

# Deformation of partially molten rocks at the grain-scale: first results



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## Abstract

Grain boundary migration is one of the most important processes that can change a microstructure under static conditions. The movement of grain boundaries depends on the grain boundary surface energy and mobility. If a liquid phase, like melt, is also present in the aggregate, an order of complexity is added, since above a certain melt fraction (and/or below a certain wetting angle) the melt pockets are interconnected by tubes or channels that allow rapid transport within or out of the aggregate. Under static conditions, i.e. crystallization and annealing, the melt has a defined wetting angle at triple junctions (where two solid grains are in contact with melt).

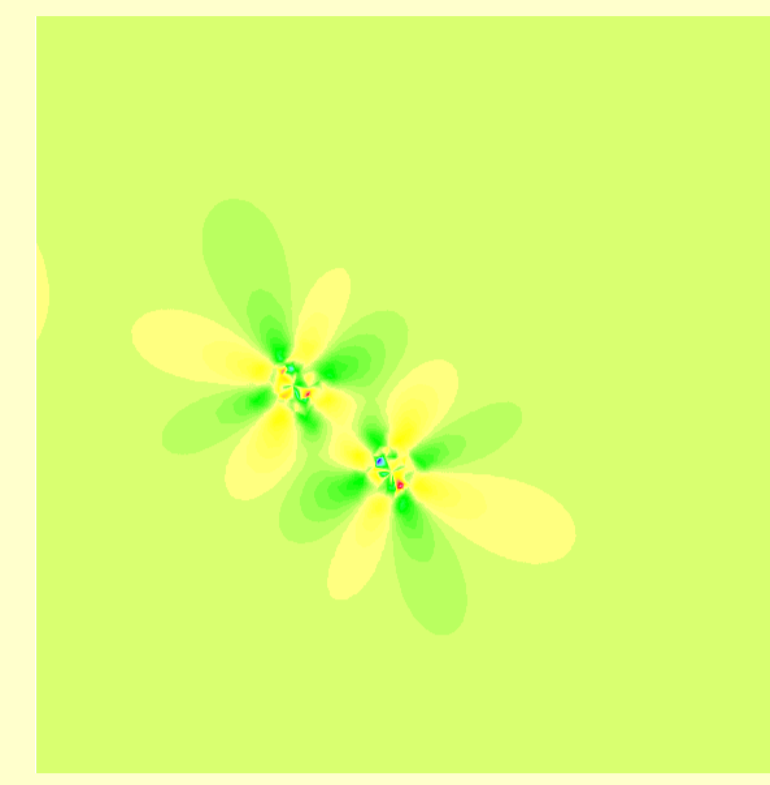
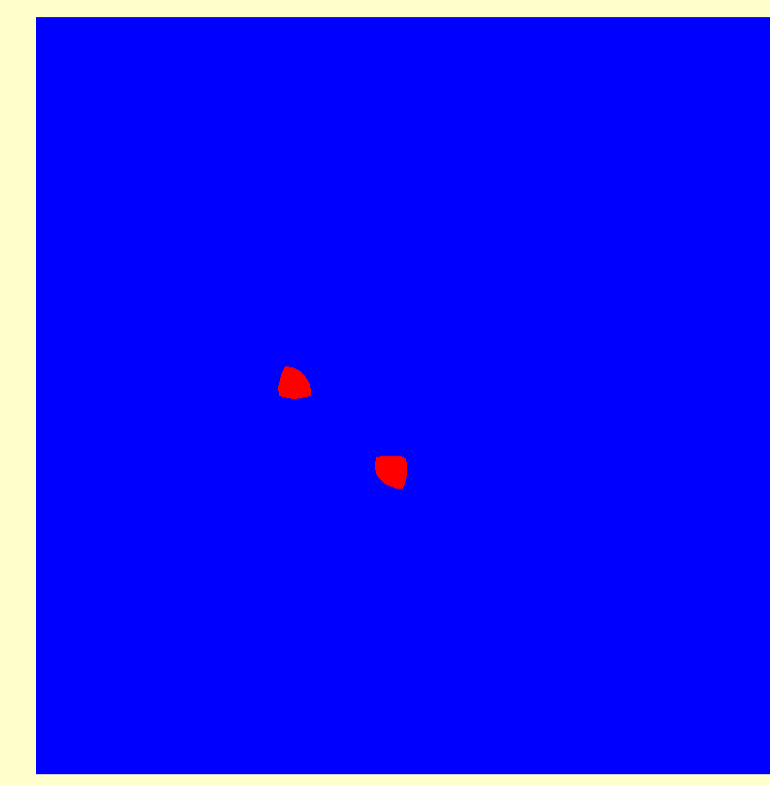
In dynamic conditions such as pure or simple shear of the microstructure, the evolution of the shape of melt pockets obviously is greatly influenced by the stresses acting on the microstructure. However, grain boundary migration and the accompanying change of melt topology still play an important role. This poster shows numerical simulations that have been performed using the numerical simulation package Elle and the finite element code Basil. While grain boundary migration is simulated using Elle (a front-tracking model), Basil simulates the deformation of the microstructure.

The aim of this study is to investigate topology changes of a microstructure and the localization of strain during deformation.

More simulations are available and most of the simulations are available as movies, please ask if you are interested to see them.

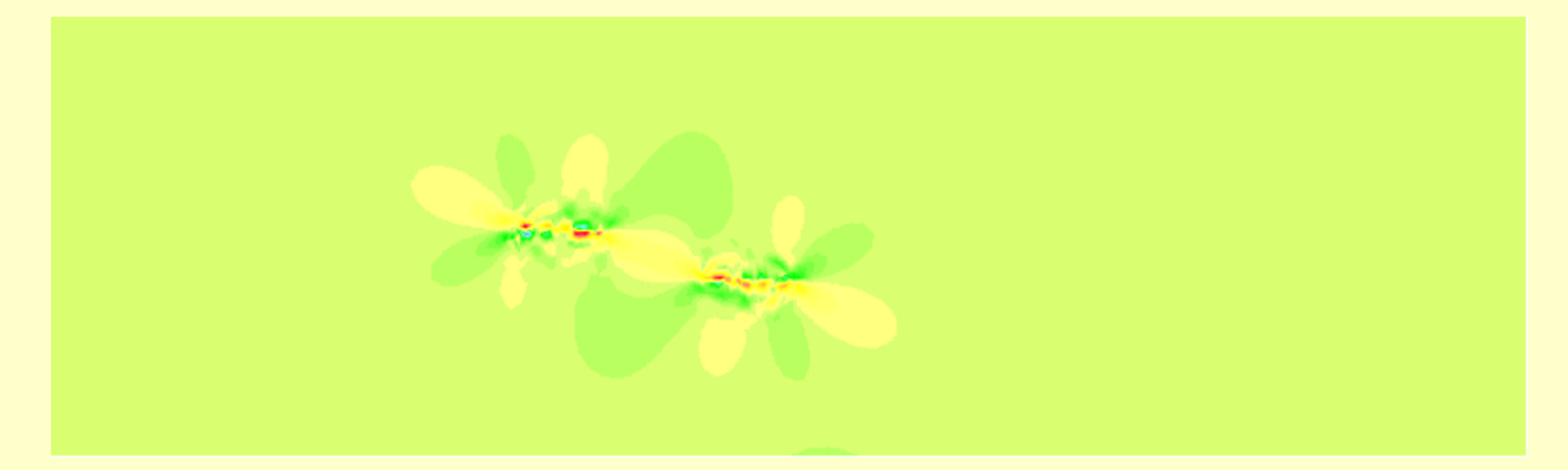
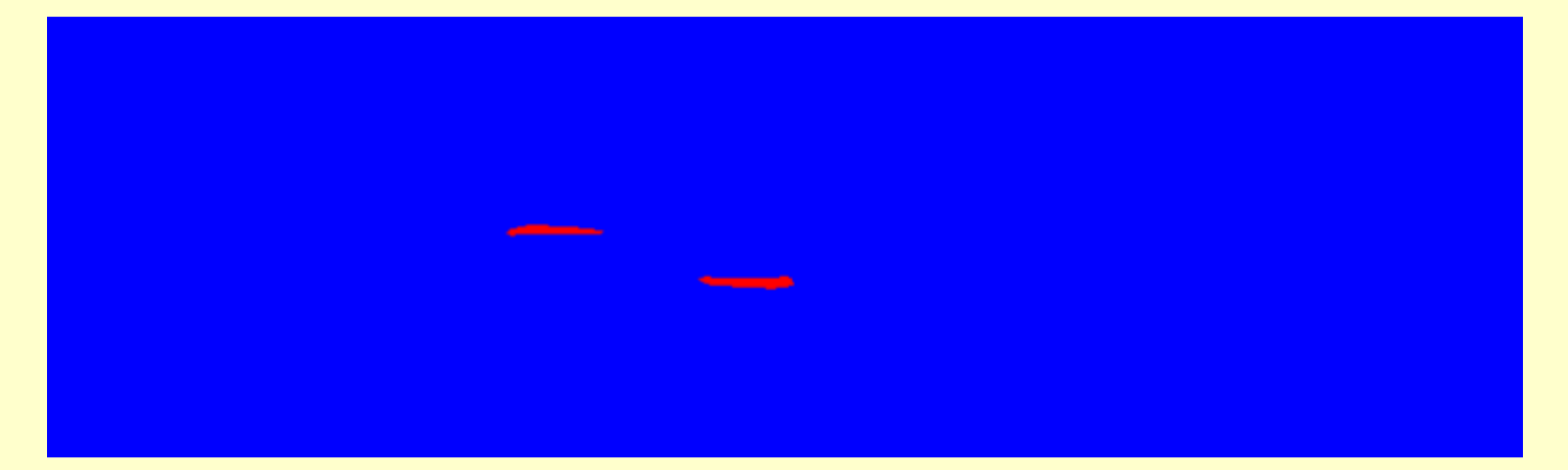
## Acknowledgments

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t=1

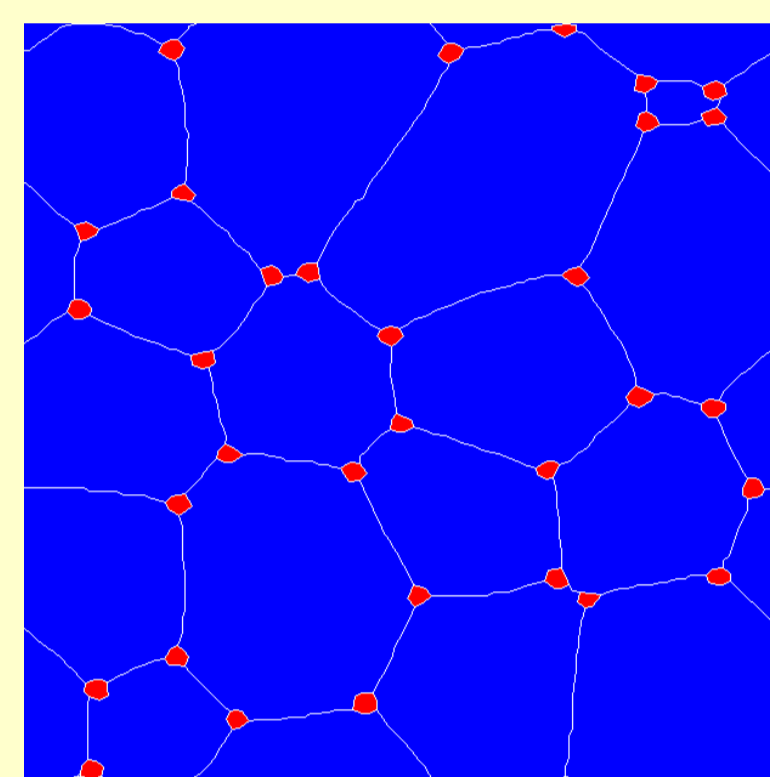
## Strain localization at melt pockets



t=50

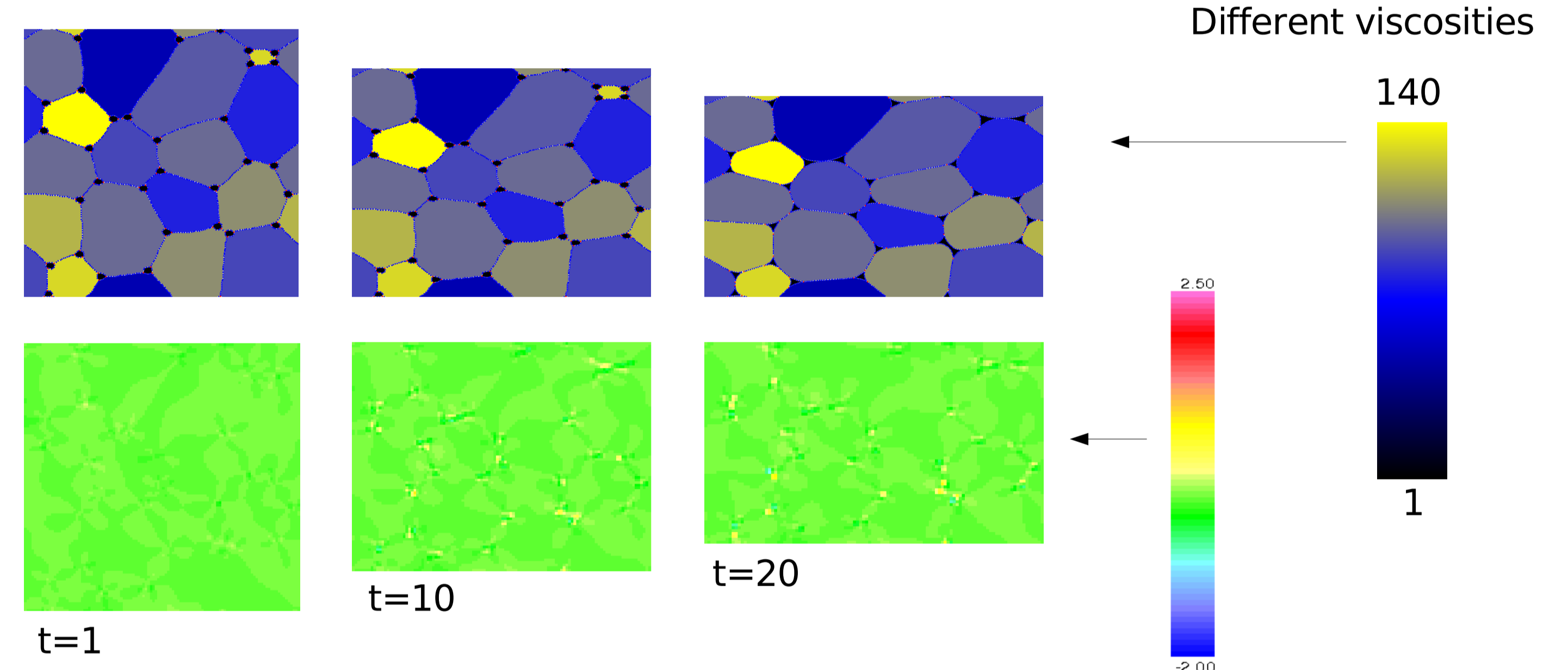
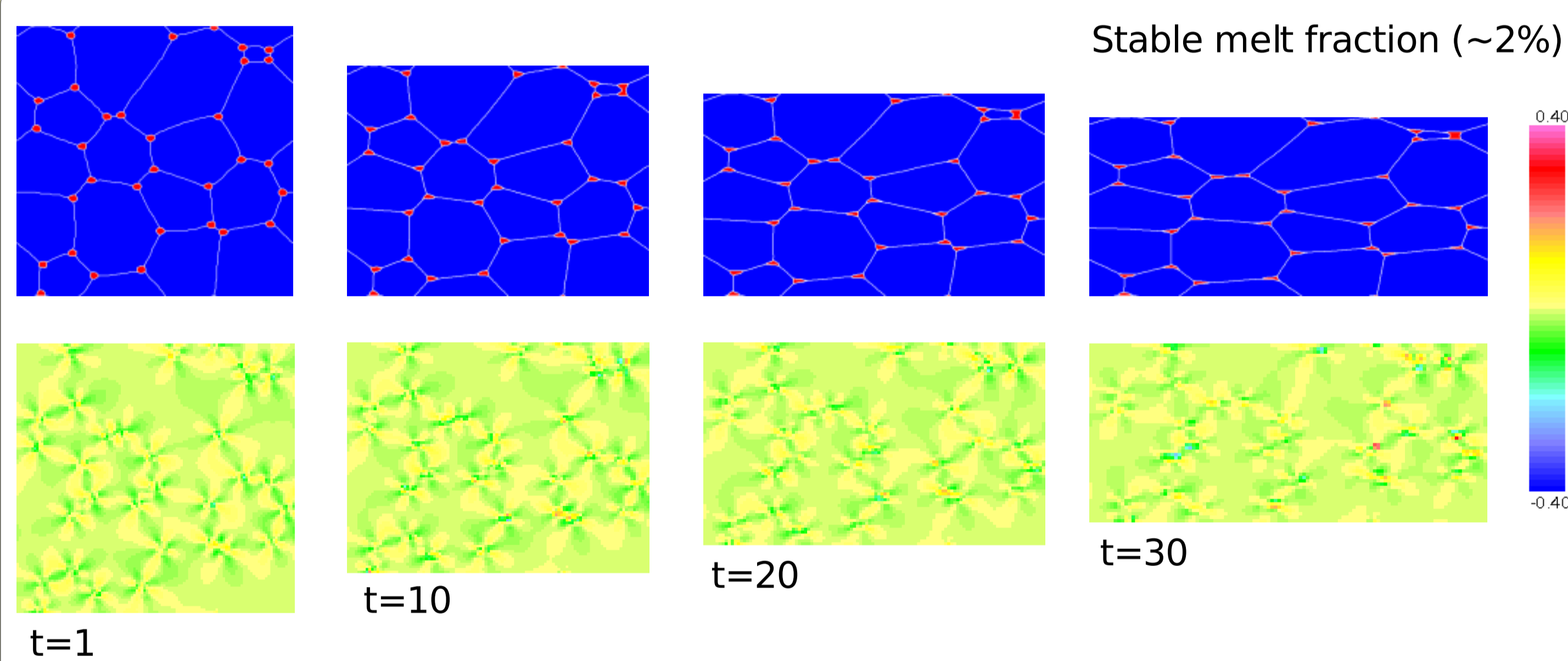
Single Basil run, 0.25% of shortening each step, no grain boundary migration. Viscosity contrast 1:10, wetting angle at t=1 120°

## Starting microfabric for the simulations

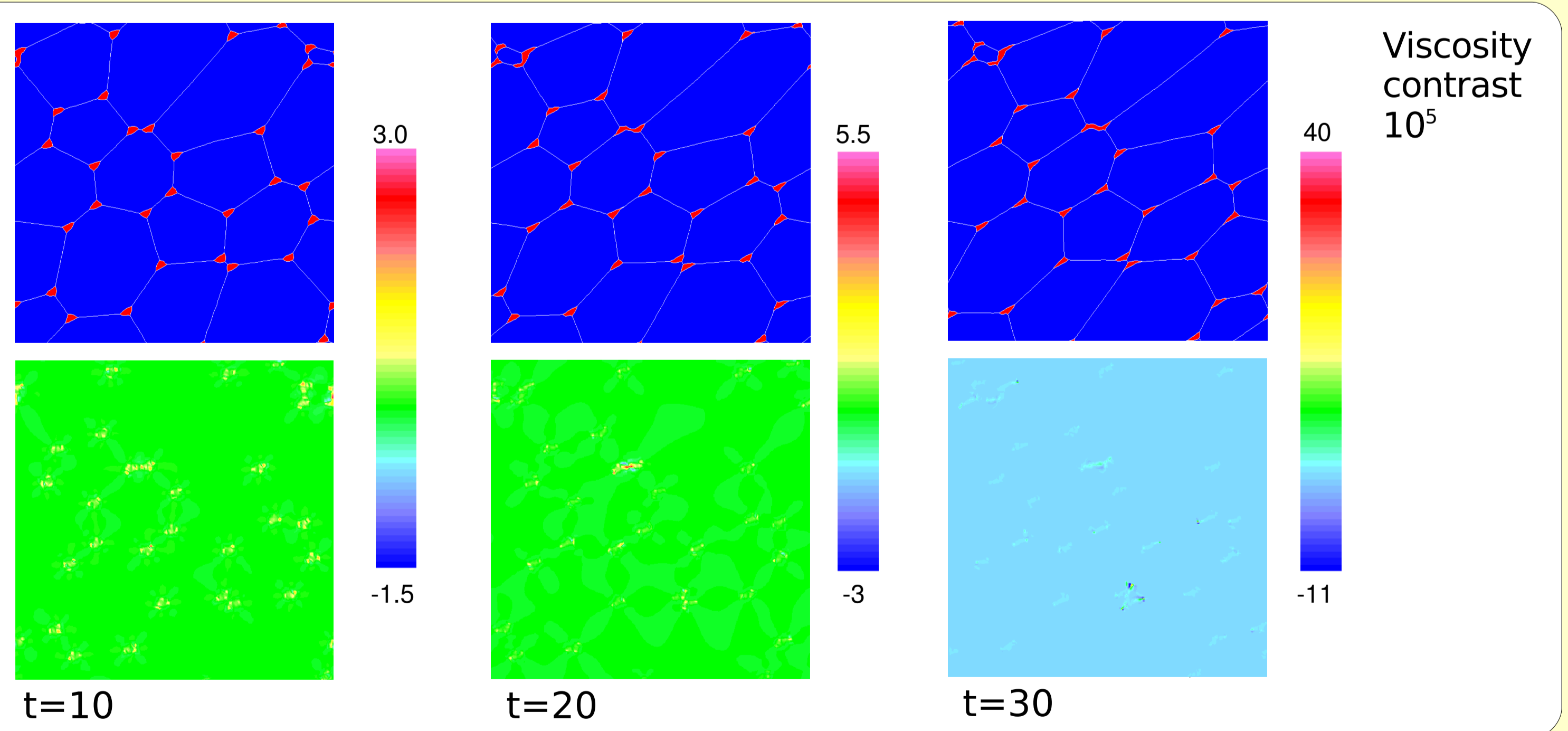
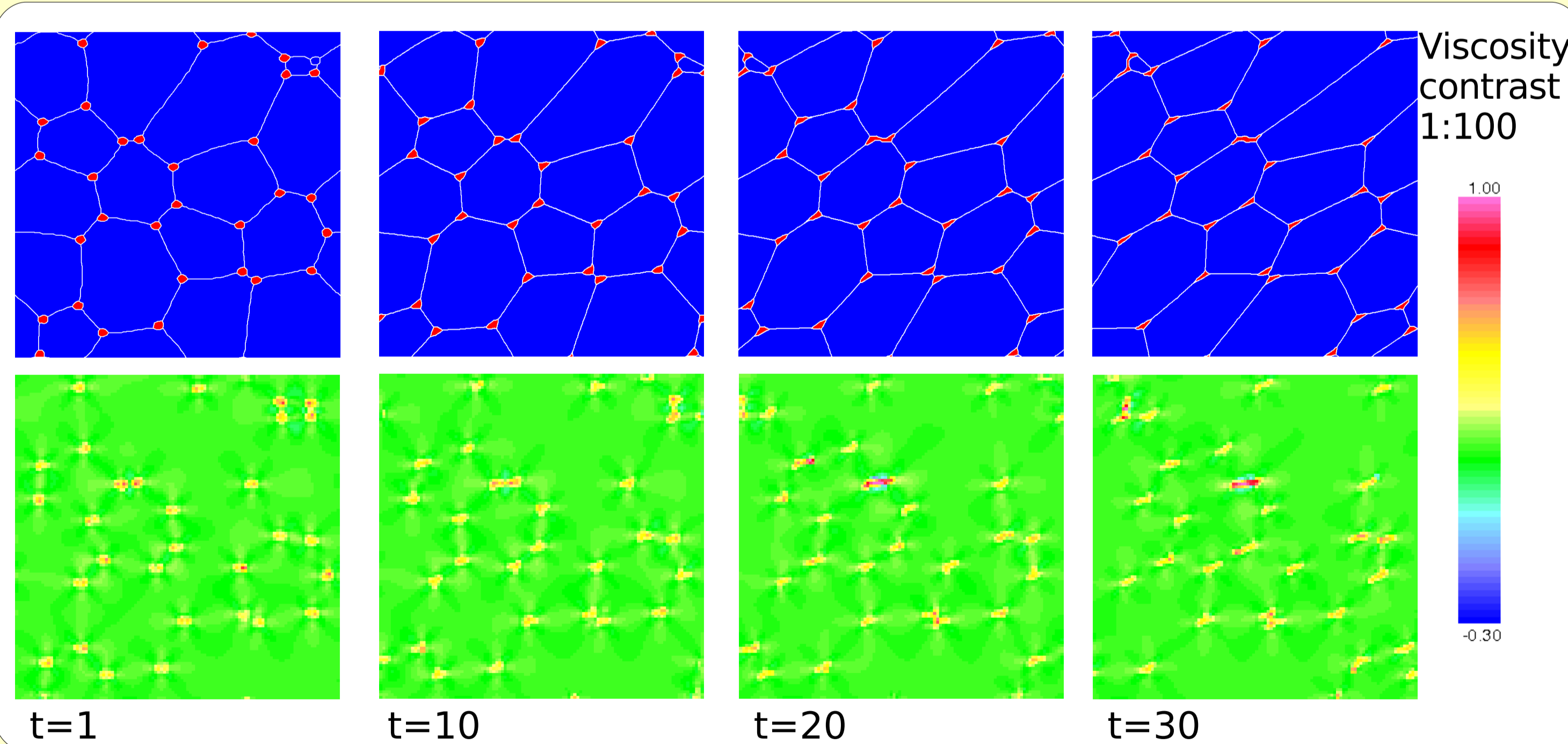


Original starting grain fabric for the numerical simulations presented below. Solid grains (quartz) are in blue, liquid phase (melt) is in red. None of the melt pockets has an equilibrium shape, they are all roughly circular. The melt fraction at the beginning is ~2%, the surface energies of the solid-solid and solid-liquid boundaries have a ratio of 1:0.502 (which reflects a wetting angle of ~10°, 1:0.5 ~2° for example 3).

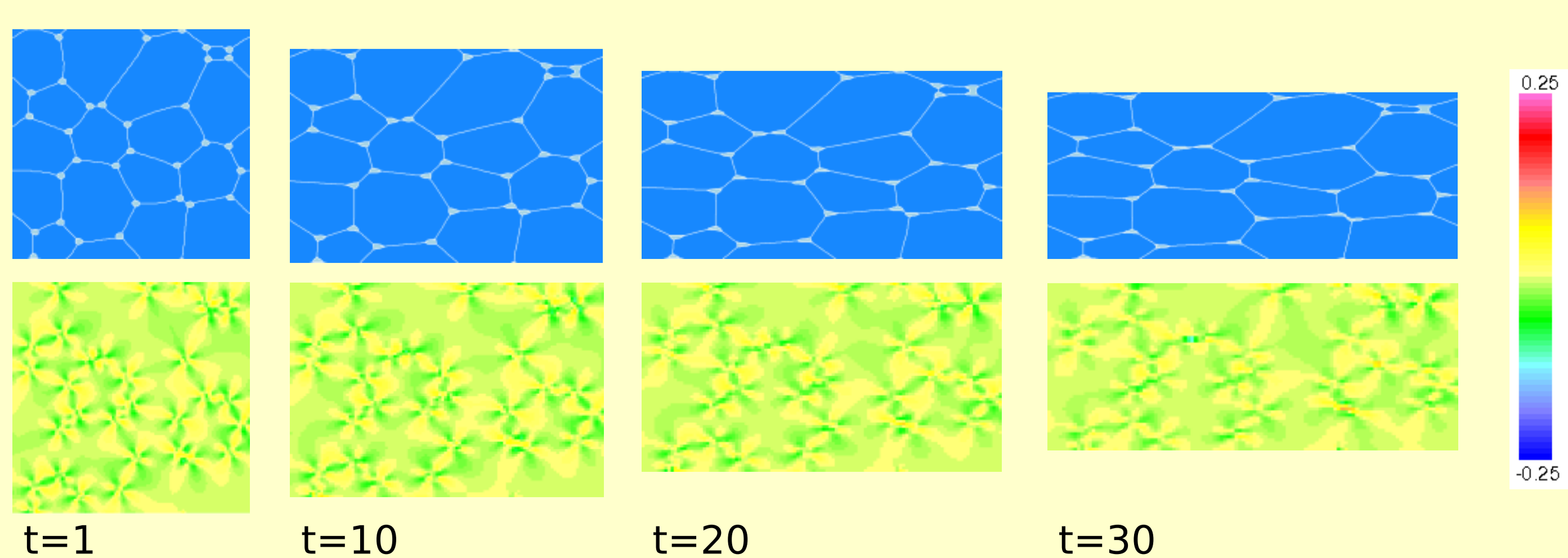
**Example 1: Pure shear:** Simulation of pure shear, surface energies have been adjusted for wetting angles of ~10°. Each step shortens the microstructure by 0.25%, viscosity contrast between solid and liquid is ~1:100 (ask to see 1:10<sup>3</sup>). After each step of deformation, the microstructure has 20 steps to regain a stable shape. The upper image sequence shows the topology of the microstructure, the lower sequence the strain in the xy-direction.



**Example 2: Simple shear:** Simulation of simple shear, surface energies are chosen to reflect a wetting angle of ~10°, melt fraction is stable at ~2%. Each step of shearing distorts the microstructure by 0.25% ( $\gamma = 0.25$ ), viscosity contrast is 1:100 (1:10<sup>3</sup>). Between each step of deformation, the microstructure undergoes 20 steps of grain boundary migration. Upper sequence – topology, lower sequence strain (xy).



## Example 3: Deformation of ice



Simulation of pure and simple shear with grain boundary migration of ice and water. The surface energies are adjusted so that the wetting angle is ~2°. Viscosity contrast 1:10. Time between deformations: 100 steps, strain maps display xy-direction.

