KRISTALLISATIE IN ERFGOED EN KUNST

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Middelbare school

Studie: Advanced matter and energy physics

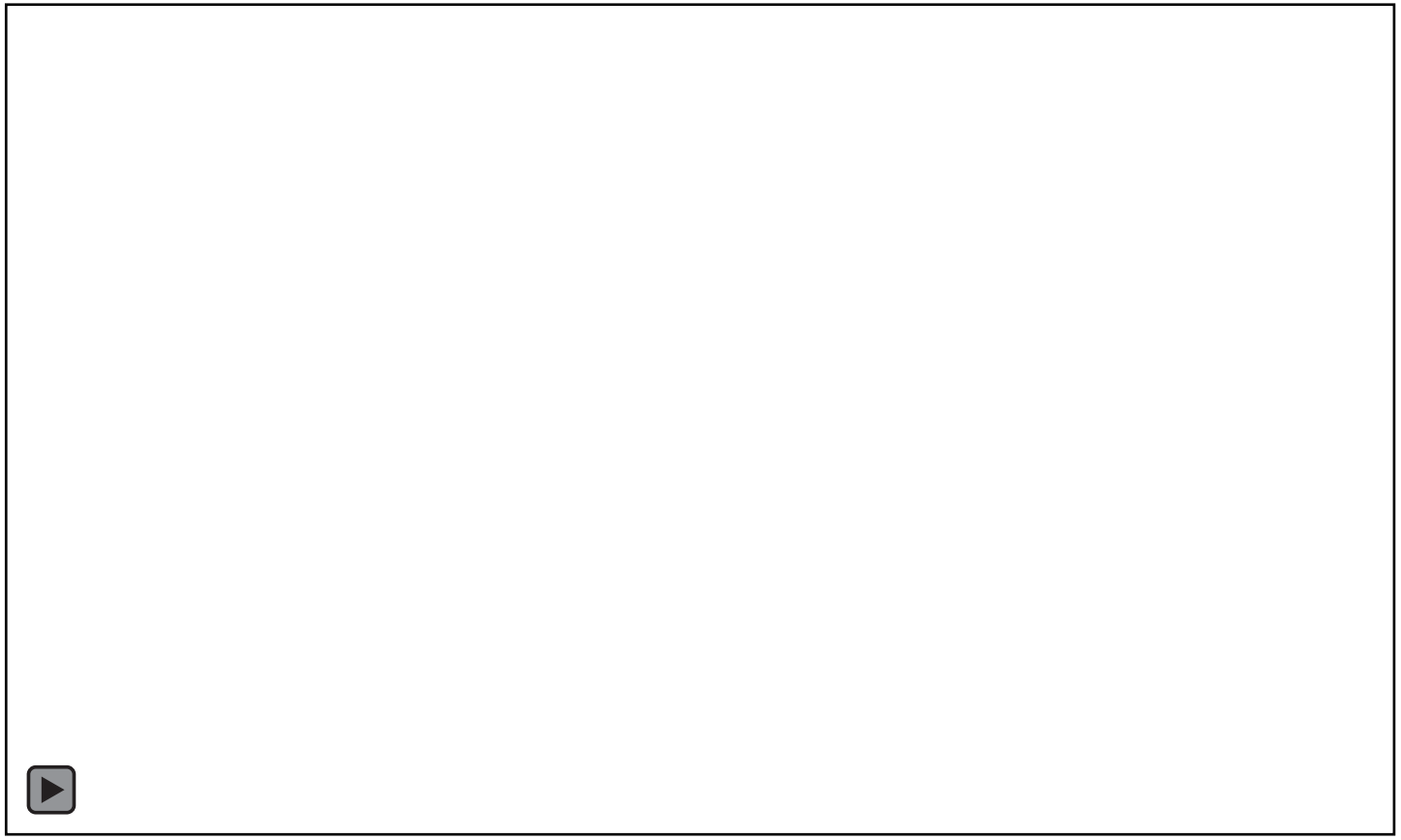
Promotie onderzoek

Kristallisatie schade

‘In time and with water, everything changes’

Leonardo Da Vinci c. 1513

In time and with water, everything changes…



VOORAL POREUZE KUNSTWERKEN

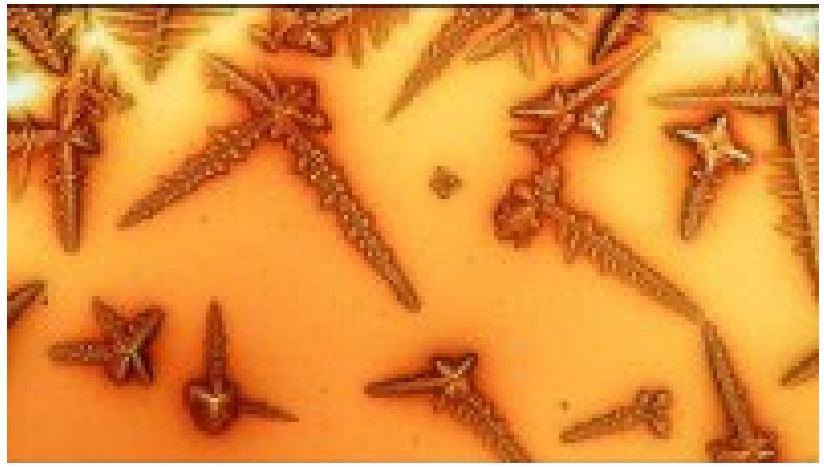
Kristallisatie schade

Kan zorgen voor het losraken van verschillende lagen

Hoe werkt dit?

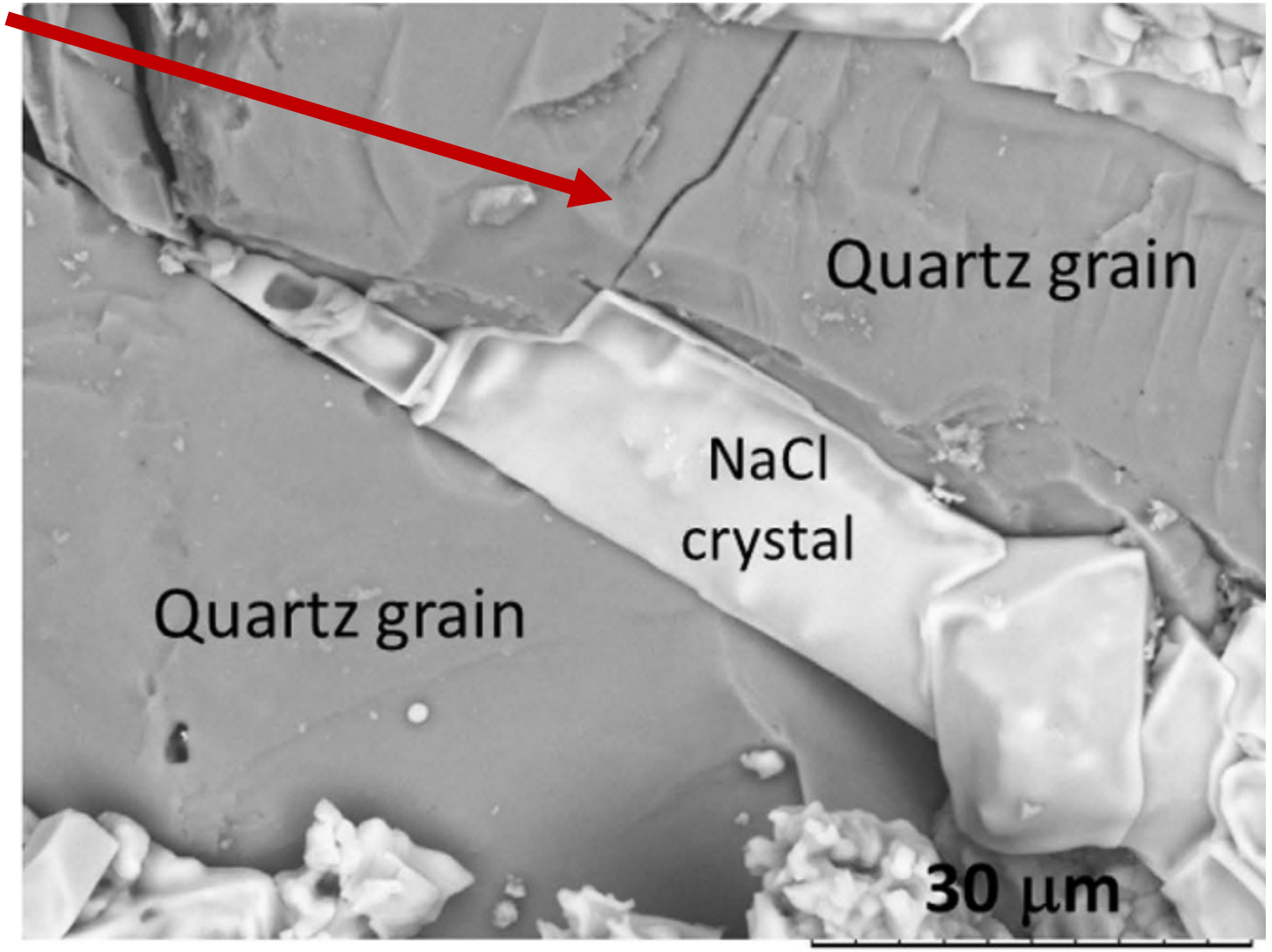
Poreus medium

Vloeistof stroom:
Vaak door capillaire werking (adhesie + oppervlakte spanning)



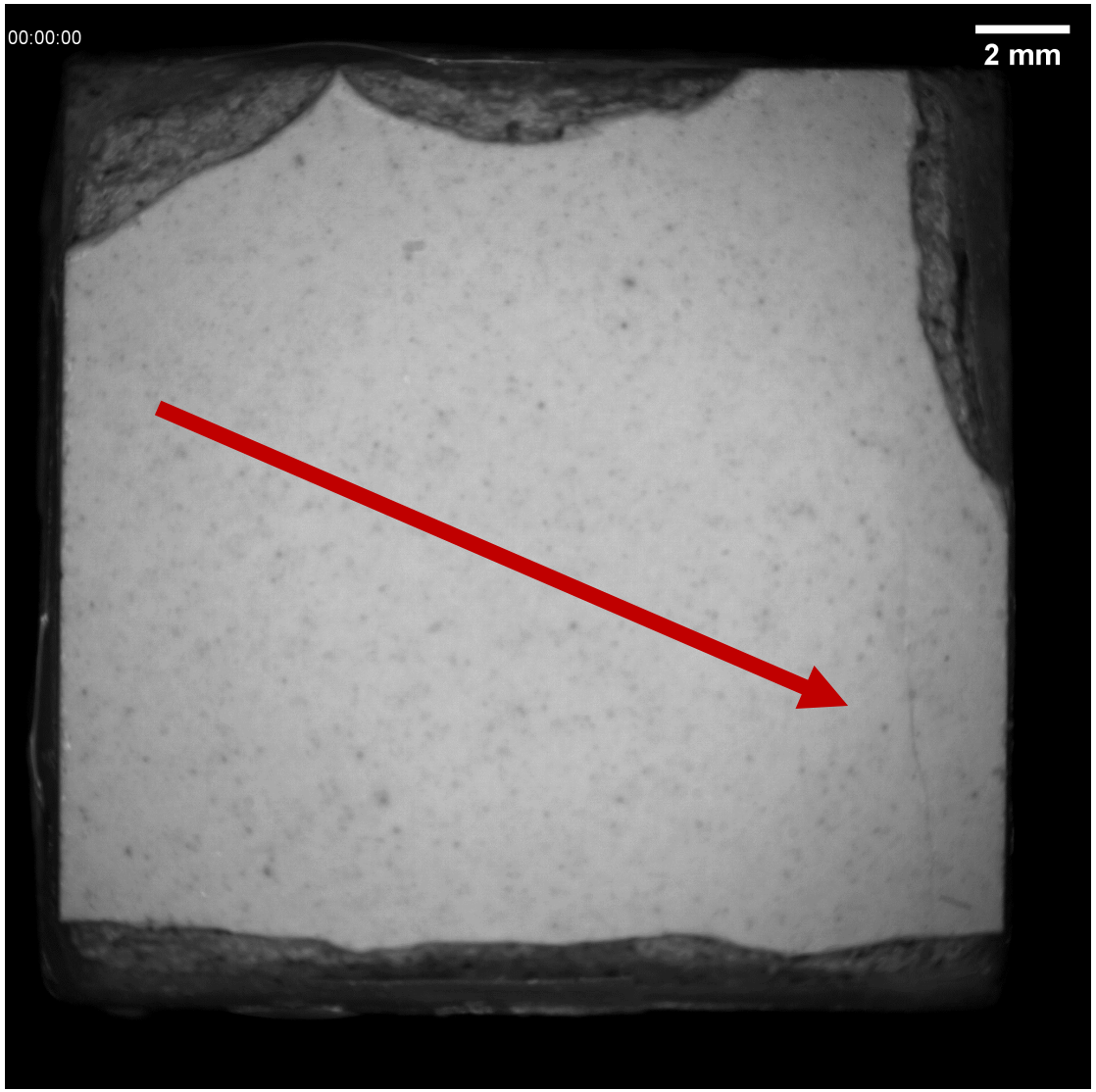
kristallisatie
Vaak door:
verdamping

Kristalgroei veroorzaakt druk



(Désarnaud et al., 2016)

Kristalgroei veroorzaakt druk



Wat moet je allemaal snappen van dit systeem om erfgoed te beschermen?

Surfactant Effects on the Dynamics of Capillary Rise and Finger Formation in Square Capillaries

Rozeline Wijnhorst, Thijs Christiaan de Goede, Daniel Bonn, and Noushine Shahidzadeh*

Cite This: *Langmuir* 2020, 36, 13784–13792

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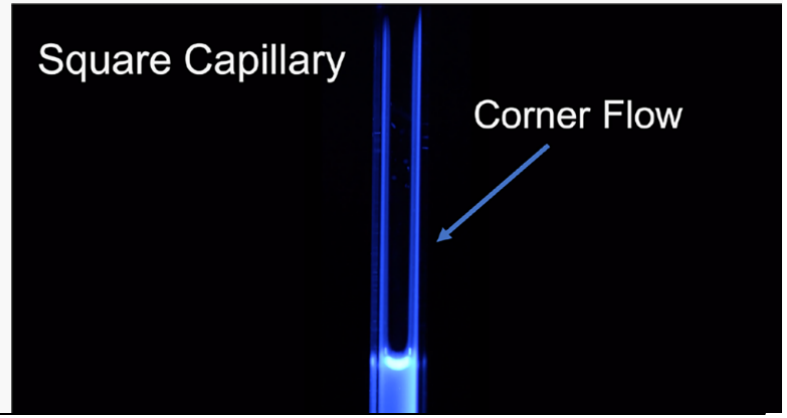
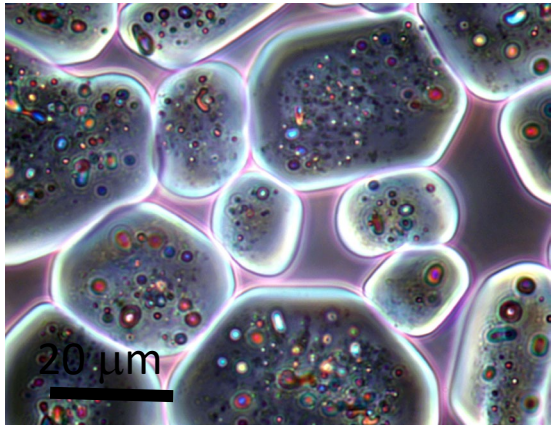
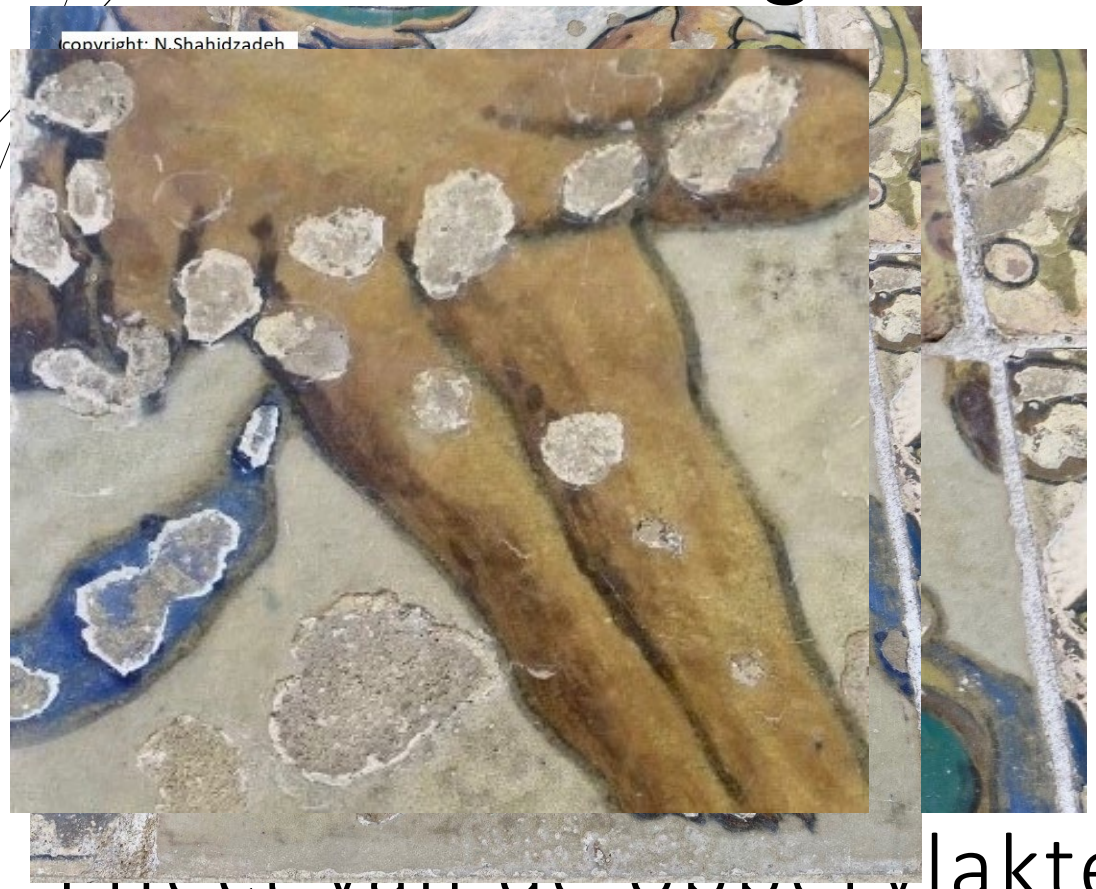
ABSTRACT: We investigate the influence of surfactants on capillary rise and corner flow in angular pores. We therefore study capillary rise for simple fluids and surfactant solutions, comparing square to cylindrical capillaries. We show that fingers start to form in the corners of the square capillaries when the capillary rise slows down before reaching the equilibrium height. The corner flow scales as $t^{1/3}$ and its quantitative understanding necessitates that the surface wettability is taken into account in terms of the liquid's advancing contact angle on the capillary walls inside the corner. Adding surfactants to water greatly influences the corner flow in square capillaries: depending on the nature of the surfactant, the corner flow can be either suppressed completely due to autophobic

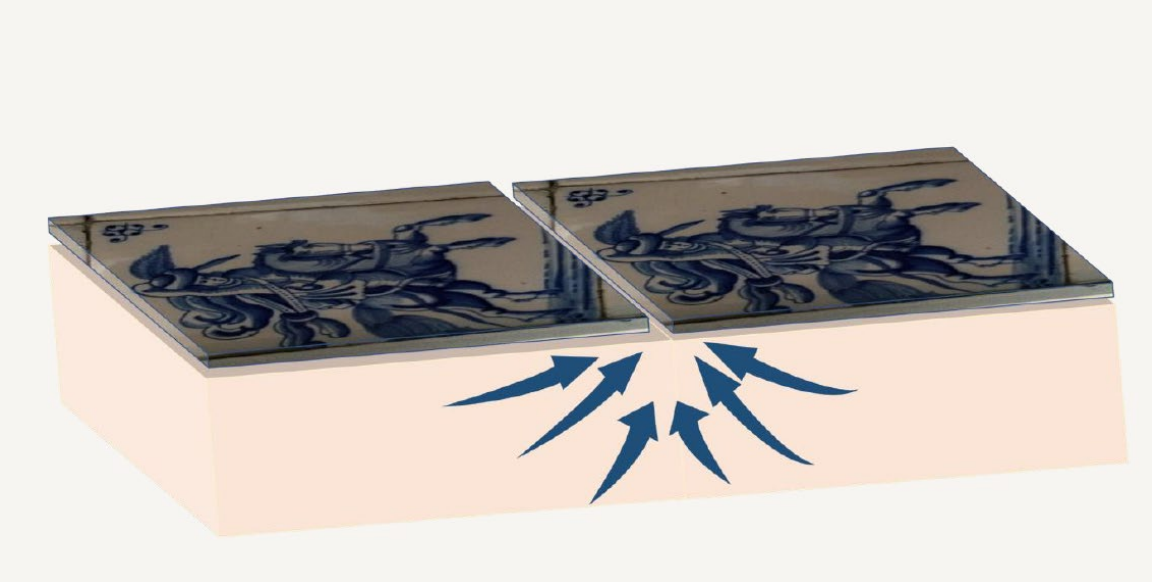




Meer weten? Labtour!

Als er schade is krijg, je scheuren en gaten in materialen





Effect van de oppervlakte volume ratio op het drogen en de kristallisatie

Team

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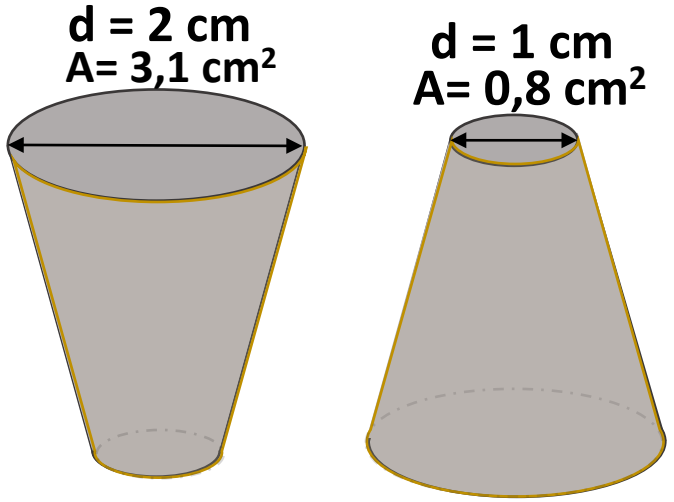
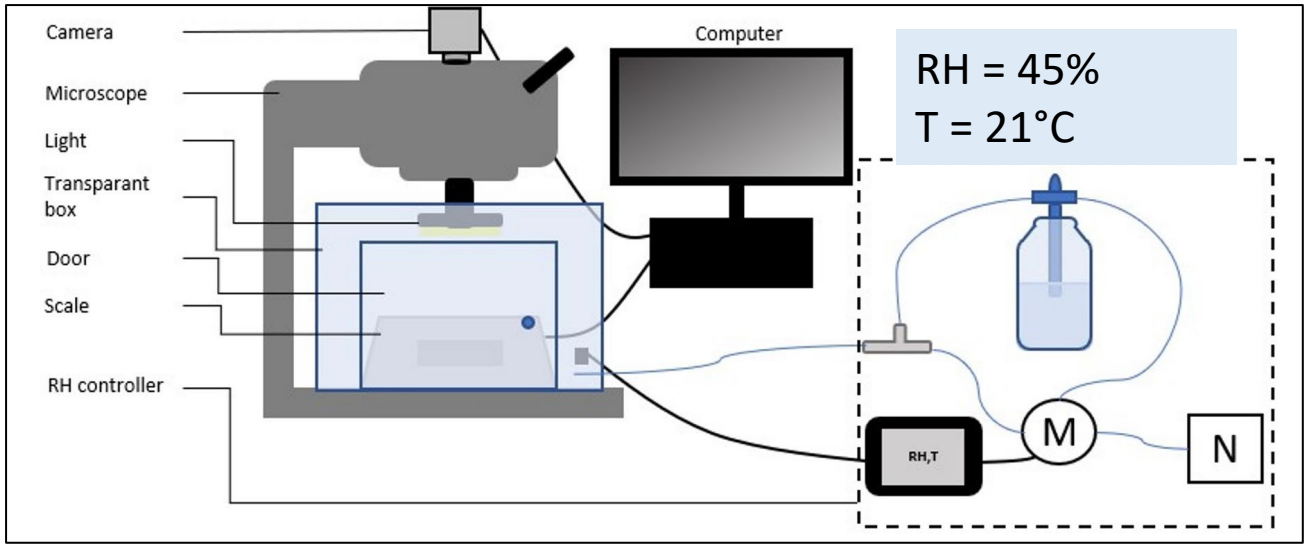
Kegelvormige samples als een modelsysteem





zandsteen

oplossing

ϕ = 28%

V = 9,2 cm^3

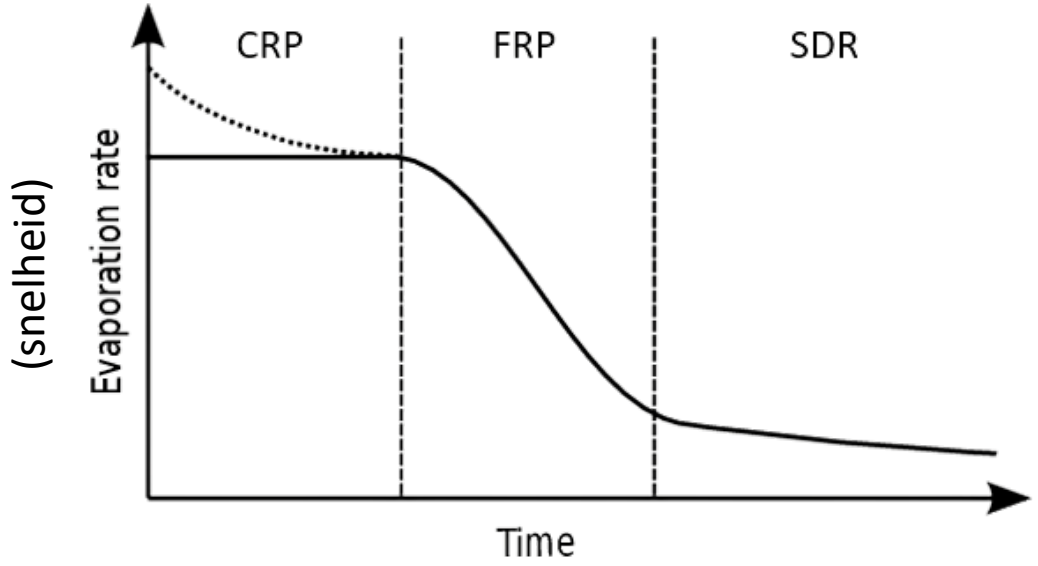
D_{pores}=30 µm

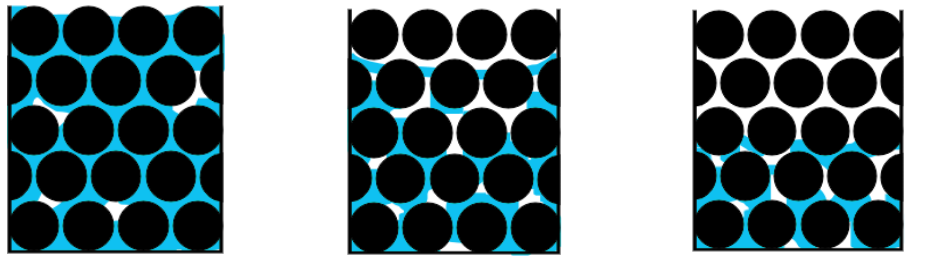
- **Water**
- **1.7 M NaCl solution (10% wt)**
- **S=m_i/m_s = 0.3 understaturated**

Droog experimenten uitgevoerd met de kleine of de grote top omhoog

Hoe werkt een droog proces?

Drying of water: 3 drying regimes:





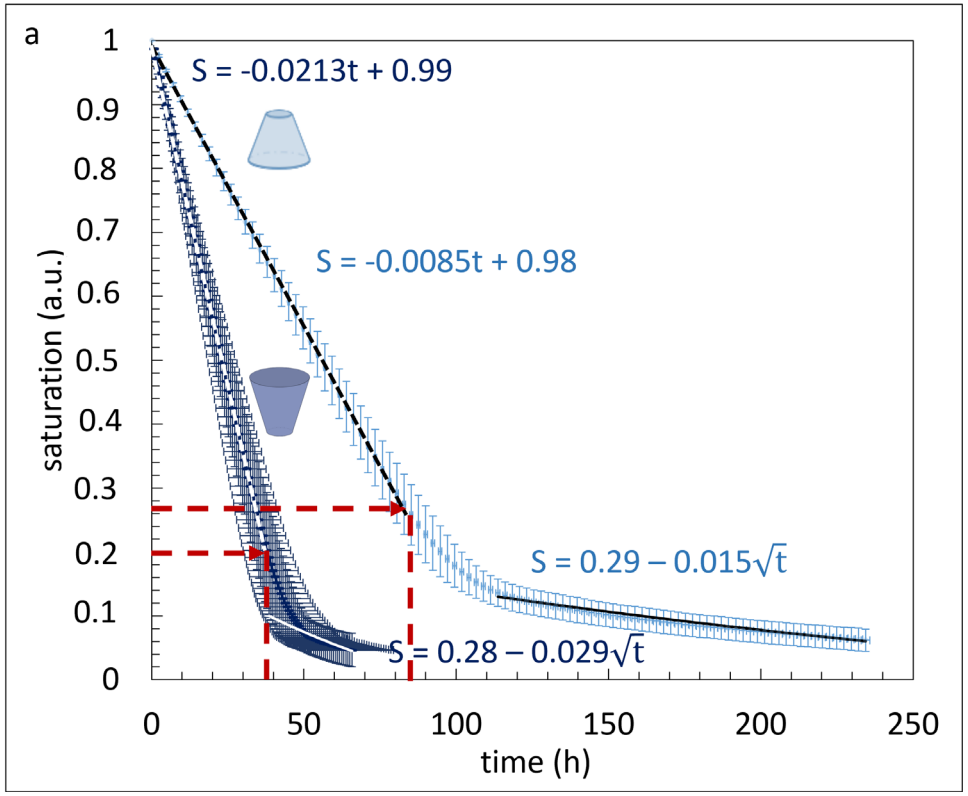
Constant rate period (CRP)

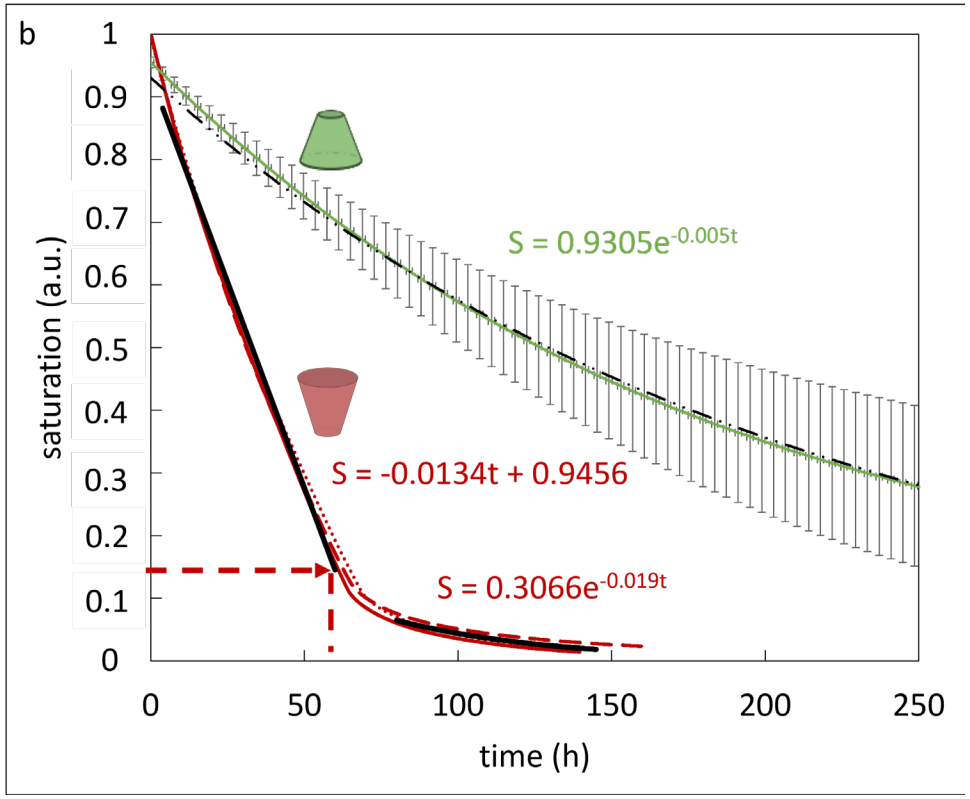
Falling rate period (FRP)

Second falling rate period (FRP)

We verwachten dit ook voor de kegels als ze gevuld zijn met water

Droging van 10% zoutoplossing





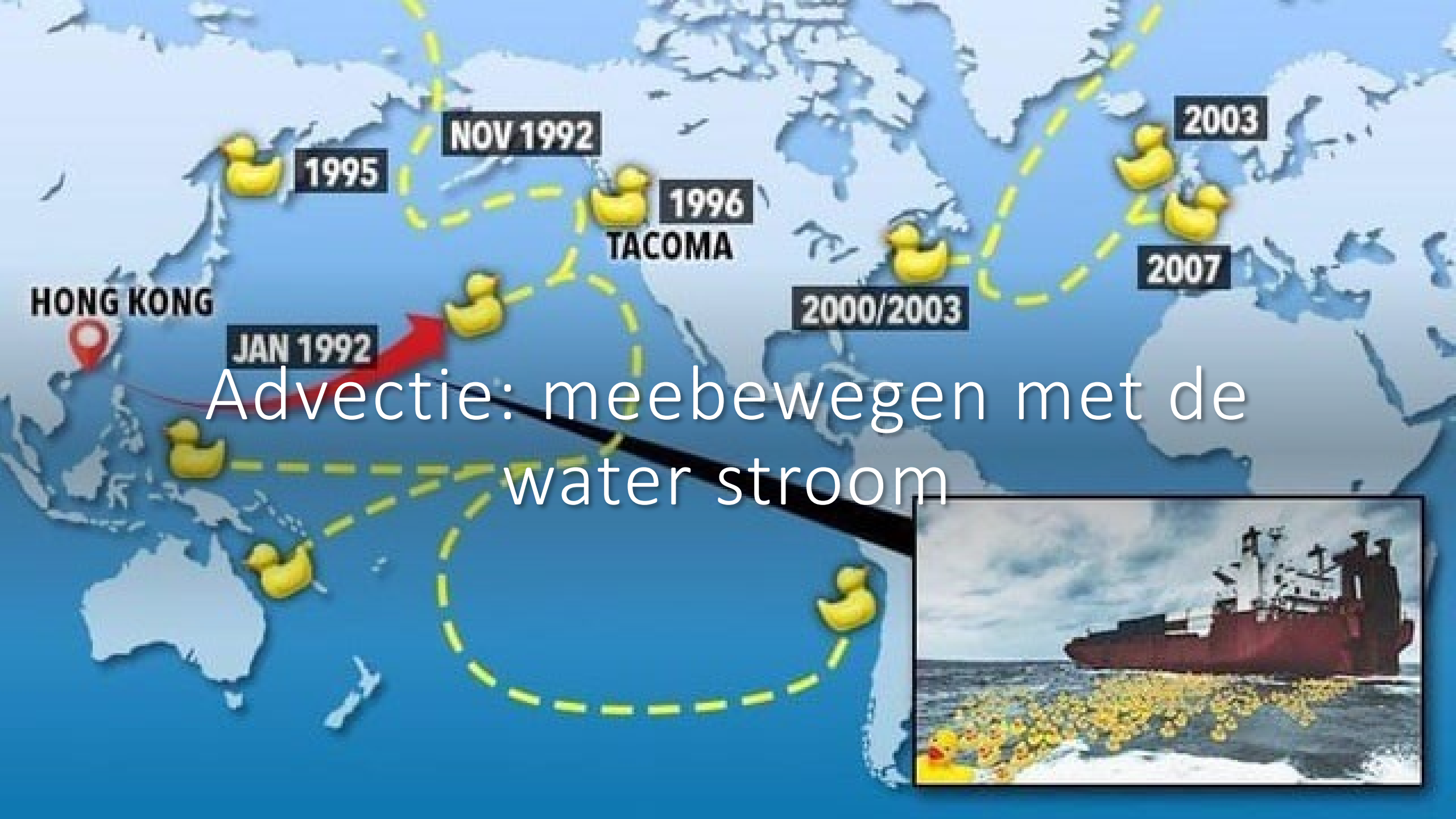
- Per experiment 2 droogperiodes zoals verwacht
- Grote top droogt ~2x sneller dan de kleine top

Zoutoplossing droogt veel langzamer

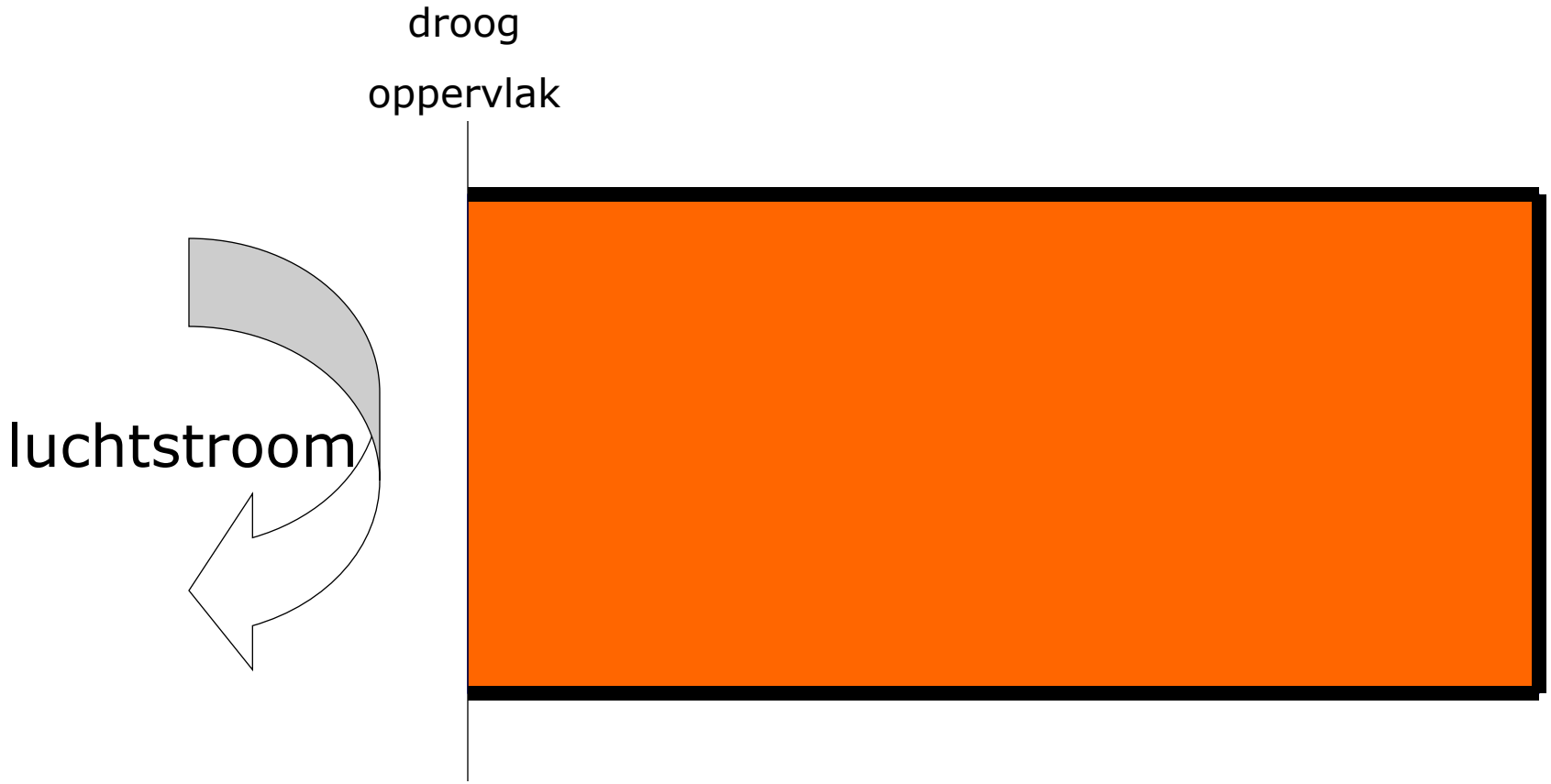
Ander droog gedrag als de kleine top boven is, dan als de grote top boven is

Diffusie: de neiging om uiteindelijk gelijk verdeeld te zijn

Advectie: meebewegen met de water stroom



Hoe werkt een droog proces met zout?



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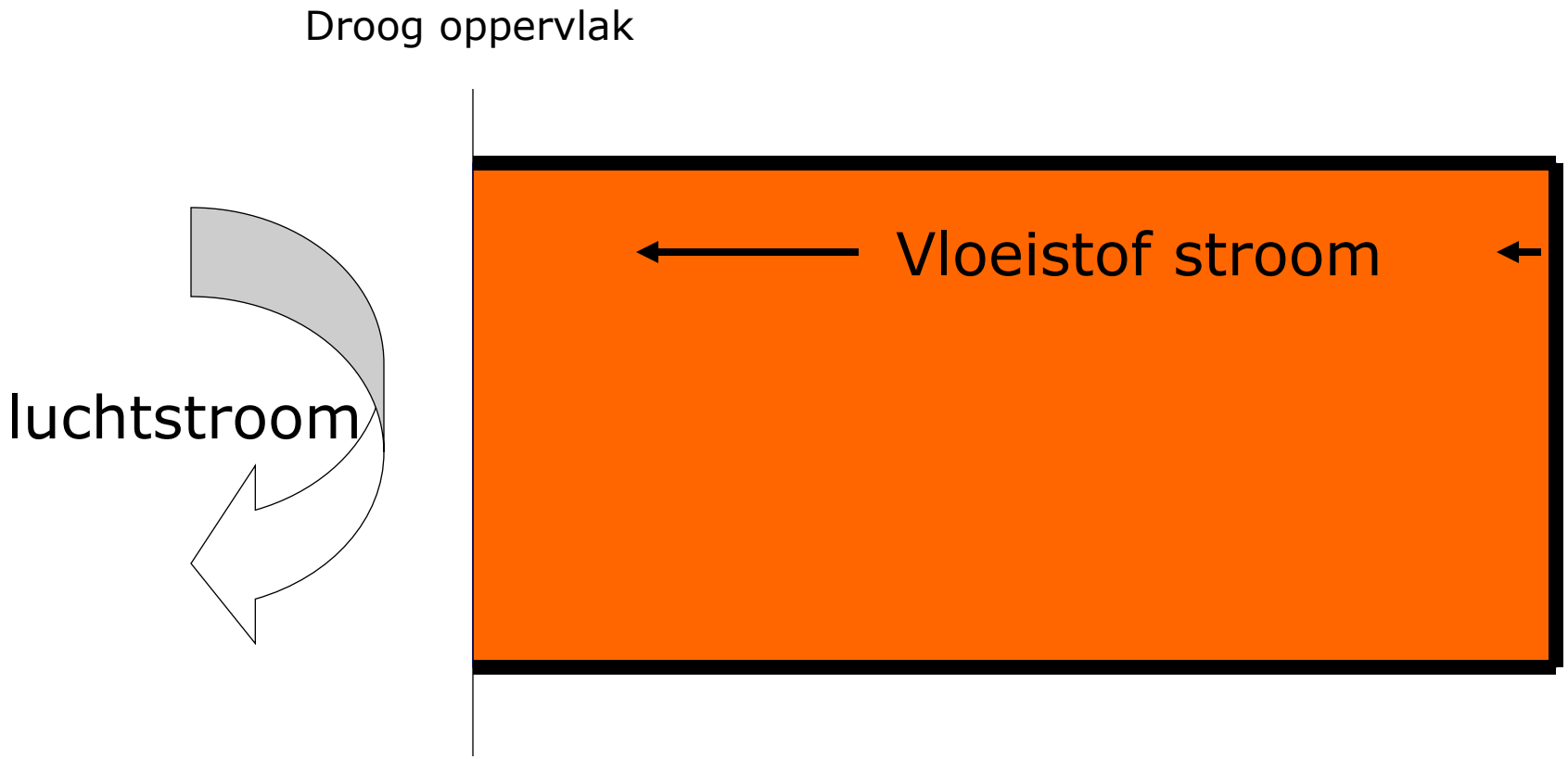

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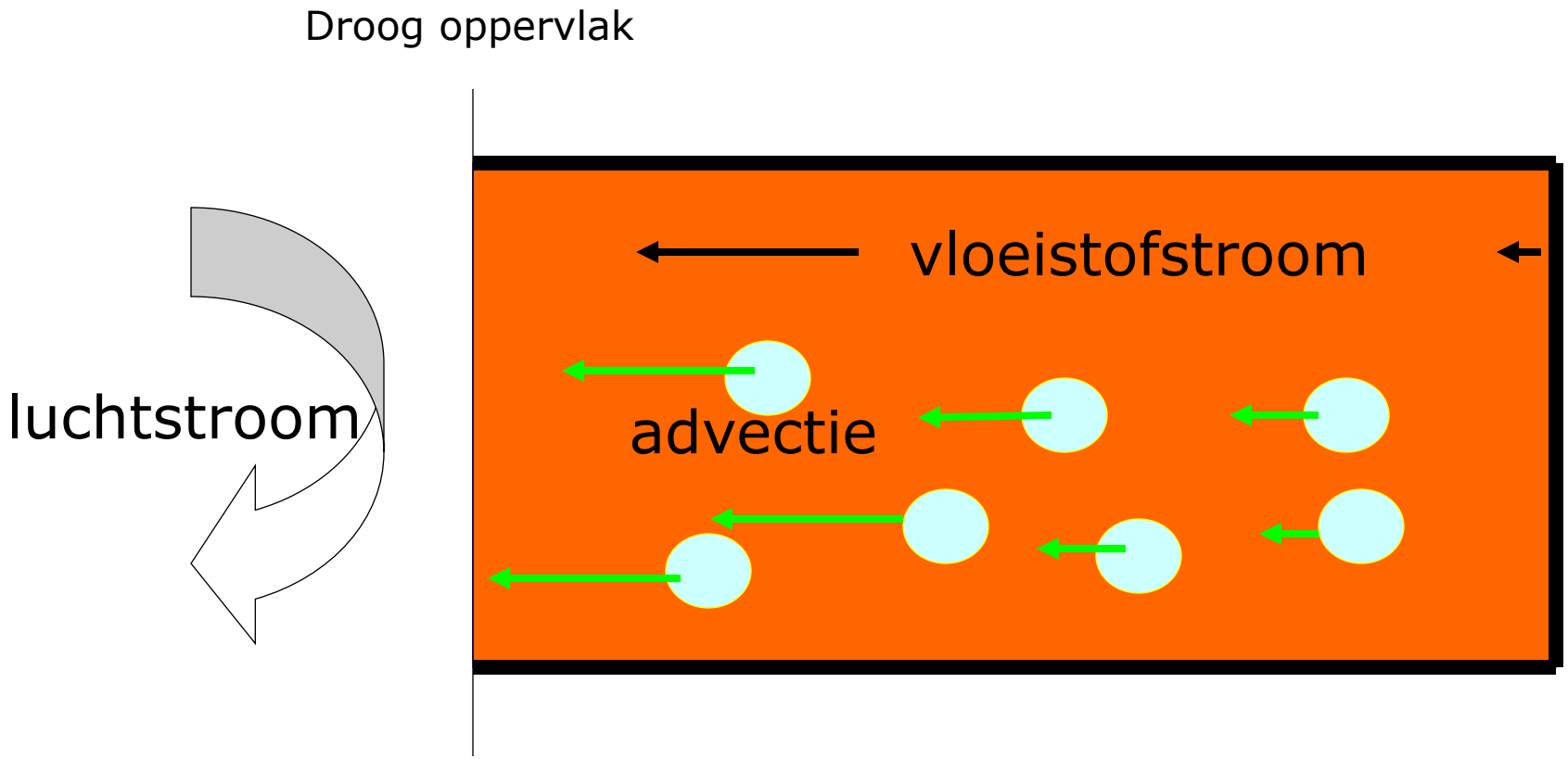

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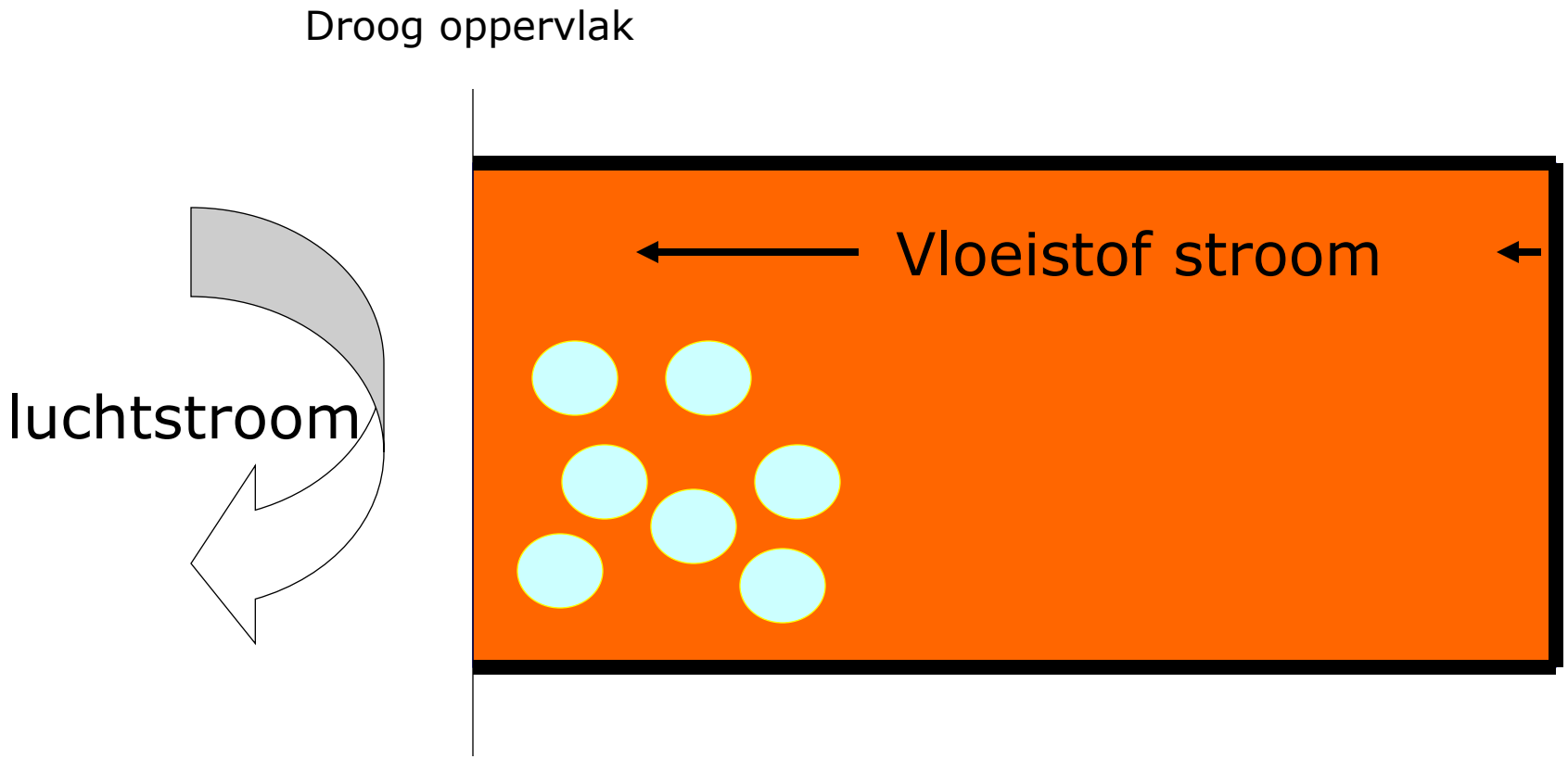

ophoping > kristallisatie

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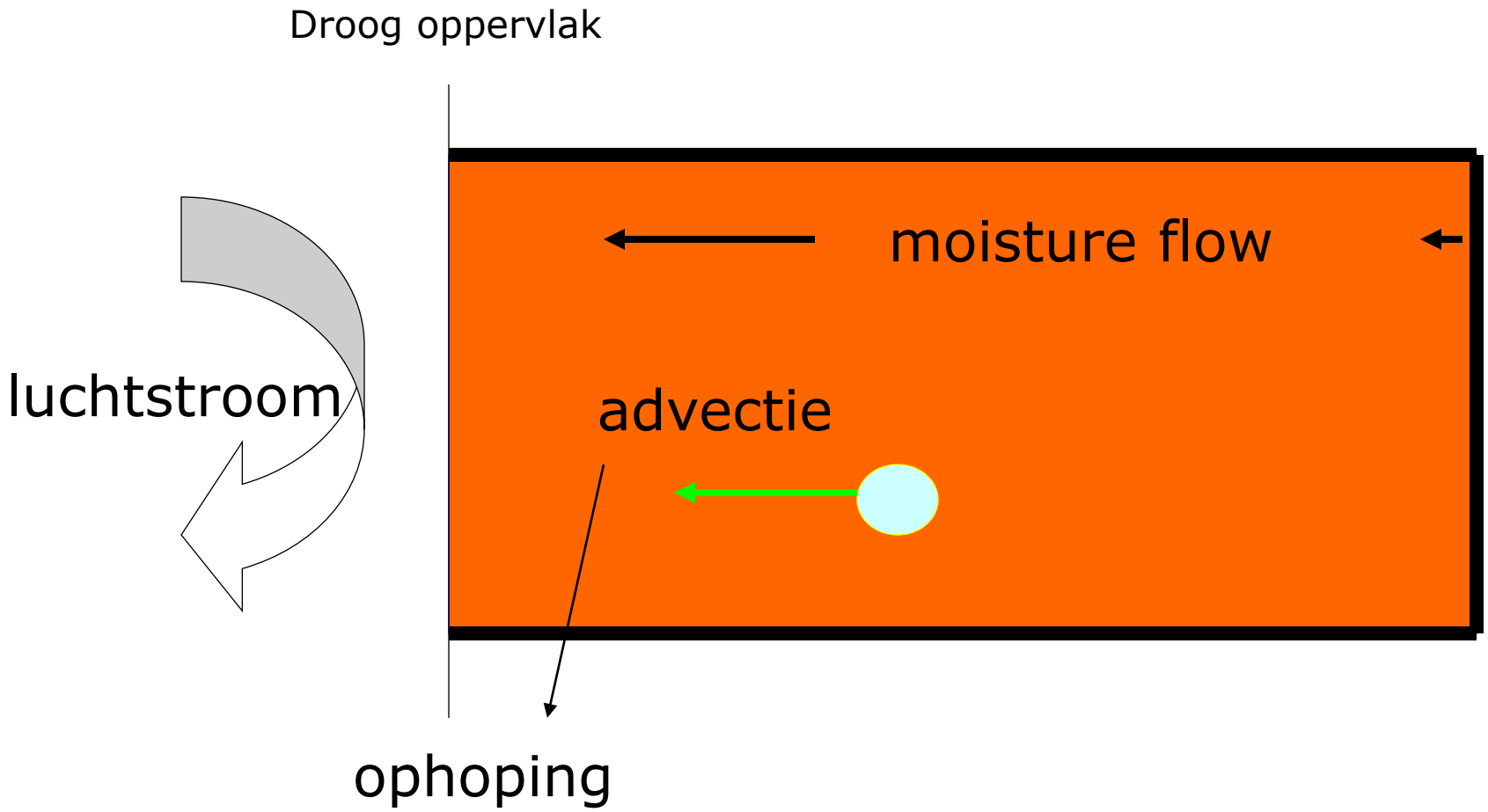

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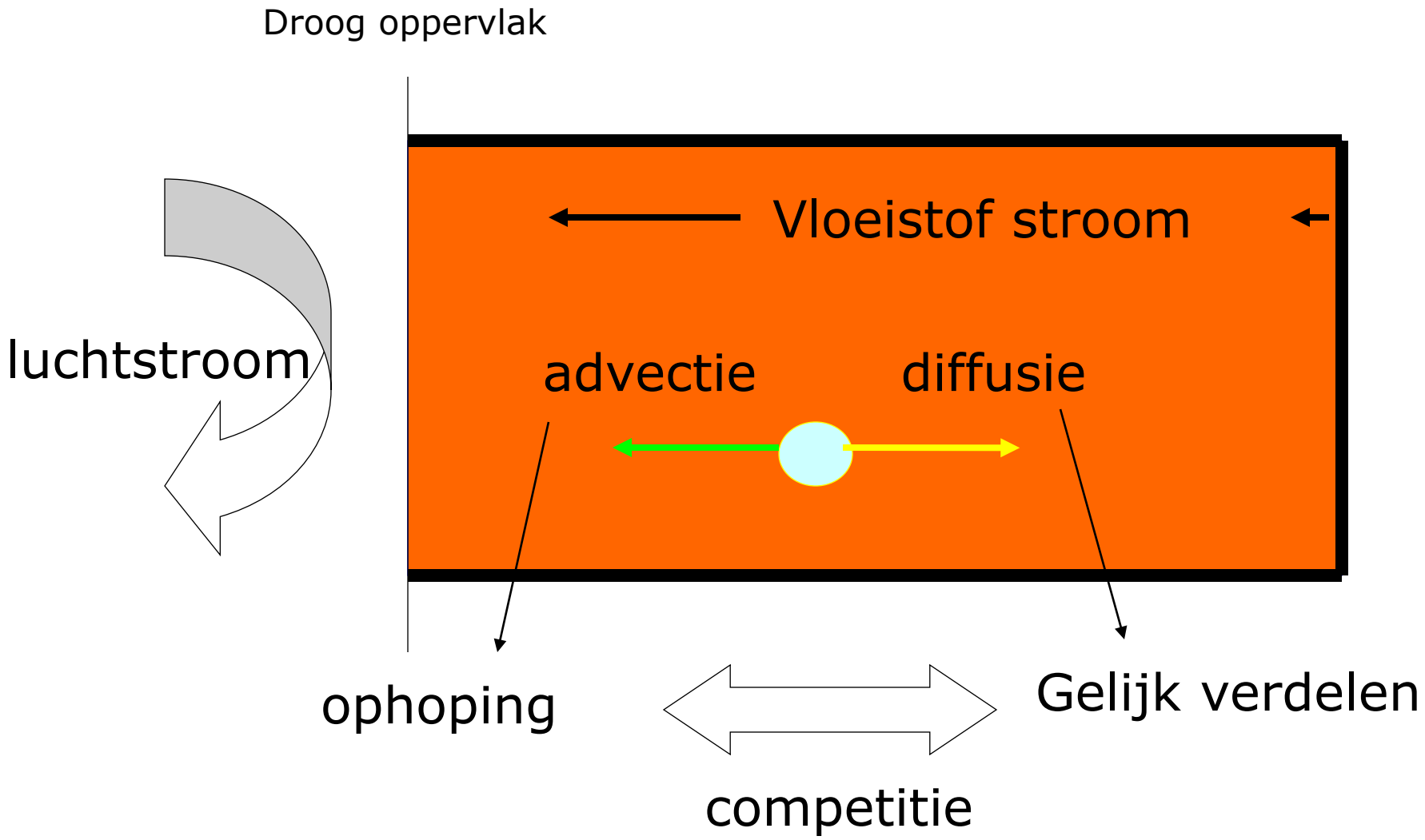


Peclet number

advectie diffusie

$$Pe = \frac{U\,L}{D}$$

U : Vloeistof snelheid

L : Lengte van het sample

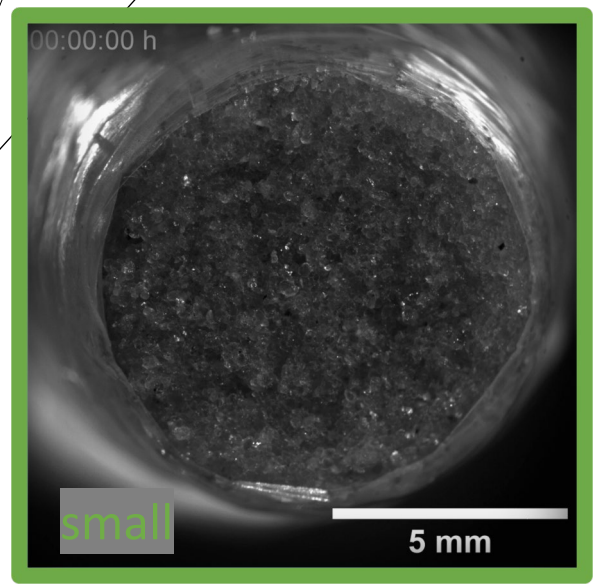
D : Diffusie coefficient van de stof

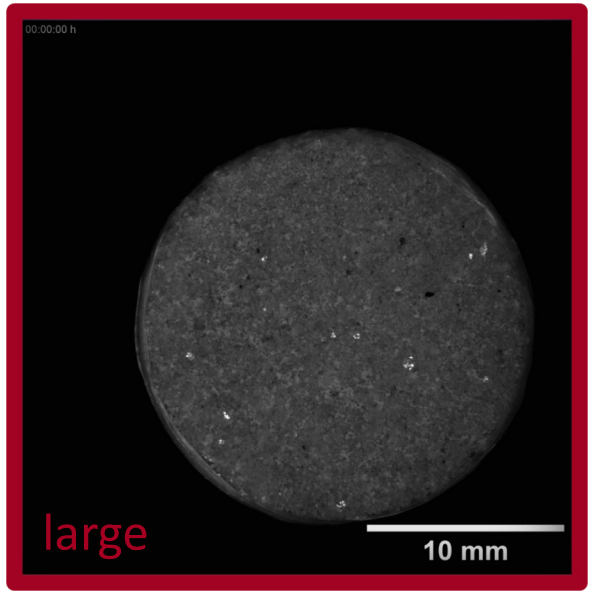
$Pe > 1$ ophoping

$Pe < 1$ Gelijke verdeling

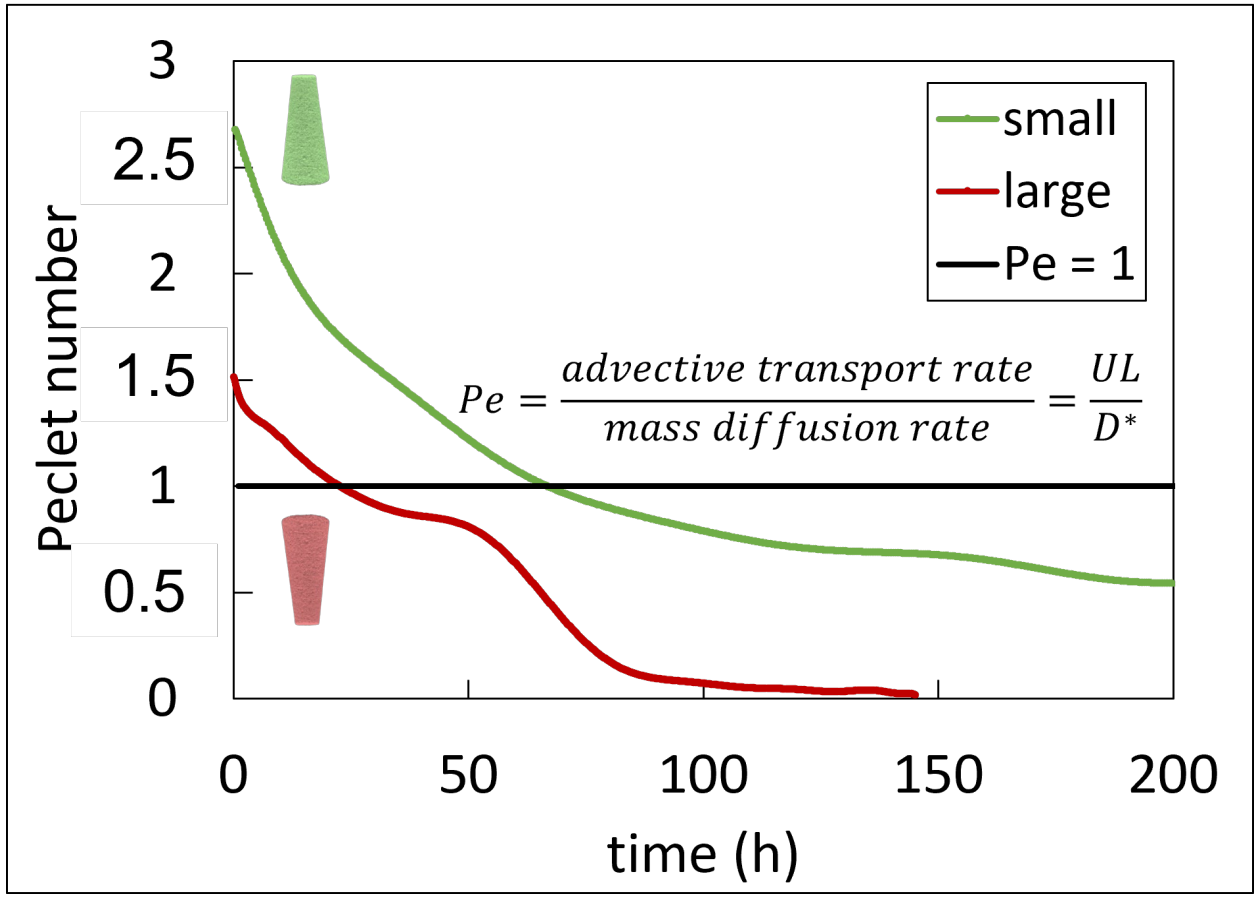
see e.g.H.P. Huinink et al, *Phys. Fluids* **14**, 1389 (2002)

Peclet nummer van kegels





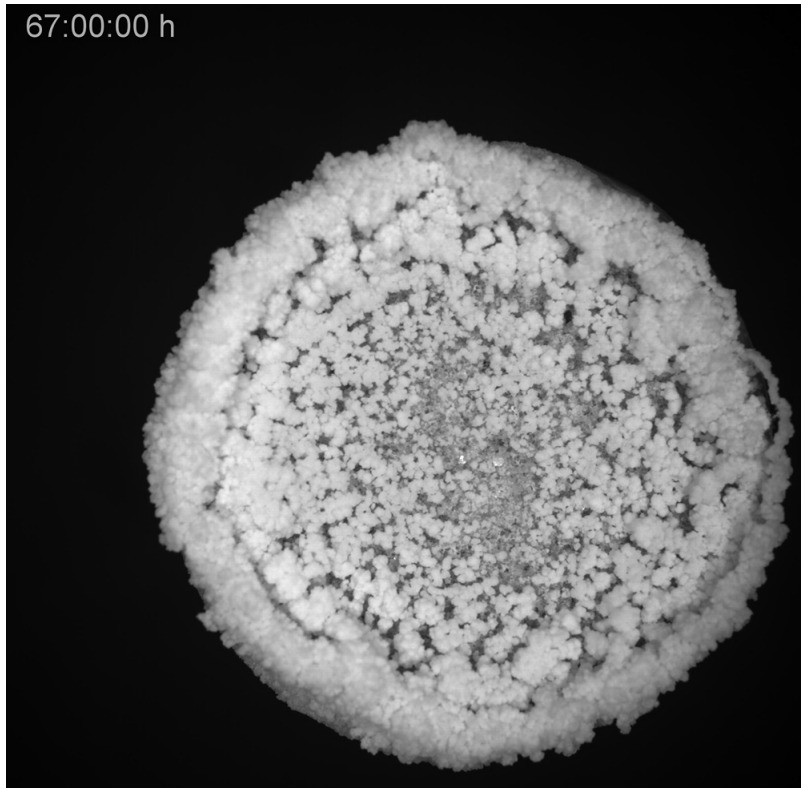
Zelfde tijdschaal

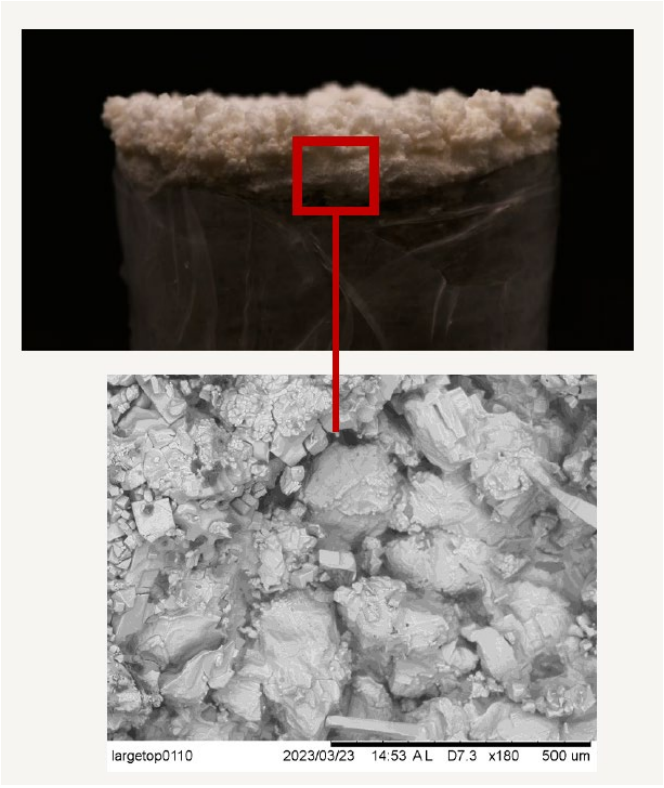


Advectie is in het begin dominant.

Met de kleine top omhoog is advectie nog dominanter: kristallisatie begint eerder!

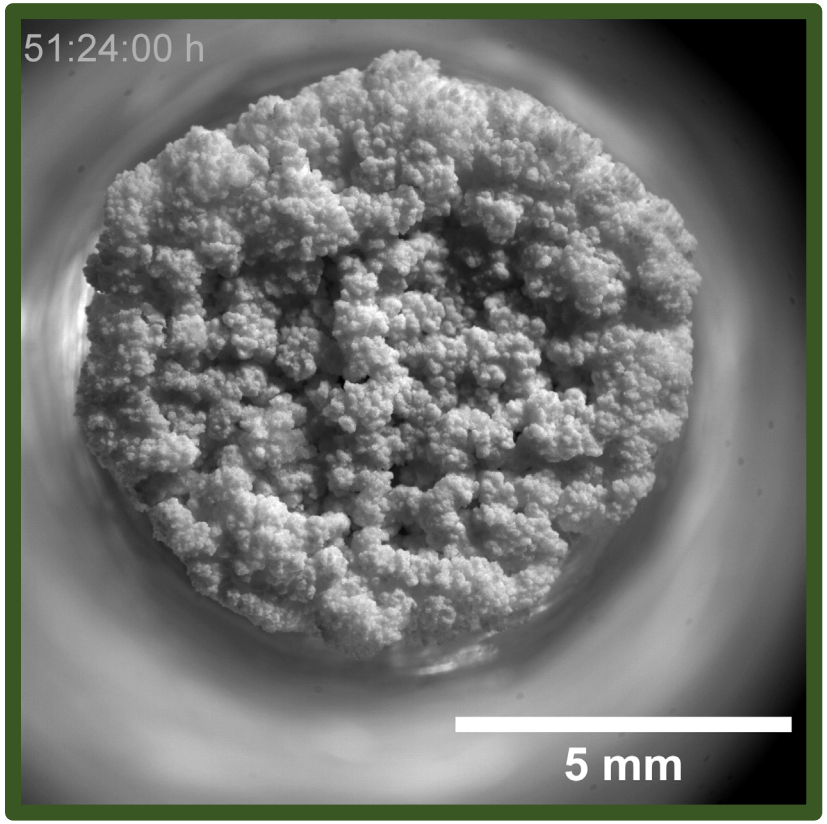
Grote top met lager Peclet getal: kristallen zitten vast aan de kegel

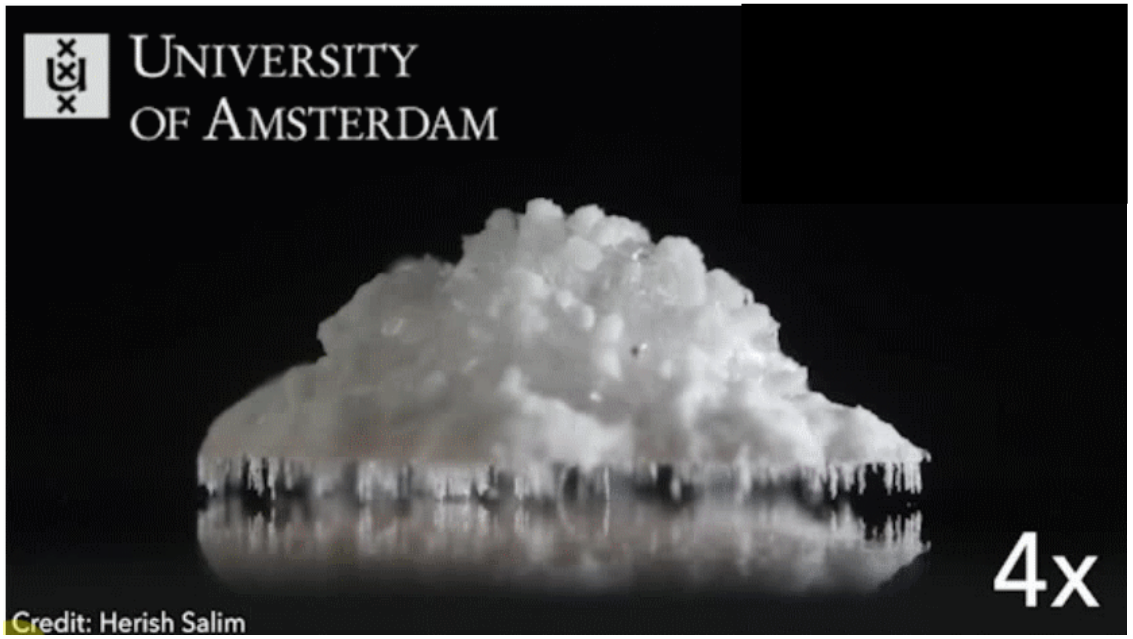




De zoutlaag zit vast aan de steen en is moeilijk te verwijderen

Kleine top met hoger Peclet getal: kristallen komen los van de kegel



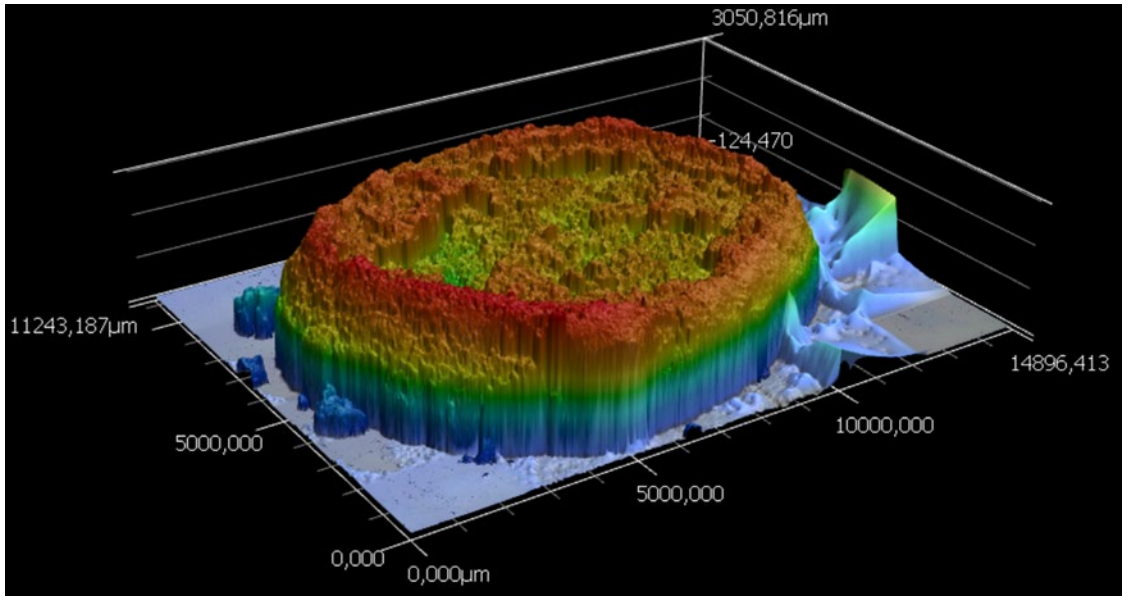


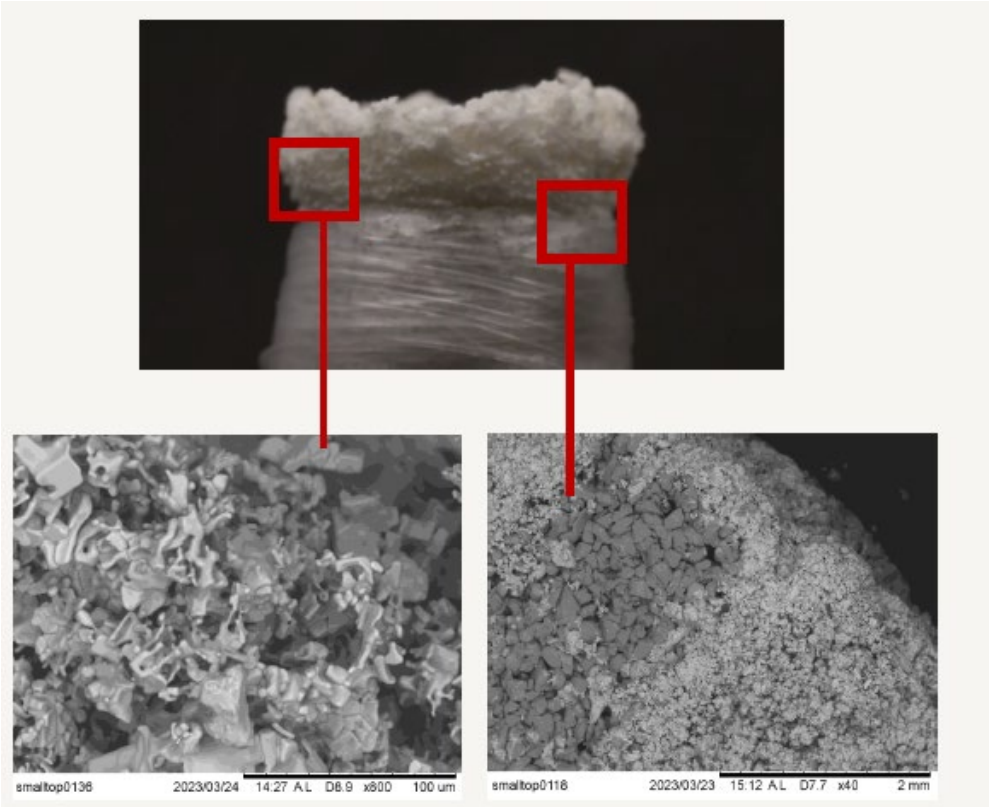
Lijkt op het omhoog liften van kristallen op hydrofiele oppervlakten(Salim et al., 2020)

De kristallaag lift zichzelf op van het oppervlak van de kegel

No Adhesion on the surface of the small top

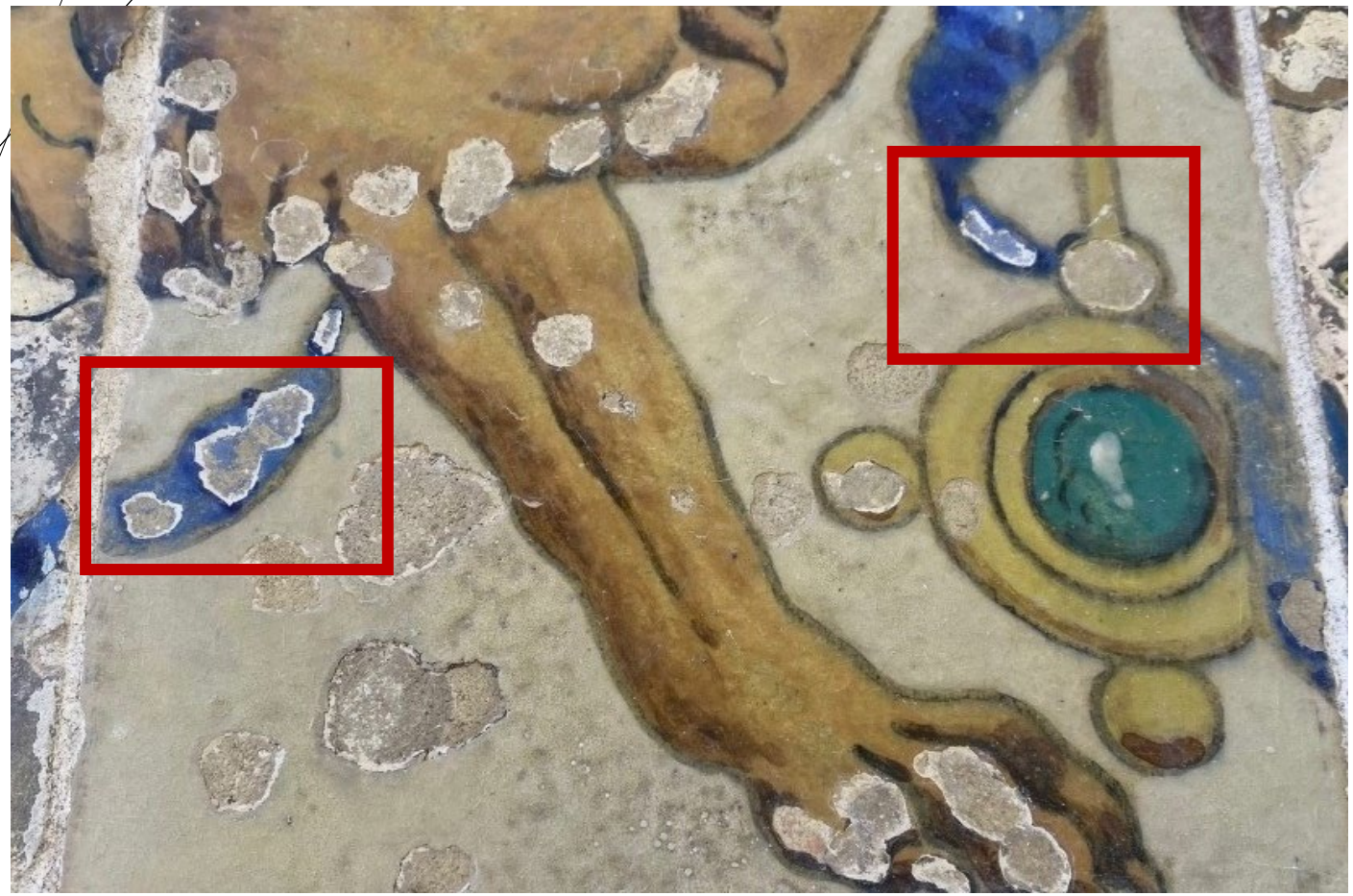
Profilometry image





The salt layer easily comes off as a crust, leaving a clean surface

Terug naar de kunstwerken



(Crystal Palace, Madrid)

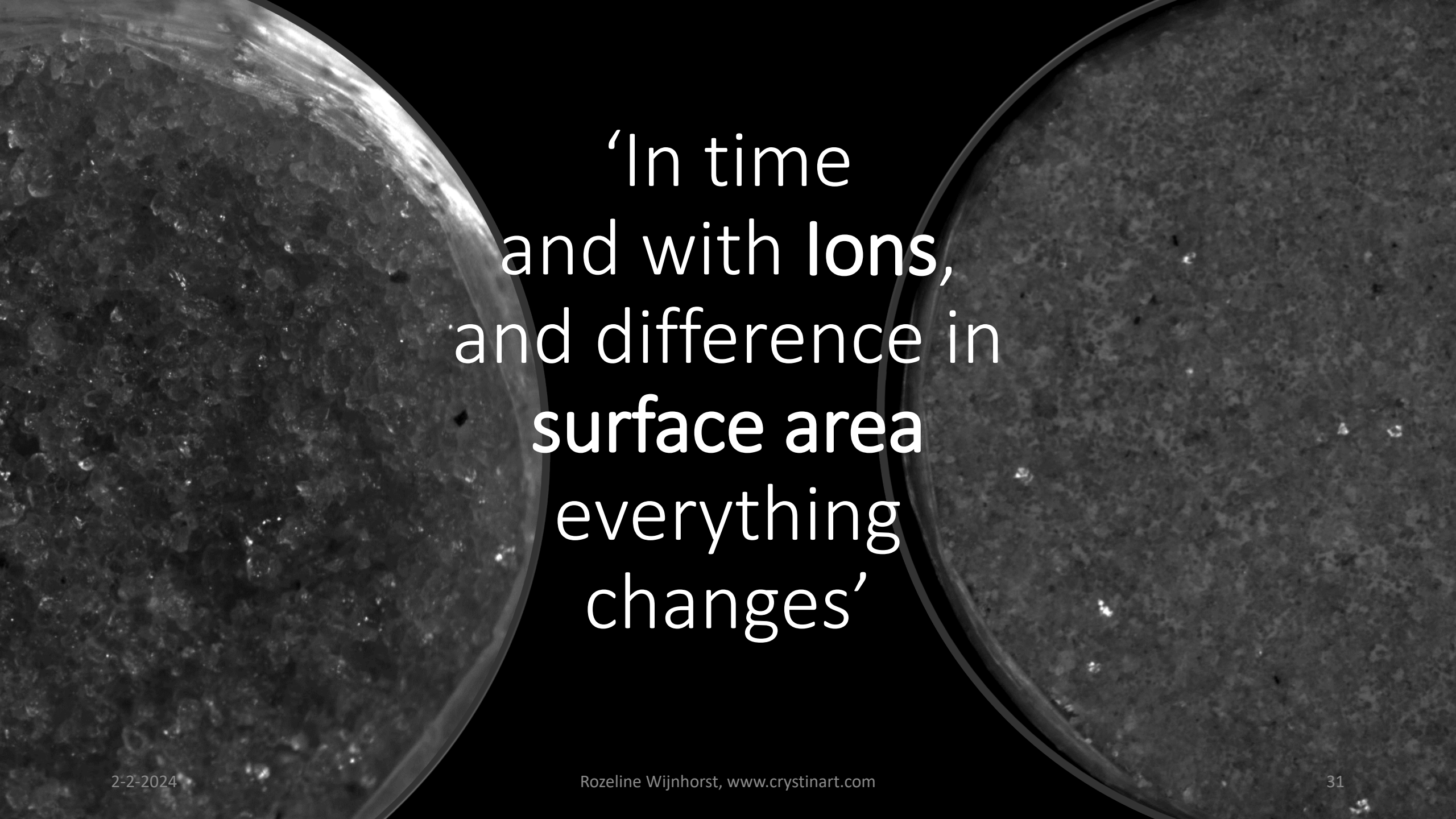
- Inderdaad meer zout in een kleiner gaatje dan in een groter gat
- Kristallisatie begint ook in een ring om het gat heen

CONCLUSIES

- De ratio tussen droog oppervlak en volume heeft invloed op diffusie en advectie en dit betekent (voor een gegeven volume) klein opppervlak: hoog Pe, groot oppervlak: laag Pe

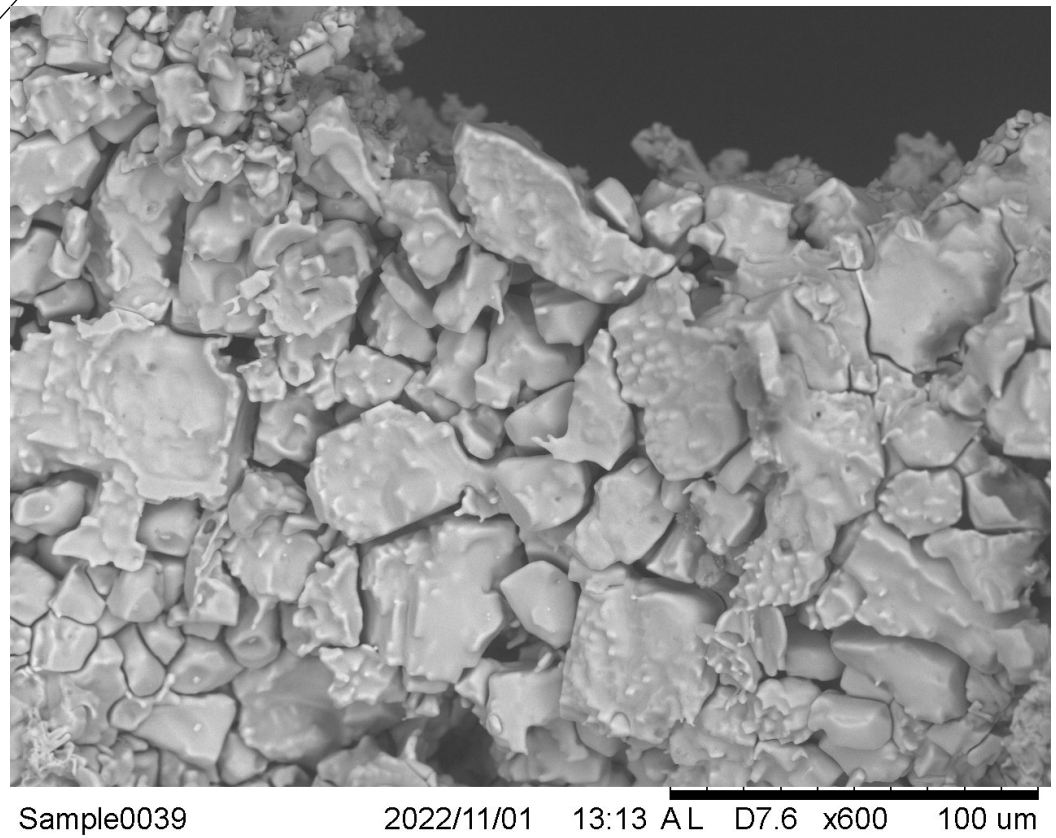
- Consequentie: ander kristallisatie gedrag en daardoor ander droog gedrag

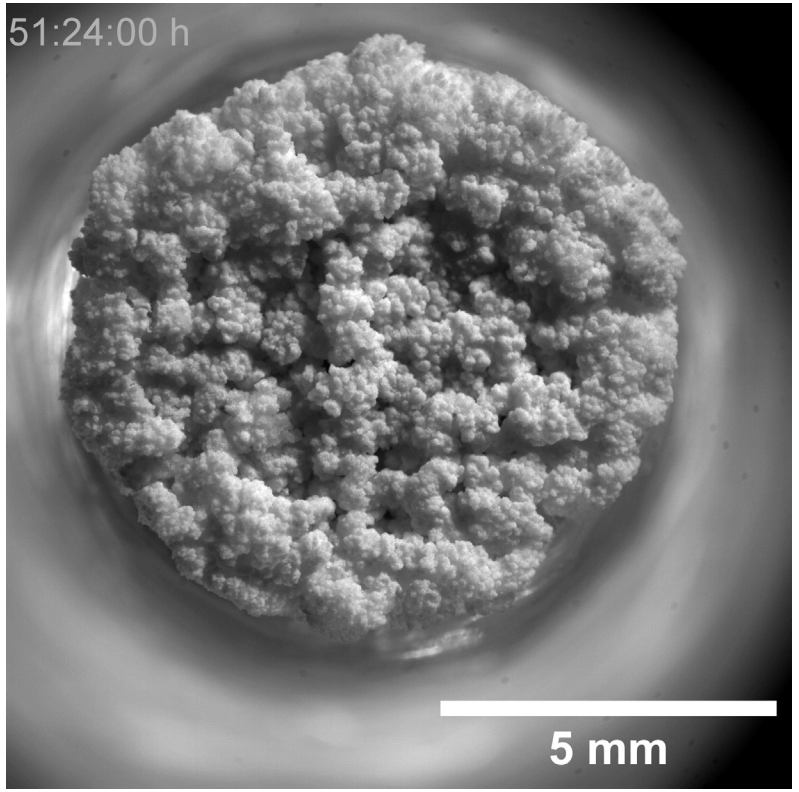
- Klein oppervlak: veel kristallen buiten de kegel die loskomen van het oppervlak
- Groot oppervlak: kristallen vormen laag op de steen en zitten heel erg vast


‘In time
and with **Ions**,
and difference in
surface area
everything
changes’

Extra slides

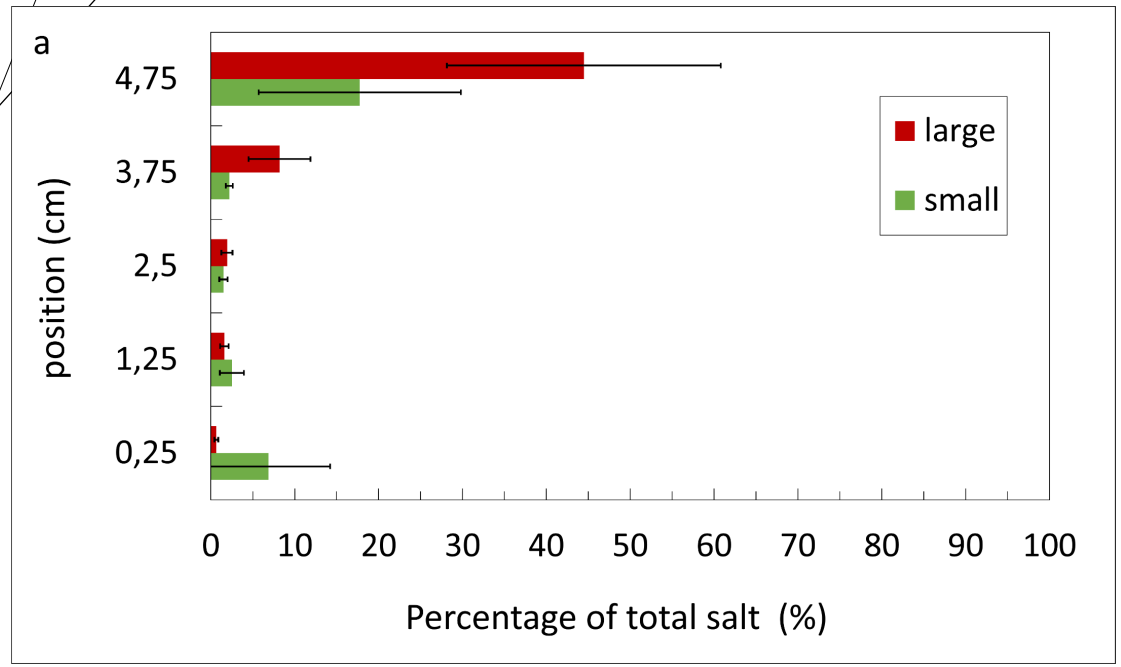
No Adhesion on the surface of the small top

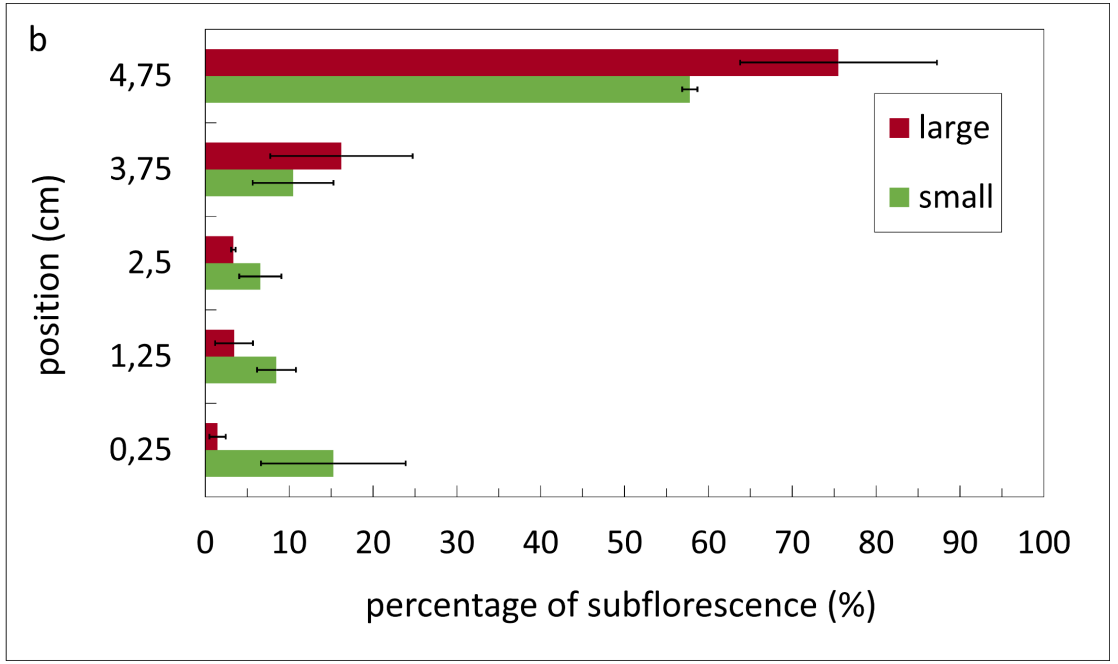




The salt crust lifts itself up from the surface during drying due to downwards diffusion of the ions trough the porous salt crust

Zout dat achtergebleven is in de kegels





Titration shows:

- Large top 57% of salt inside cone
- Small top 31% of salt inside cone