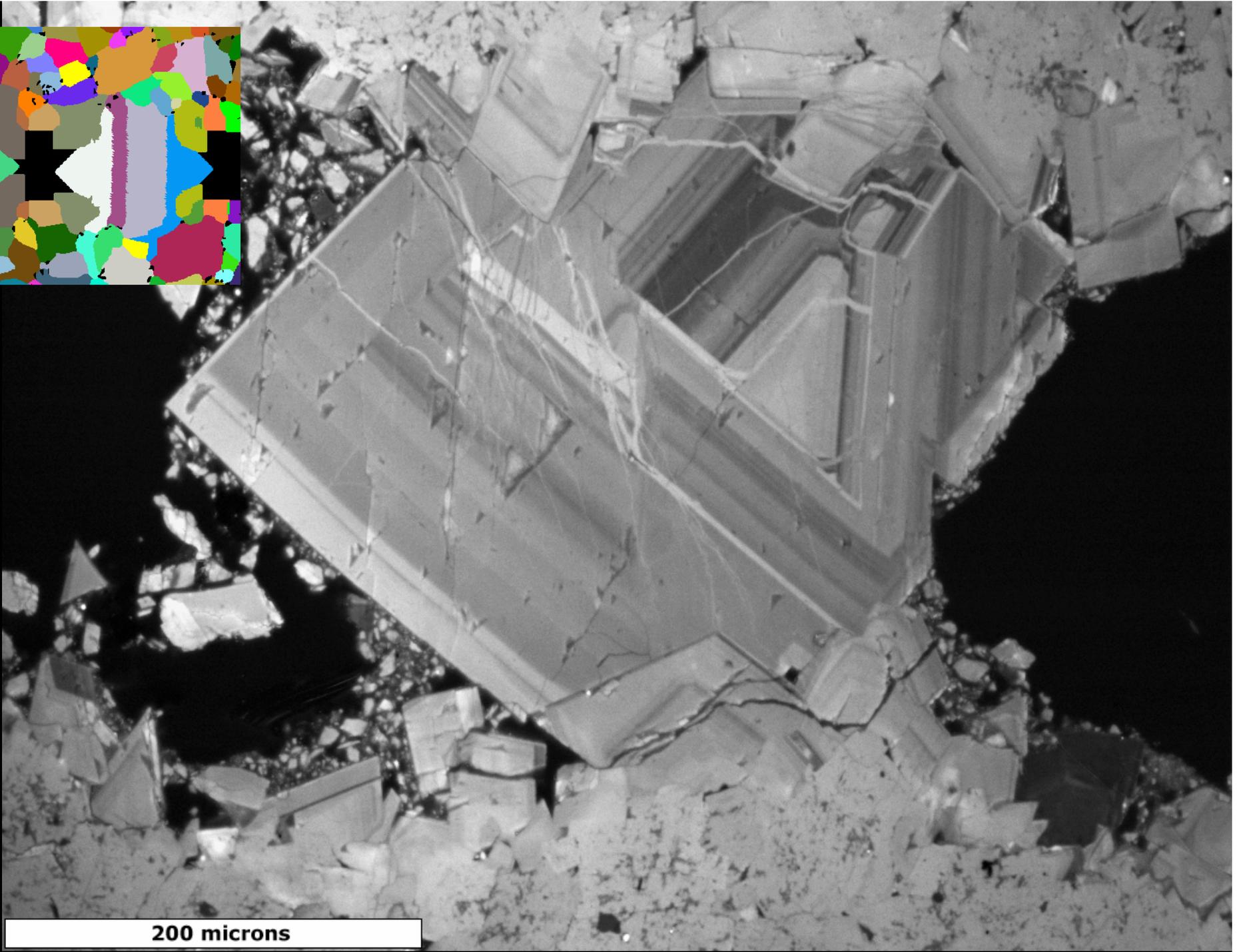
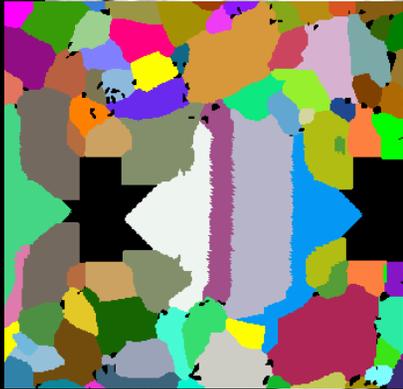
Suppression of slower-growing grains



Crystal growth



Growth rate



200 microns

Model Run

Very fast opening rate

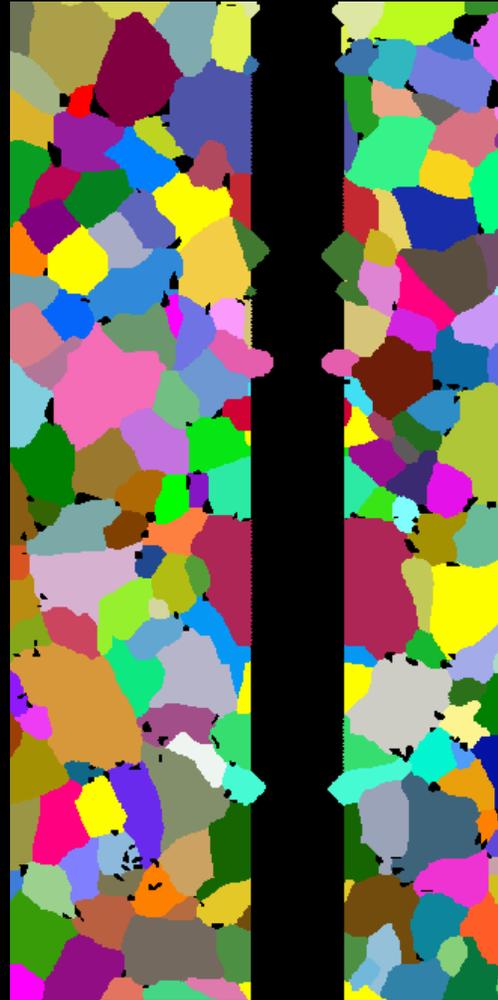
Fracture every step

Result

No bridges

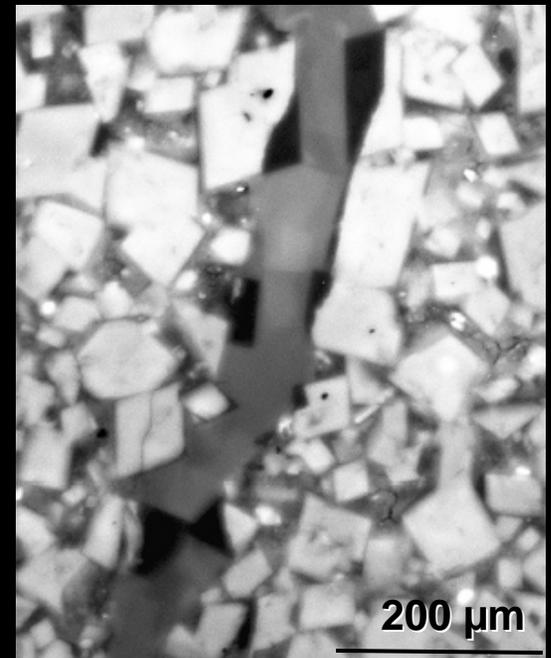
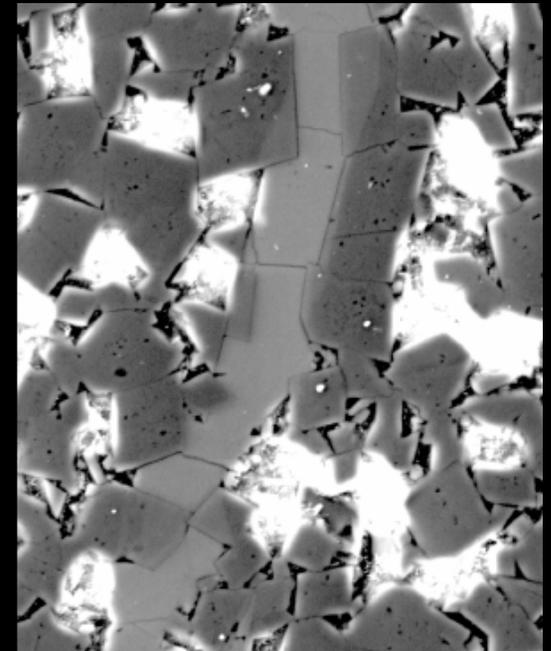
Fast grains terminate

Open, lined fracture



Crystal growth

Example, Ellenburger



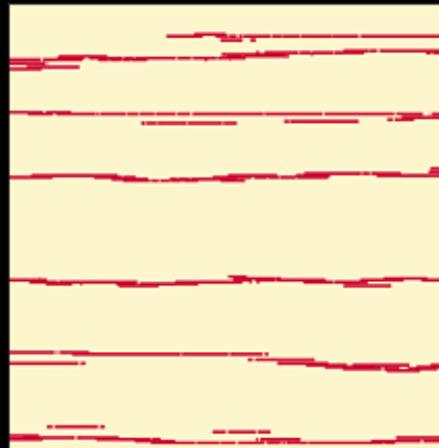
200 μm

Application

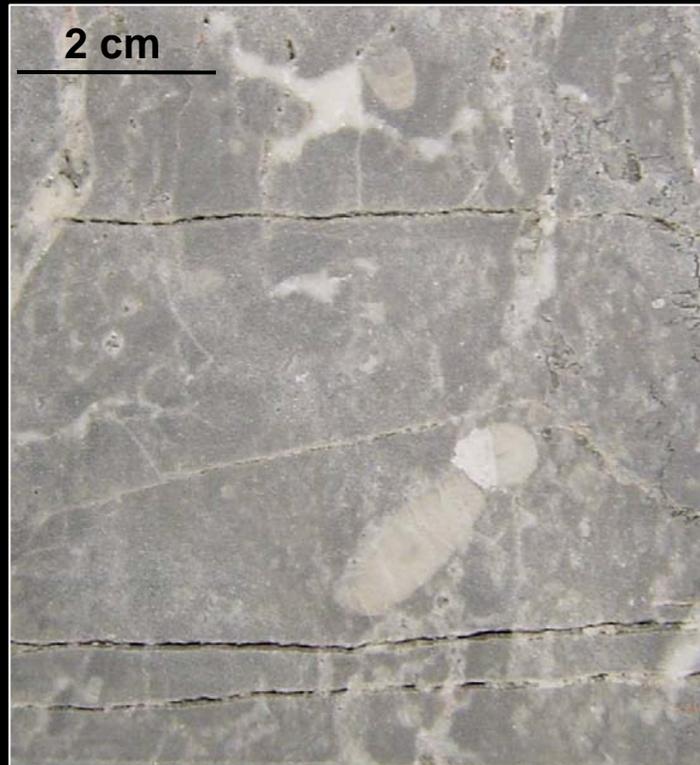
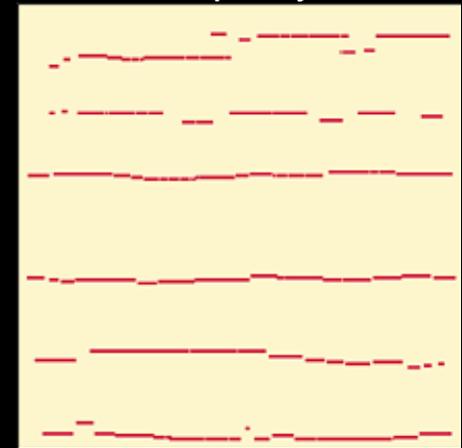
How do fractures seal? How does sealing affect flow?

Geomechanical models

No cement

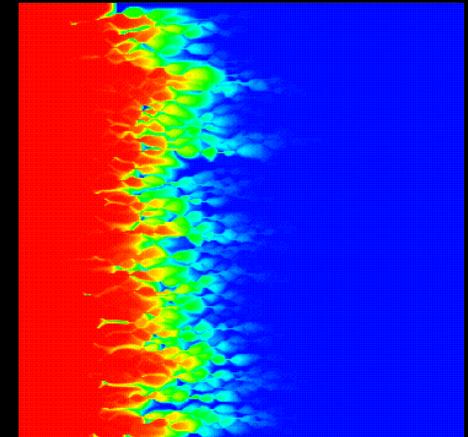
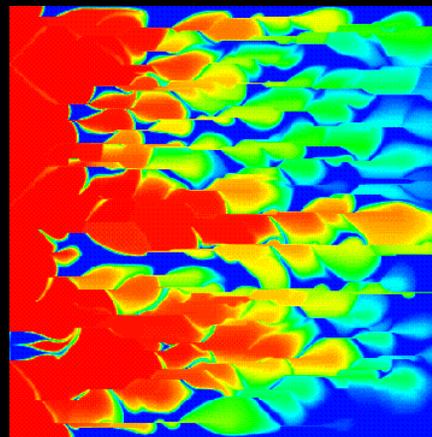


Fractures partly sealed



Pennsylvanian dolostone, NM

Flow simulation



Conclusions

- Fracture sealing mechanisms for dolostones and sandstones are similar
- Simple geometric modeling is useful for interpreting dolomite cement growth in fractured dolostones
- Models give similar structures to those observed with SEM-CL
- Opening rate vs growth rate governs open vs sealed fractures
- Relative rate of growth on non-euhedral vs euhedral surfaces governs formation of bridges or pores
- Bridges are characteristically rhombohedral with “noses” normal to fracture wall
- Sealing patterns, if incorporated into fracture models and flow simulators, will help produce more realistic models of fluid flow in fractured carbonate reservoirs