Why do I study foams?

the 1001 reasons...

PLAN

- *introduction*

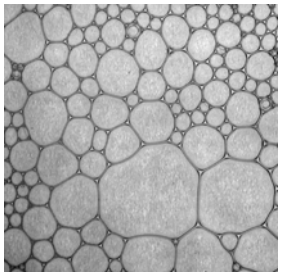
- *applications in industry and in daily life*

- *applications in research*

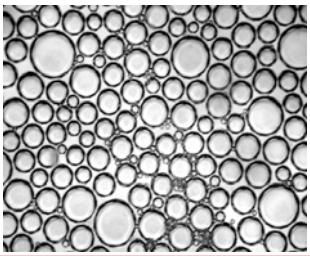
WHAT DO WE TALK ABOUT ?

liquid foams

gas bubbles separated by a continuous liquid phase



liquid fraction Φ :
liquid / **total** volume



wet or dry
no consensus on this distinction

emulsions

liquid drops separated by a continuous liquid phase
diluted or concentrated
analogous to liquid foams
different density and dynamics

solid foams

gas bubbles separated by a continuous solid phase
closed or open cells

Andre & Simon's lectures

WHY DO WE STUDY FOAMS ?

- *fundamental questions*

  structure, coarsening, rheology, drainage

- *model for other systems*

- *applications*

Properties

Structure
low density
large surface per unit volume
large amount of air
small amount of material

Chemistry
amphiphilic
selective affinity
variable stability : destroyed
or made permanent (solid)

Mechanics
elastic
plastic
fluid
transition between these

Insulates
temperature
sound
chemicals

Waves
scatters light
scatters sound
damps shocks

First part
foams in industry
and in daily life

foams which are

according to my taste :

necessary
useful

mostly in industry
visit www.aquafoam.com

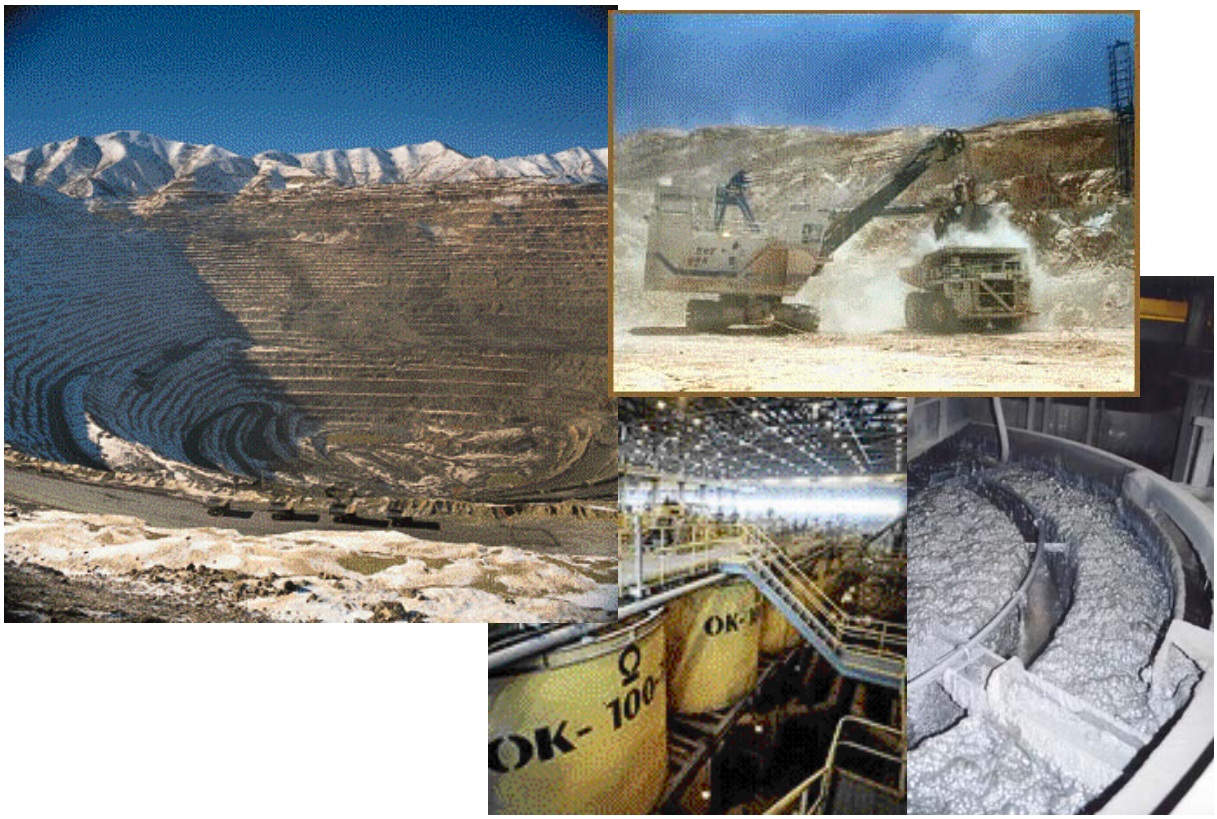
pleasant
useless

mostly in daily life

unpleasant

when foams are necessary

Mines : separation of ore by flotation



Separation

in mines

in chemical industry

large scale	*water purification*
small scale	*separation of dyes*

selective affinity	*the foam attaches to particles*
rheology	*the foam can carry particles*
low density	*the foam goes up*

Fire fighting

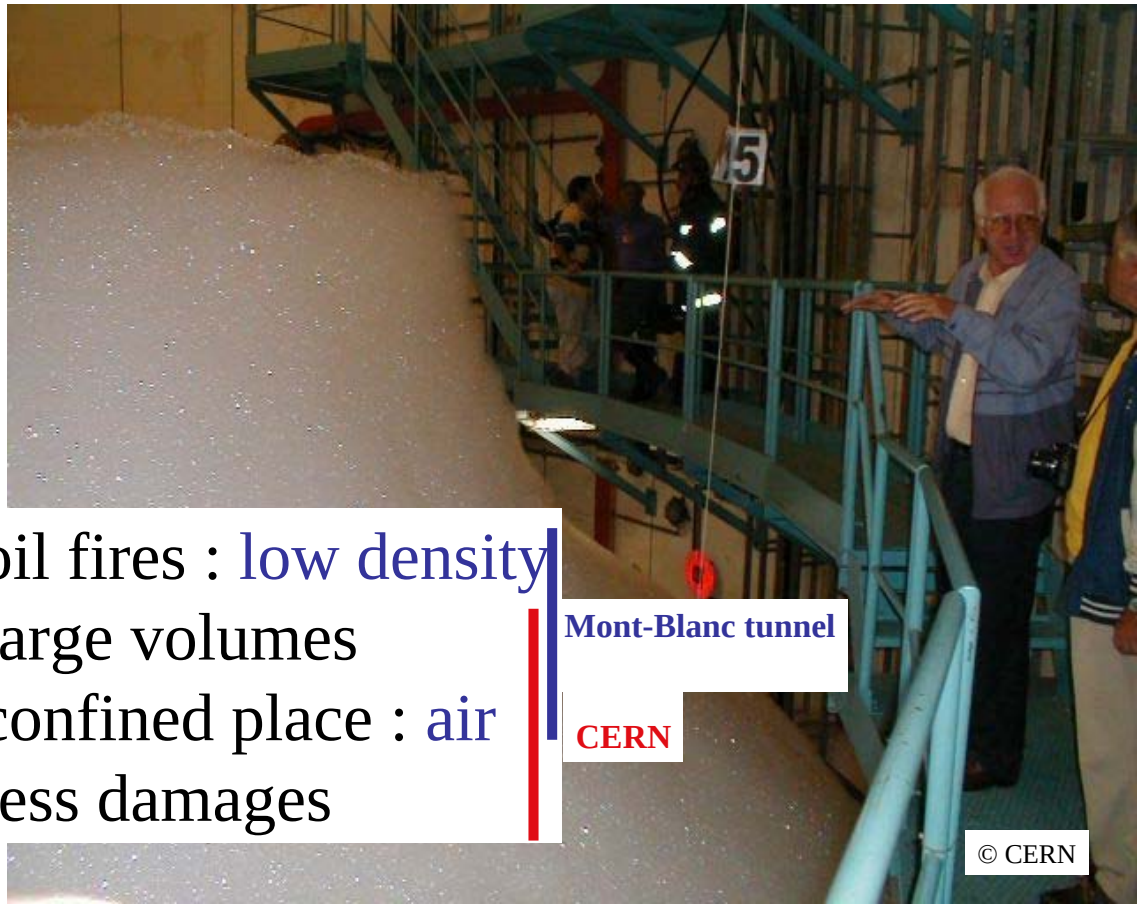
© Poncet

Foam was used this week to put out the largest peace-time fire in Europe (although they ran out of foam!)

: http://www.guardian.co.uk/buncefieldfueldepotblaze/story/0,,1665424,00.html

"Hertfordshire fire service defended its decision to contain but not fight the fire for much of yesterday, saying it had been too hot to get close enough. A spokesman admitted lacking the necessary stocks of foam to fight the fire, but said it had assembled 250,000 litres of foam concentrate from fire services across the country. Last night fire fighters began extinguishing the blaze under floodlights. They planned to work in three-hour shifts, pumping 25,000 litres of water each minute from sources including the Grand Union canal two miles away.
The fire could burn for a week, they said."

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.



Prevention of accidents

spills

prevention of fire

chemical and nuclear leaks (liquid or gas)

Preparation of solid foams

good

bad

© J. Banhart

when foams are useful

Industrial cleaning

amphiphilic
less material used
(less cost, less wastes to be treated)

nuclear decontamination
semiconductor industry

Oil

drilling liquid

extraction
to block
the gas

Mechanical properties

Oil industry
extraction : prevents water or gas
from passing through pores
drilling : pressurised fluid
evacuation fluid

Controlled Foam Injection :
high-pressure foam to fracture rock and concrete.

Coal : traps dust and dangerous gas

see lectures by Andrew, Sylvie and me

Active agent

asbestos removal — foam with an inorganic acid + fluorine source to degrade magnesium and silica-containing asbestos

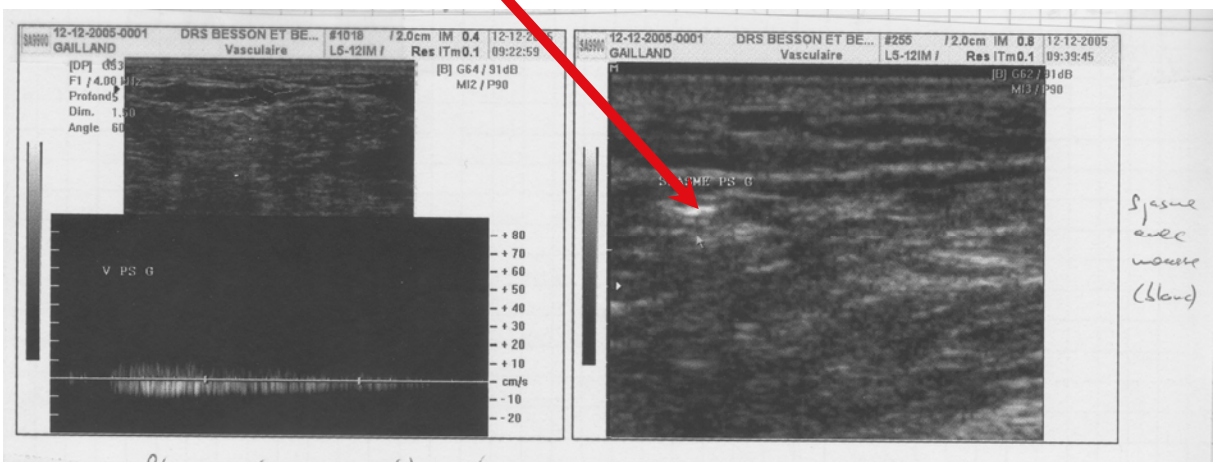
treat fibers
treat crops
herbicide
termiticide
spermicide

Active agent in medicine

Dr Benbarka *from Grenoble's « Foam club »*

veins : varices

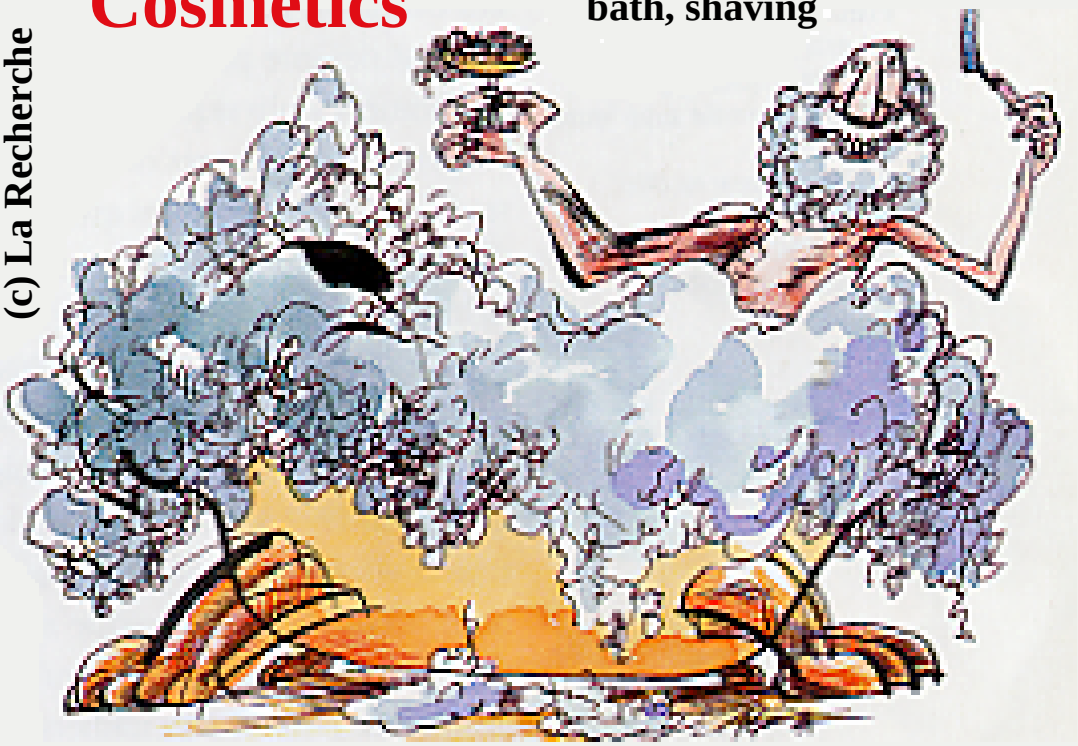
better flow properties
inject 6 times less product
visible at echograpy for real-time control of injection



when foams are pleasant

Cosmetics

bath, shaving



(c) La Recherche

Drinks

champagne
beer
cider
soda

Food

different ways to increase the sensation
- fat
- alcohol
- salt
- air **= foam**

restaurant El Buli (Catalunya)
Fantin-Latour (Grenoble)

omelette norvégienne
bake an ice cream in an oven ?
yes, surrounded by a foam
egg white + sugar

QuickTime™ et un
ompresseur TIFF (LZW)
pour visionner cette image.

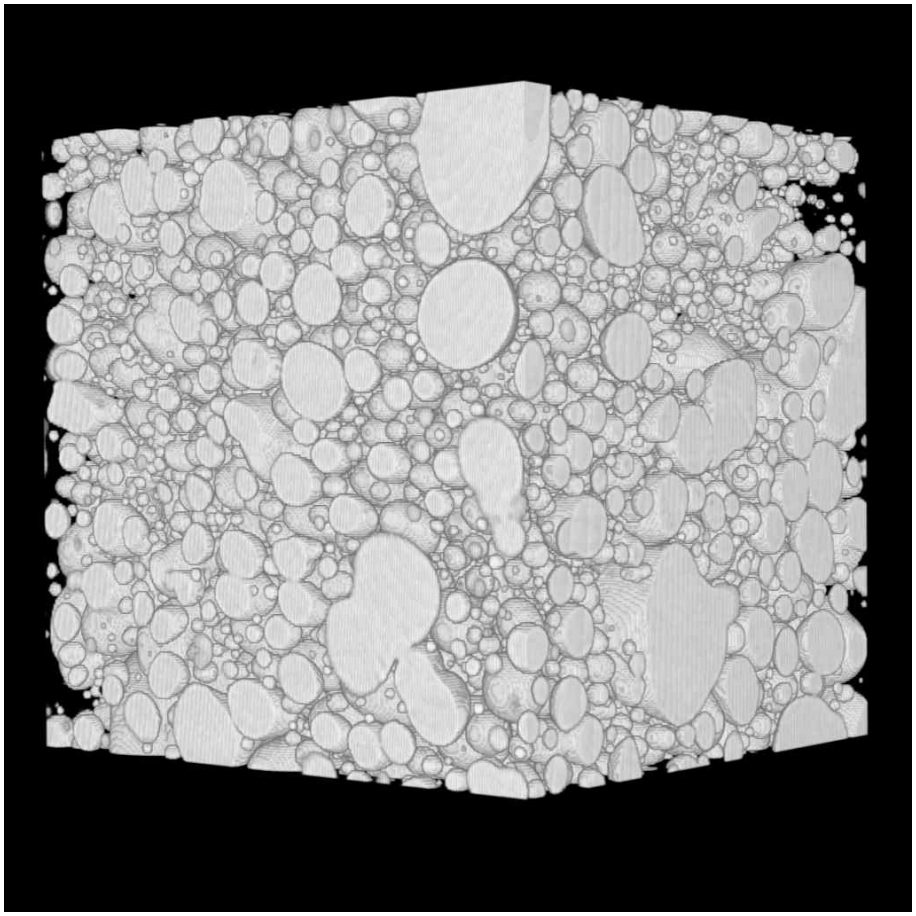
QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

Chocolate mousse

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

Photos :
C. Goldenberg
Les Houches
foam school



3D image

see Rajmund's talk
and my 3rd lecture

photo P. Cloetens, ESRF

in M. Adler, F. Graner, Pour la Science

Foam parties

require

- second-hand firemen's machine
- empty room
- N x 400 litres of water
- corresponding evacuation
- warn participants

swimming suits, T-shirts

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

motivation : close contact

popular science

science festivals
schools
World Year of Physics

See Antje's demonstration
and thursday evening's chat

Large bubbles

N. Thomas

QuickT
décompress
sont requis pour vis

A soap wall ?

Water and dishwashing liquid, dripping on two fishing wires, pull them gently apart

QuickTime™ et un
décompresseur H.263
sont requis pour visionner cette image.

QuickTime™ et un décompresseur
Photo - JPEG sont requis pour visualiser
cette image.

QuickTime™ et un
décompresseur H.263
sont requis pour visionner cette image.

Blow it like a bubble

10 m high !

15 m high…

… and 100 millions times thinner

P. Ballet
F. Graner
Villeneuve (Grenoble)
mai 2005

QuickTime™ et un décompresseur
Photo - JPEG sont requis pour visualiser
cette image.

shake hand

across

a soap film

18 m high

2 m wide

μm thick

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

art


It is really useful
because it is beautiful
St Exupéry *The Little prince*

On stage

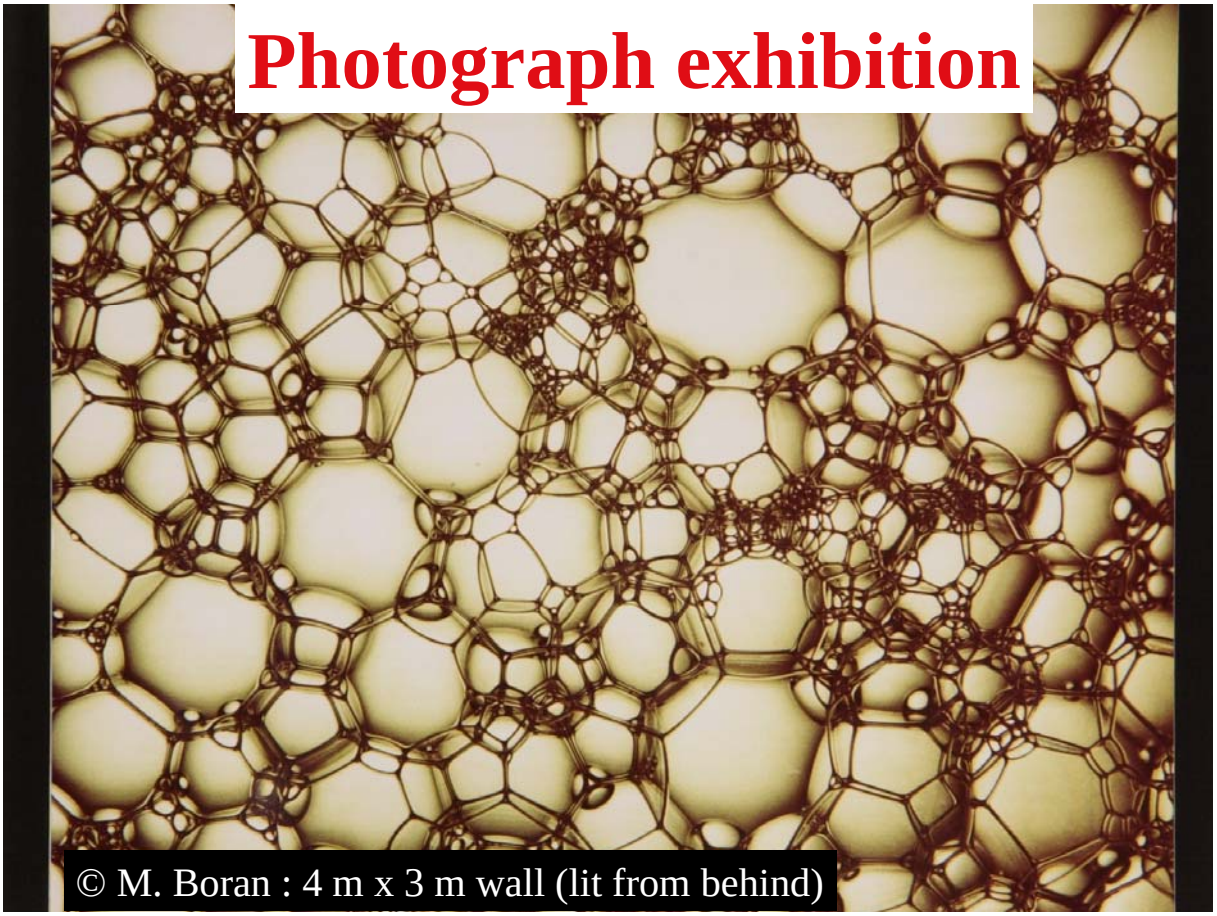
Foams	movie	**The Party** Blake Edwards Peter Sellars
Giant bubbles	theater	**Macbeth**
Giant films	dance	**Dalcroze (Geneve)**

Performances

or magic
mostly with bubbles

Photo © Tom Noddy

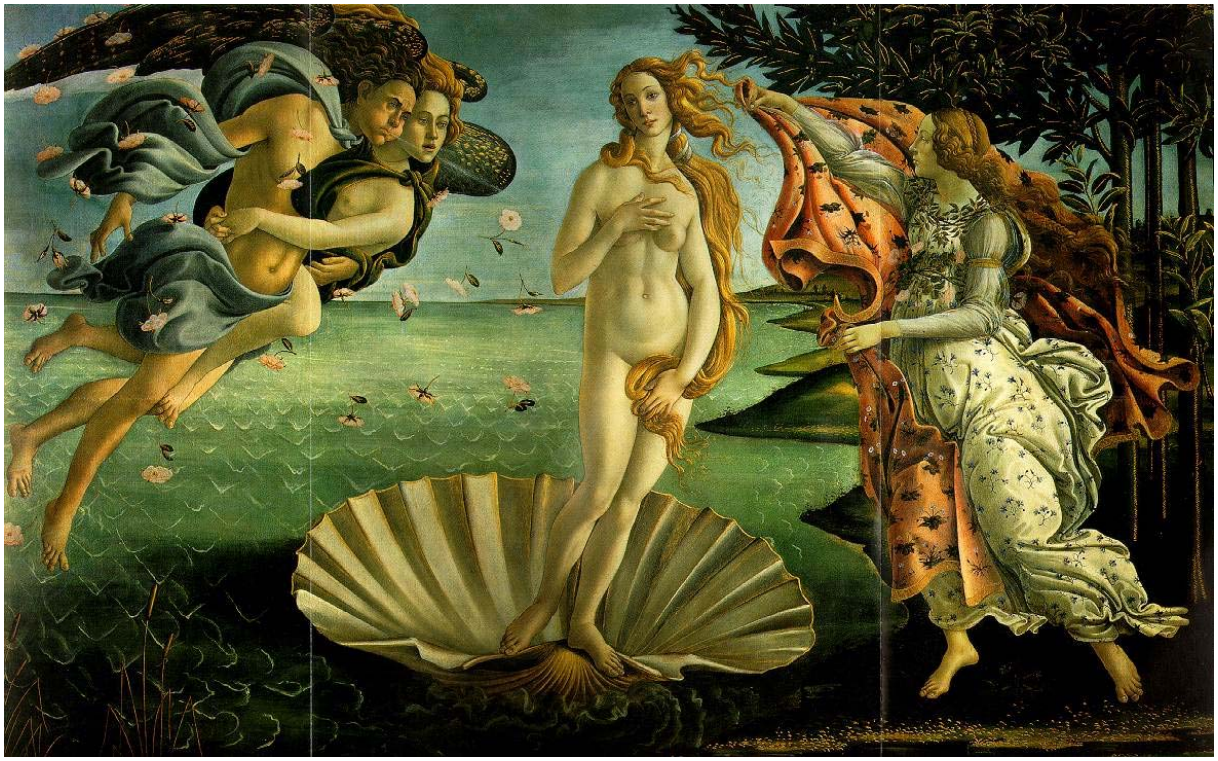
Photograph exhibition



© M. Boran : 4 m x 3 m wall (lit from behind)

Painting

Aphrodite = born from the foam



Birth of Venus, Sandro Botticelli, 1486

foam dynamics = aphrodynamics

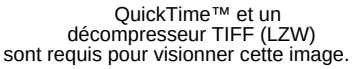
when foams are useless

domestic cleaning

consumers union's test *Que Choisir ?*

oven cleaners with and without foams are equivalent

when foams are unpleasant



Harmful by-products

Requires an antifoam Nikolai's lecture

- Water pollution
- Washing machine clothes, dishes
- Stomach acidity requires drug + antifoam
- Industrial processes
  - paper
  - decantation basins
  - water-based paintings
  - fermentation
  - sugar

High flow rates

Strombolian eruption
due to foam bursting
in the magma chamber
photo S. Vergniolle

QuickTime™ et un décompresseur TIFF (LZW) sont requis pour visionner cette image.

Shishaldin
Etna, Kilauea,
Piton de la
Fournaise

Military, repression

QuickTime™ et un
décompresseur TIFF (non compressé)
sont requis pour visionner cette image.

Military, repression

- riot repression
- H bombs :
  - fabrication
  - storage
  - elimination
- protection against toxic weapons
- forced explosion of bombs and mines
- silencer for guns
- mask a boat's propeller wake

Second part
foams as model systems

see also Florence's lecture

grains in crystals
2D foams
biological cells
miscellaneous

grains in crystals

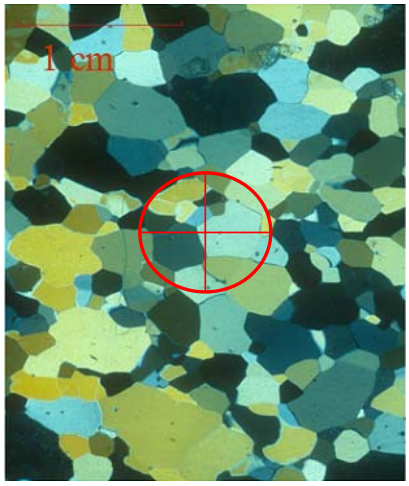
coarsening

C. Smith 1952

Rivier, Weaire, Glazier

see Rita's talk

Microstructure: witness of deformation



362 m

under crossed polarizers

2629 m

Grains have different shapes

Antarctica ice
Durand, Weiss, Graner

2D foams

-visualisation
-simpler theory
-simpler simulations
-no gravity

Observation & force measurement

Langmuir foam
1 molecule thick

QuickTime™ et un décompresseur Cinepak sont requis pour visualiser cette image.

image = 800 μm

S. Courty et al.

Three types of 2D soap froths

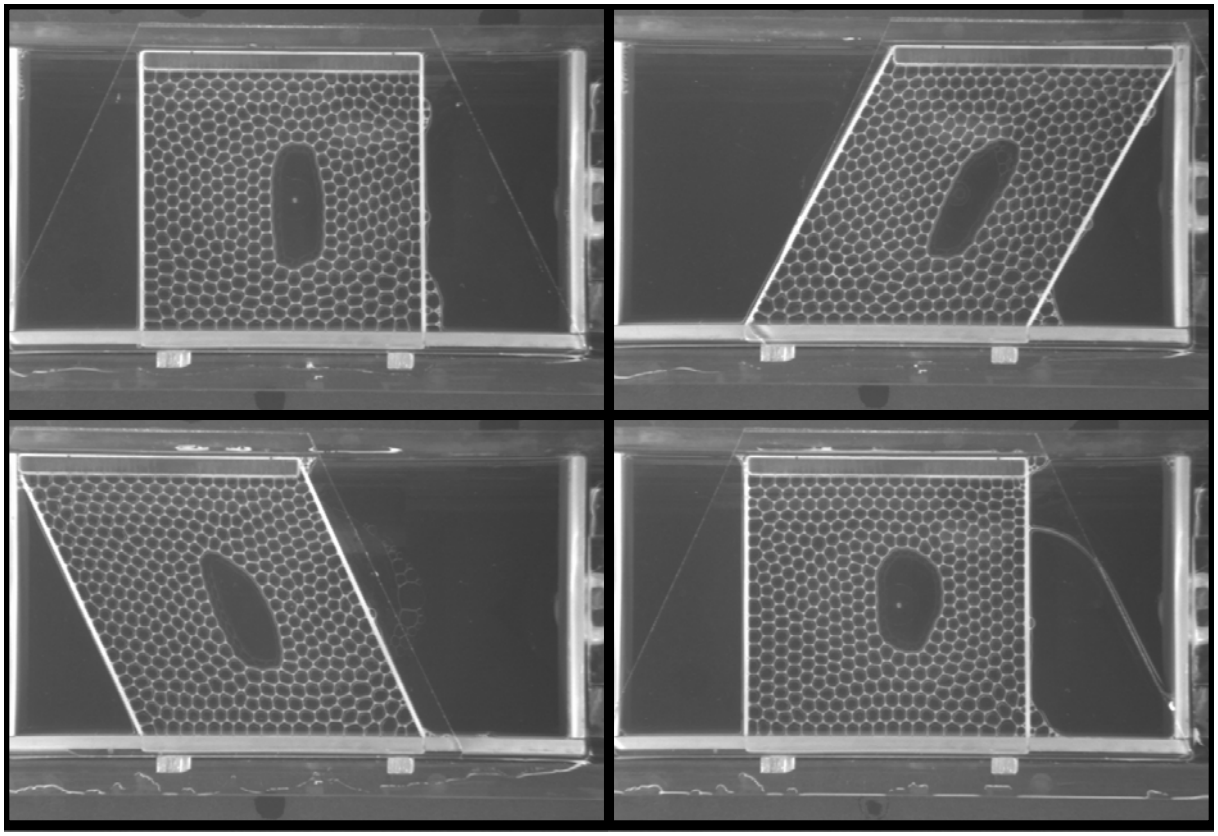
different fluid fractions **different external friction**

Cox, Vaz, Weaire

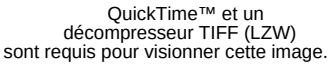
QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

bubble raft **compressible foam** **Hele-Shaw**

talk by Kapil *demonstration by Christophe* *lecture by Wiebke*



Shearing cycles **Model for elastic properties** C. Quilliet et al.



E. Janiaud

ferrofluid foams

emulsion of oil *slow time scales*

in iron-laden water *can be manipulated*

Sorting according to size

model for perimeter minimisation problem

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

annealed foam
E. Janiaud et al.

biological cells

see also Jos' talk

Drosophila wing

later more hexagons why?

QuickTime™
décompresseur T
sont requis pour visionne

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

Classen & Eaton
(Dresden)

4

5

1 6a

2 6b

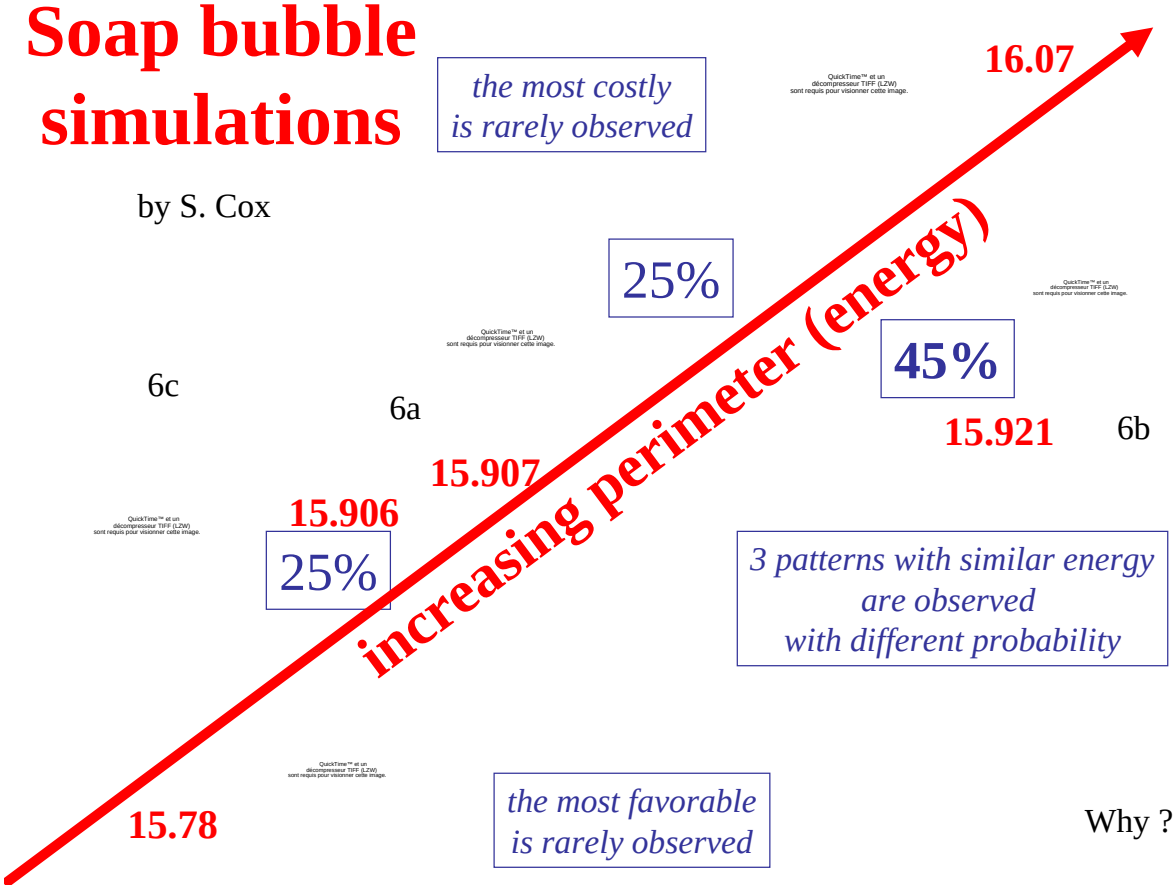
3 6c

Retina cells & bubble clusters Hayashi & Carthew

Soap bubble simulations

by S. Cox

the most costly is rarely observed



3 patterns with similar energy are observed with different probability

the most favorable is rarely observed

Why ?

miscellaneous

Vesicules

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

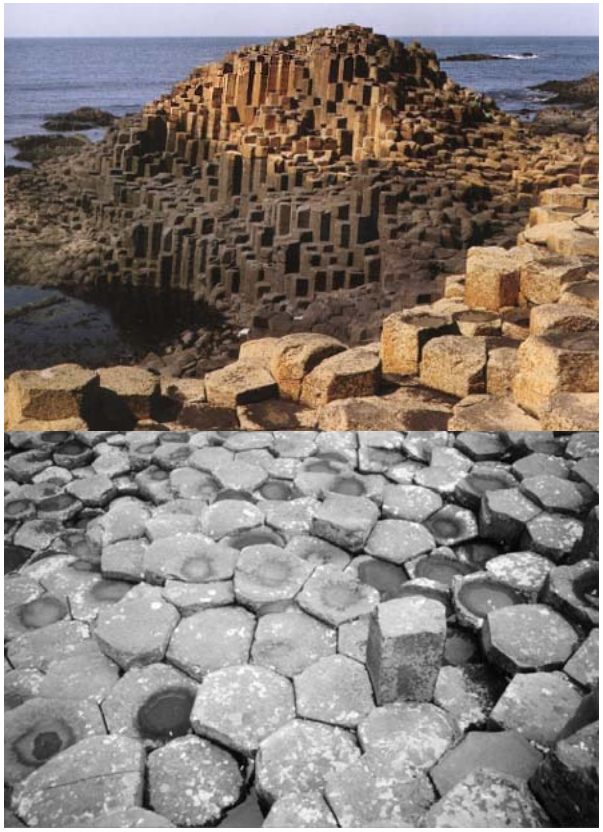
size ~ 10 μm

O. Sandre

Fractures

QuickTime™ et un
décompresseur TIFF (LZW)
sont requis pour visionner cette image.

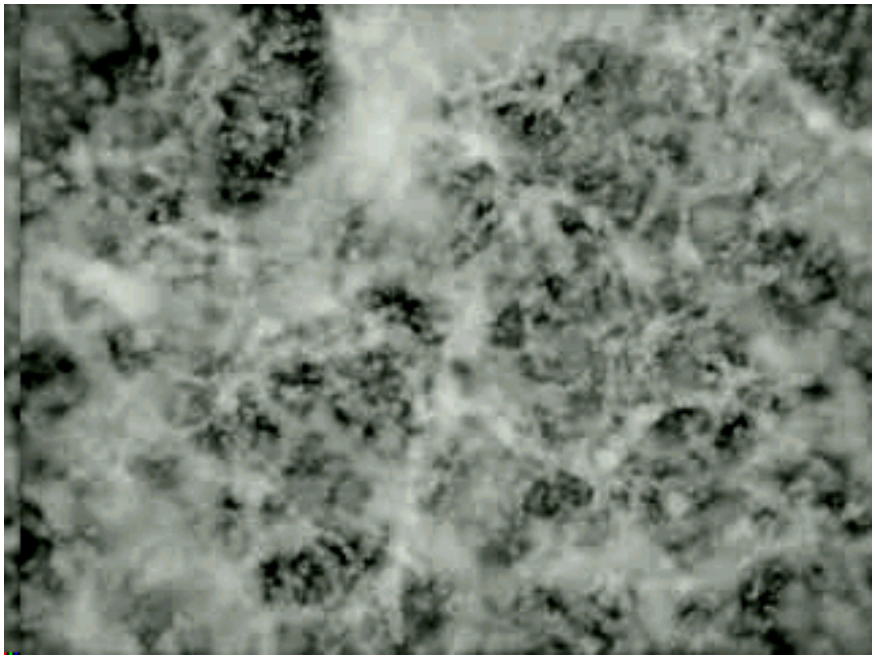
Giant's causeway, Northern Ireland



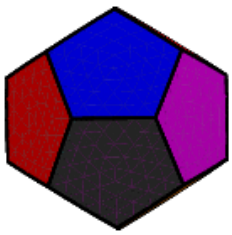
Salt lake, Uyuni, Bolivia / (c) Depardon

Astrophysics

A new fashion ? The distribution of galaxies looks like a foam



Joerg Colberg.,
Jenkins et al,
Astrophysical Journal,
499,20-40, 1998



S. Cox

**Is the whole universe
a dodecahedron
obeying Plateau rules
& periodic boundaries ?**

The end ?

it depends on you