MIGRATION OF PARTICLES IN ICE: SOLUTE EFFECTS

LABORATORY : Institut Lumiere Matiere

LEVEL : M2
TEAM(S) : LIQ@INT

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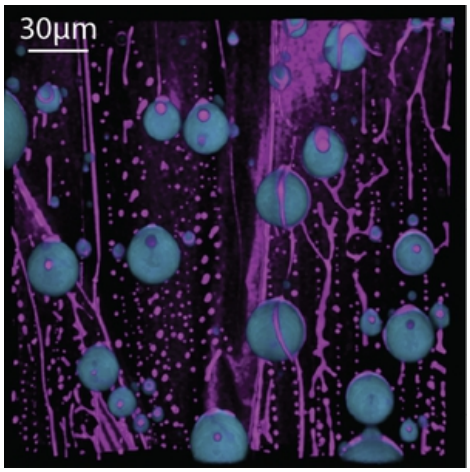
KEYWORD(S) : freezing / geophysics / confocal microscopy

SCIENTIFIC CONTEXT :



Oil droplets (cyan) and liquid pockets (magenta) entrapped in ice

Understanding the migration of objects (particles, liquid pockets, bubbles) in ice is fundamental in many domains, and in particular in ice physics [1], geophysics, and climate science. Entrapped air bubbles, for instance, are used as proxy for the atmosphere composition at the time the bubbles were entrapped in ice. Knowing how and how fast they are likely to migrate is thus essential in this context. The mechanisms associated to the migration of bubbles are also essential to characterise the albedo of “sea glaciers” on Snowball Earth . One of the main driving force for the migration is the pressure-induced premelting around the object. Recent results in our group on freezing emulsions [2] and freezing in porous media [3] revealed that solute, again, can drastically impact the presence and thickness of premelted films around objects. Solutes such as salt, which are naturally encountered and segregated during solidification, may thus play a key role on the migration of objects in ice. If some old work can be found on the migration of mineral particles, bubbles or brine pockets, the cryoconfocal microscopy tools developed in our group should provide an unprecedented understanding of the migration of such objects, and in particular how they relate to the solidification conditions and microstructure. A theoretical paper [4] recently predicted that solute can indeed have a considerable impact on the migration velocities.

MISSIONS :

The objective is to evaluate how solute, concentrated around encapsulated objects or at grain boundaries, impact the migration of objects in ice, in a temperature gradient. This will be investigated using a custom cryoconfocal microscopy setup developed in our group [2]. This will let us verify if the role of solute has been underestimated and if the migration kinetics in ice in more realistic systems (with solute) must be re-evaluated. We may, in particular, track solute redistribution.

We will primarily work with hard particles, with and without solute at different concentrations. By controlling the solidification conditions (front velocity and temperature gradient), we can control the morphology and dimensions of the solute-rich liquid veins and pockets in ice. We will vary the temperature gradient to investigate its impact on the migration. The migration velocities will be confronted to predictions of the the recently developed physical model.

OUTLOOKS :

Possiblity to apply for a PhD grant at the University or within an ANR project.

BIBLIOGRAPHY :

1. Römkens, M, et al, Migration of mineral particles in ice with a temperature gradient. J. Colloid Interface Sci. (1973)
2. Dedovets, D. et al, Five-dimensional imaging of freezing emulsions with solute effects. Science (2018)
3. Ginot, F. et al, Solute strongly impacts freezing under confinement. Appl. Phys. Lett. (2020)
4. Marath, N. et al, Impurity effects in thermal regelation. Soft Matter (2020)

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