Dripping flow with solidification : an analogue system for the growth of tubular stalactites

Anne Mongruel, Antonin Eddi, Philippe Claudin

Physique et Mécanique des Milieux Hétérogènes (PMMH), CNRS, ESPCI Paris, PSL Research University, Sorbonne Université, Université Paris Cité, 75005 Paris, France
anne.mongruel@sorbonne-universite.fr

Among the various and beautiful shapes shown by calcite concretions in limestone caves, the soda-straw speleothems exhibit an astonishing regularity in diameter (Fig.1a). The drop size ($\cong$ 5 mm), fixed by gravity and capillary forces, templates the growing structure [1,2]. Tubular stalactites can also grow in open air from concrete exposed to rainwater (Fig.1b). Here, the calcite deposition occurs by absorption of CO_2 from the atmosphere, as opposed to cave growth where deposition relies on the degassing of CO_2 from solution. This difference leads to faster growth rates in open air than in caves : 1 cm/year as compared to 10-100 microns/year [3].

Whereas the chemical processes leading to calcium deposition are well known, the factors determining these growth rates are still far from being understood and difficult to be quantified in field conditions. In order to relate the spatio-temporal scales to the relevant physical parameters, and to elucidate the growth mechanisms, we study in the laboratory an analogue system for the formation of soda-straws. We work with a saturated solution of strontium hydroxide, $Sr(OH)_2$, dripping in an atmosphere containing gaseous CO_2. Precipitation of strontium carbonate, $SrCO_3$, occurs at the drop interface by absorption of CO_2. A hanging tube grows downwards as successive drops leave a ring of solid material, with growth rates of 10 microns/min (Fig.1c). The influence of dripping rate and CO_2 concentration is investigated. Comparisons with field measurements are under progress (Fig.1b).

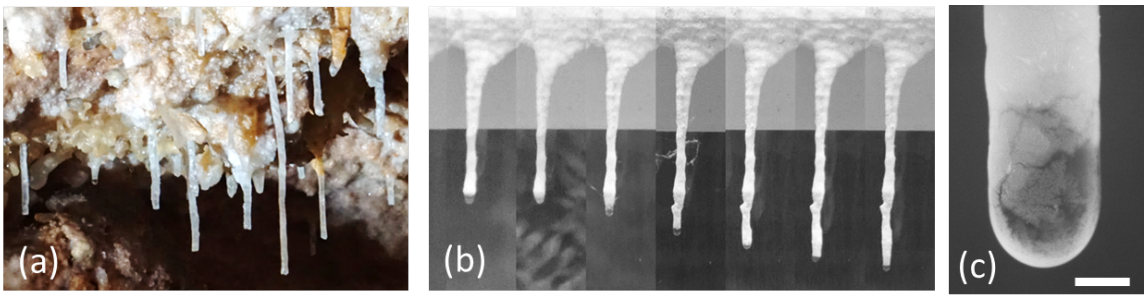

Figure 1. (a) Natural soda-straws (Grotte de la Madeleine, Ardèche). (b) Temporal evolution of a tubular stalactite growing in open air (campus Jussieu, Paris), time between successive images : 2 weeks. (c) Interfacial solidification of a strontium hydroxide solution dripping in an atmosphere containing gaseous CO_2 (scale bar : 2 mm).

References

1. B. Schmidkonz, Geochemistry in action : Watch a dripstone grow ! *J. Chem. Educ.*, **94**, 1492-1497 (2017).
2. D.A. Stone & R.E. Goldstein, Tubular precipitation and redox gradients on a bubbling template *Proc. Natl. Acad. Sci. USA*, **101**, 11537-11541 (2004).
3. A. Hartland, I.J. Fairchild, J.R. Lead, D. Dominguez-Vilar, A. Baker, J. Gunn, M. Baalousha & Y. Ju-Nam , The dripwaters and speleothems of Poole's Cavern : a review of recent and ongoing research *Cave and Karst Sci.*, **36**, 37-46 (2009).