

(dm-)Beach Creation by Breaking Waves

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Walsh Cottage GFD, July 2010

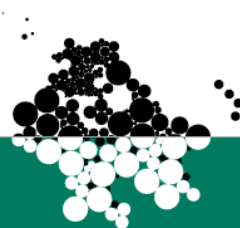
Thanks: Wout Zweers & Anthony Thornton, Hans Kuipers

Stichting Qua Art Qua Science project:
“Fluid Fascinations” with artist Valerie Zwart
inspired by Prof. Howell Peregrine

<http://www.math.utwente.nl/~bokhoveo/> & SFFF

IMPACT

INSTITUTE OF MECHANICS,
PROCESSES AND CONTROL TWENTE



Motivation

- Qua Art Qua Science presentation and exhibition **Fluid Fascinations** by artist Valerie Zwart & OB:
<http://www.zw-artprojects.nl/fluidgallery.html>
- Mixed media/oil paintings and digital photoworks.
- Inspired by fluid dynamics insights & slide collection on wave phenomena of late Prof. **Howell Peregrine** (1938-2007).



... Howell Peregrine...

- British applied mathematician on surface wave phenomena
- editor -28 years- Journal of Fluid Mechanics
- **used slides/photos of waves in nature/outdoors for scientific research** to obtain ideas & observations
- iconic scientific value, versus esthetical value in art (Kemp's *Visualizations*)



- E.g.,
Spring tide
oil
painting
by Zwart
- splashes
...



- E.g., *Falls*
mixed media



Hydraulic Jumps

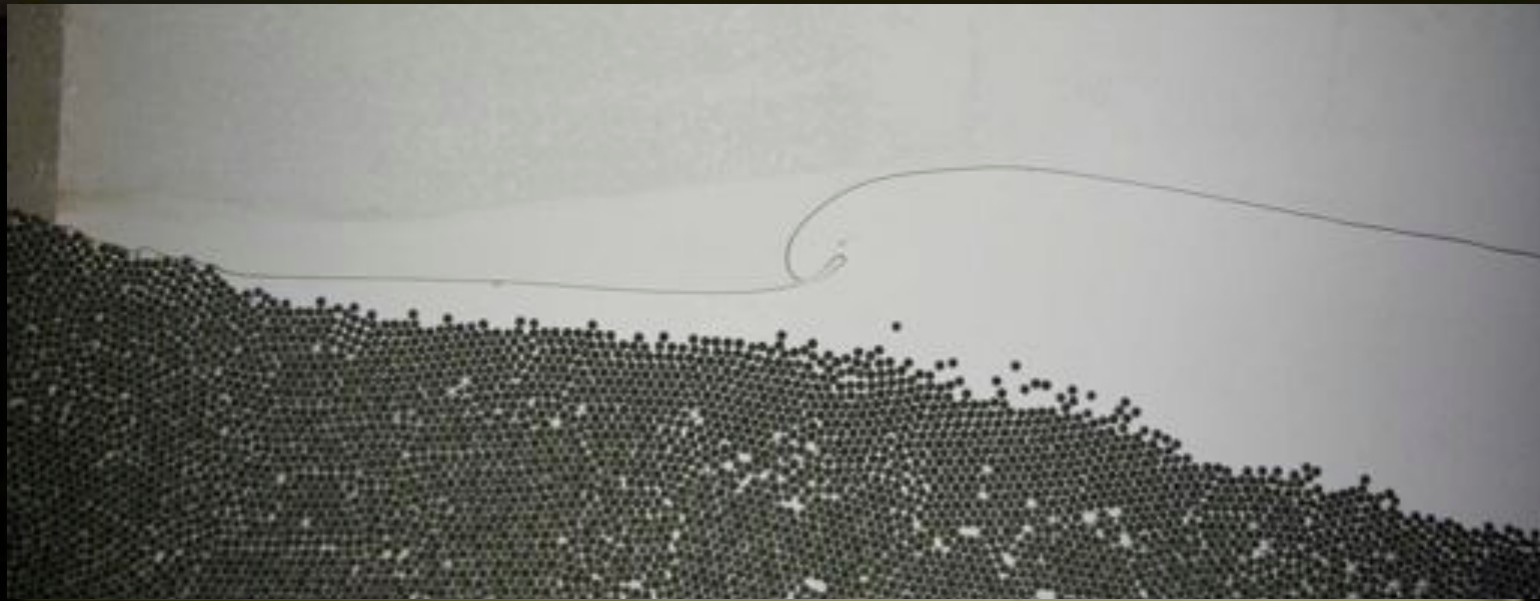
- Prominent presence in Peregrine's slide collection



Visualisation in Art & Science

- Masters: generate ideas via visualisations and sketches.
- scientists, engineers and mathematicians all work hard to transform new ideas into models/formulas
- most ideas fail; only a few reach maturity.....
- Applied maths of fluid dynamics always contains elements of playful curiosity ...
- ... playing on beach, Hele-Shaw cell (Kuipers) ...

Theatre of waves and sand



Dynamics of waves and sand

- Preliminary laboratory set-up $60 \times 30 \times 0.2 \text{ cm}^3$:
 - with artist/designer **Wout Zweers**
- 1st goal: playing and visualising (iconic value)
- 2nd goal: thorough mathematical/numerical modelling:
 - depth-averaged multi-phase/scale models
 - quasi-3D numerical multi-scale models
- **looking through a dynamic beach and wave ...**

Intermezzo on design





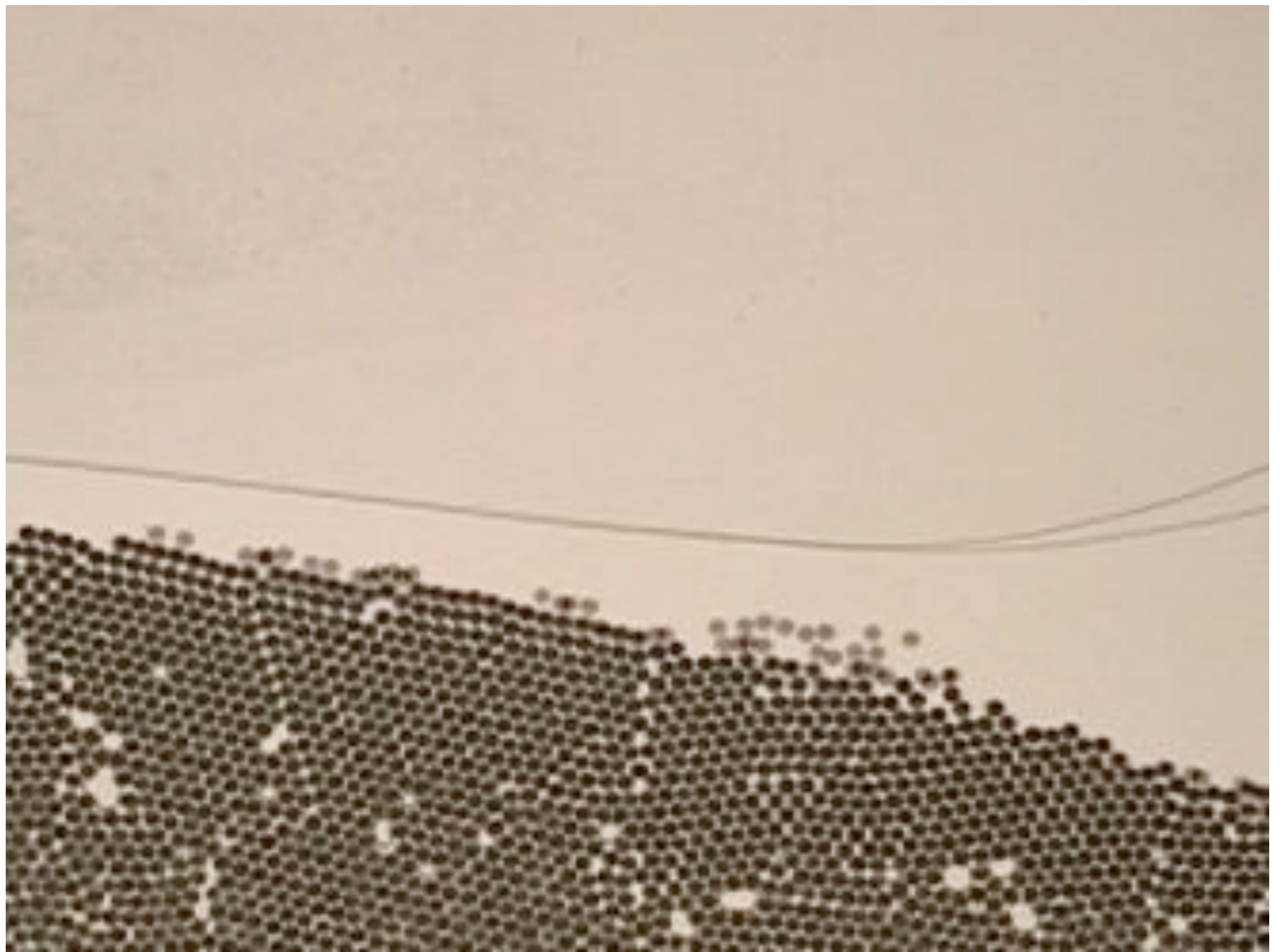
Laboratory Set-up Specs

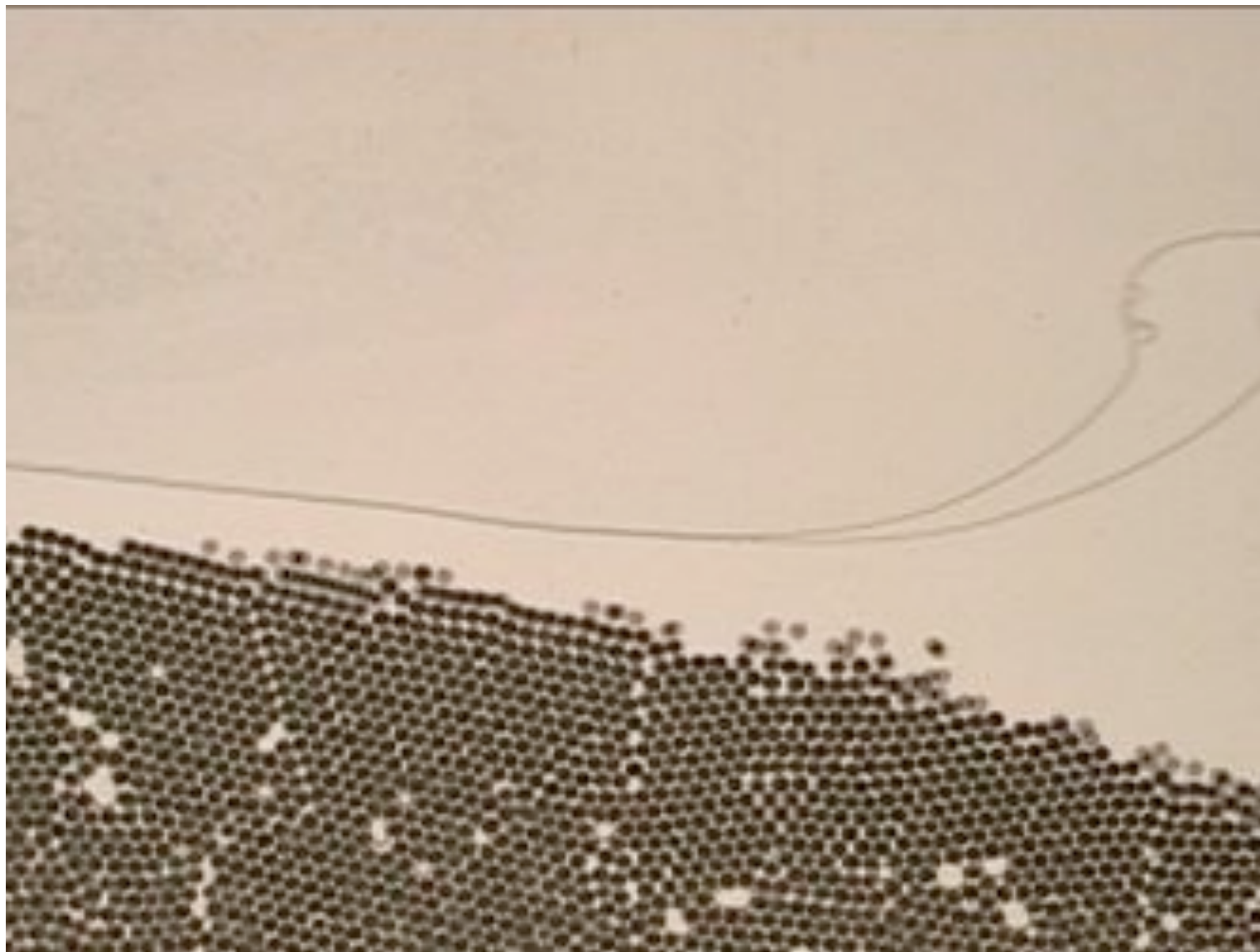
Quasi-3D; 2D vertical “Hele-Shaw set-up”:

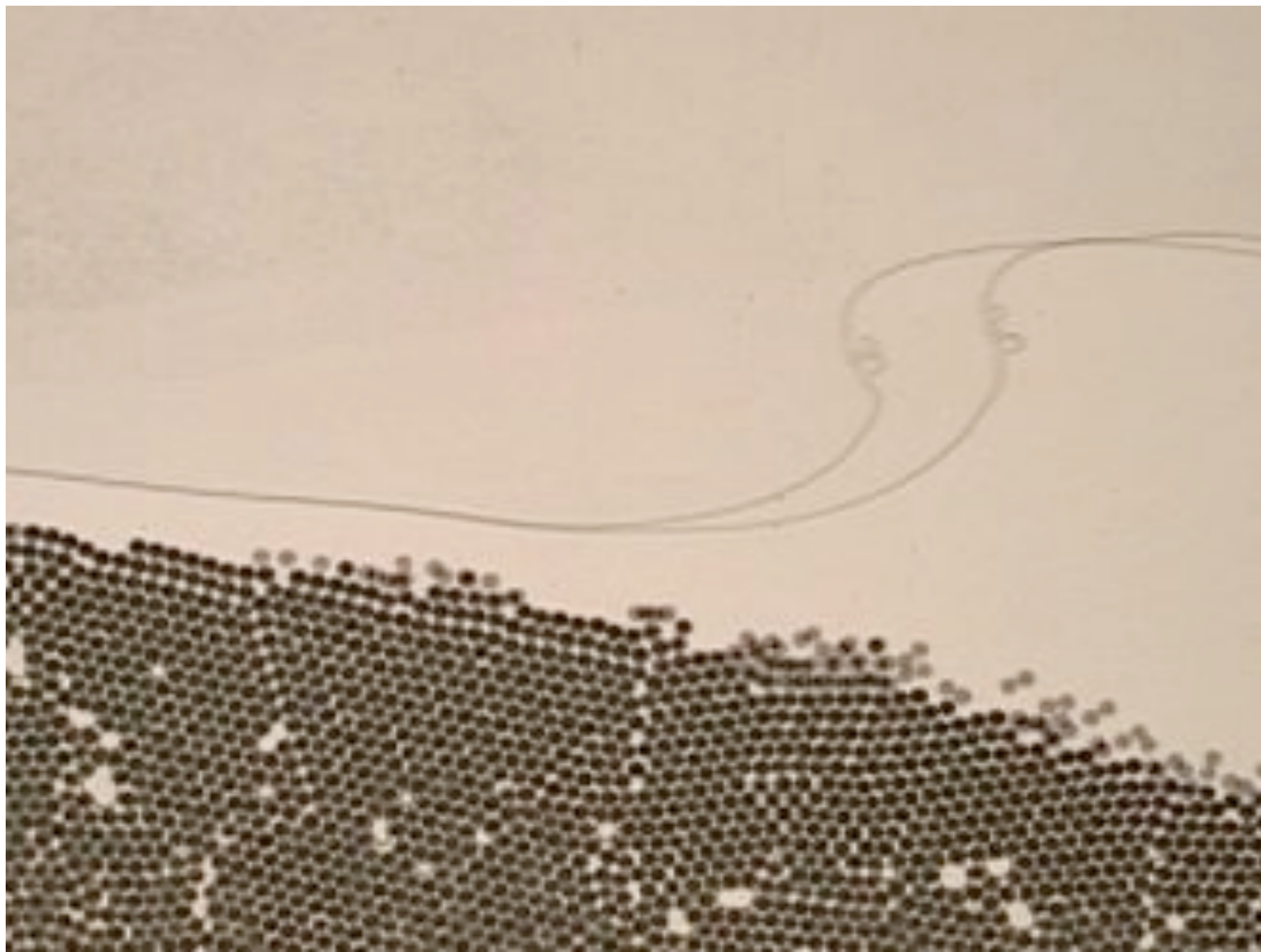
- 2 vertical glass plates (100x30 or 60x30)cm²
- 2l=2 mm or 8mm gap
- d=1.8 mm zeolite (clay) whitish particles
- density ~1780kg/m³
- water and interface
- wave maker: 1.5mm; 0.7-1.4Hz rod (driven)
- video camera (low res. 1/48s, 50ms interlacing)
- video camera (high res. 1/200s)
- still camera 1/750s

the construction, empty tank and [wave maker](#):

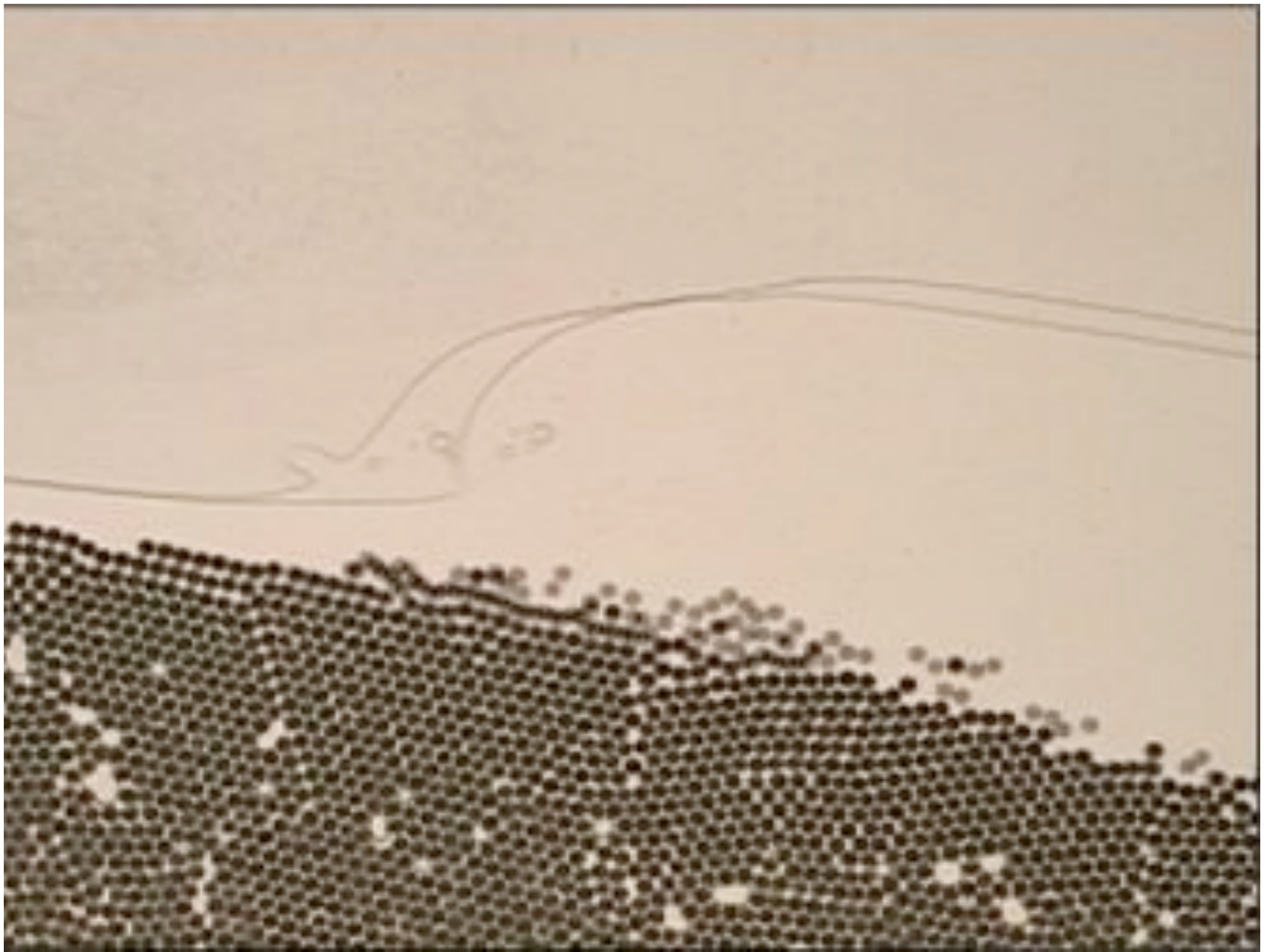


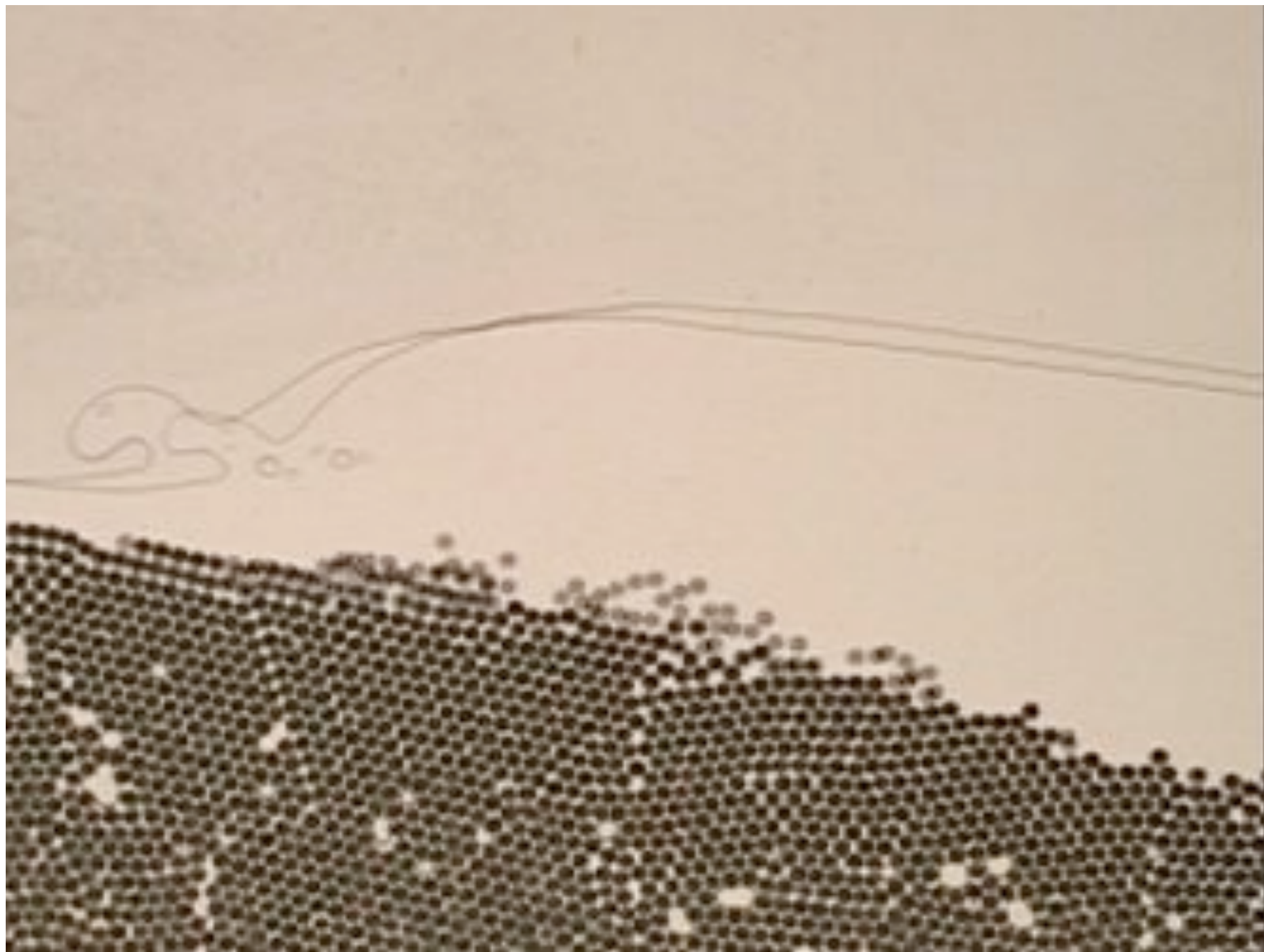


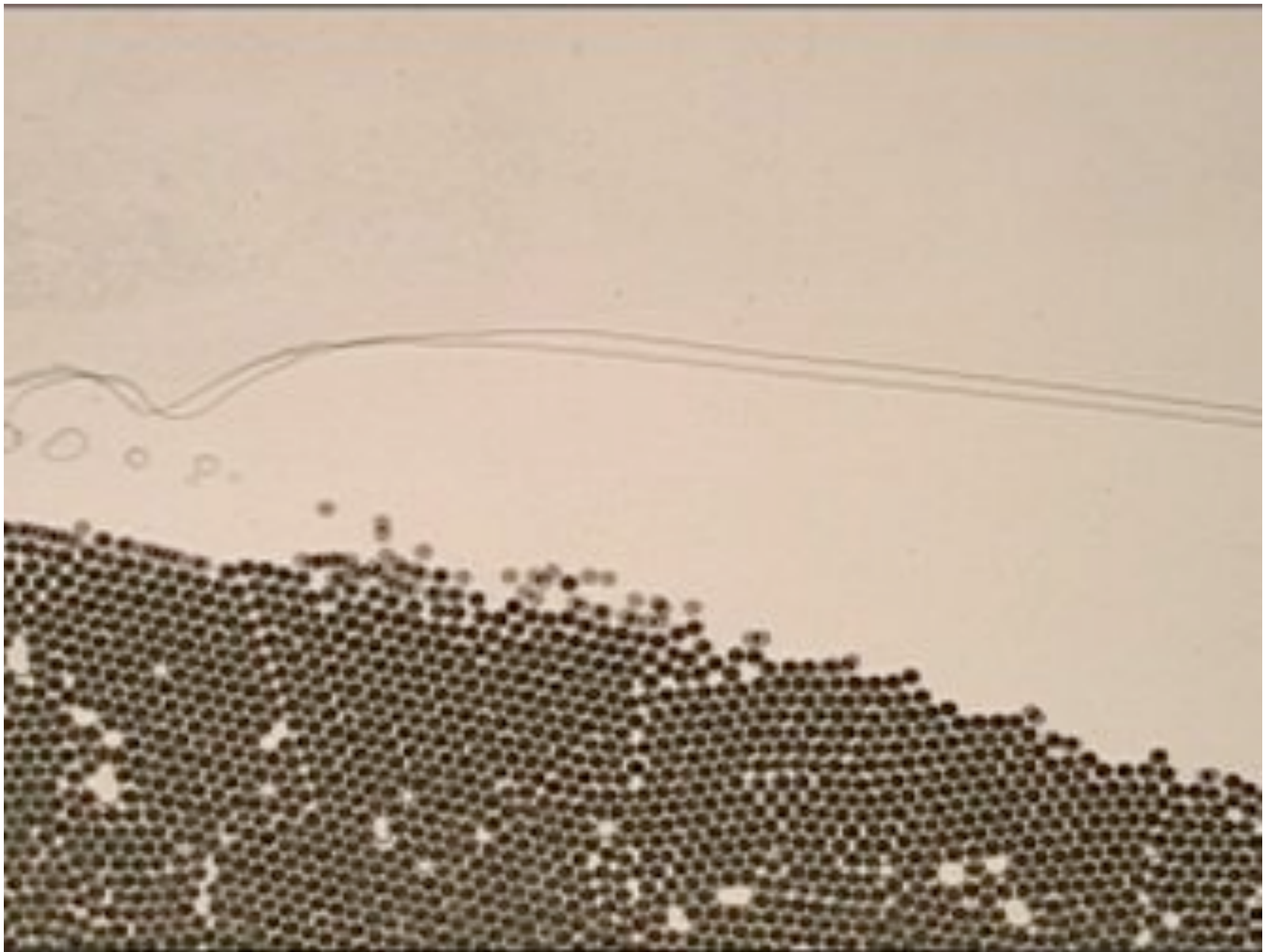


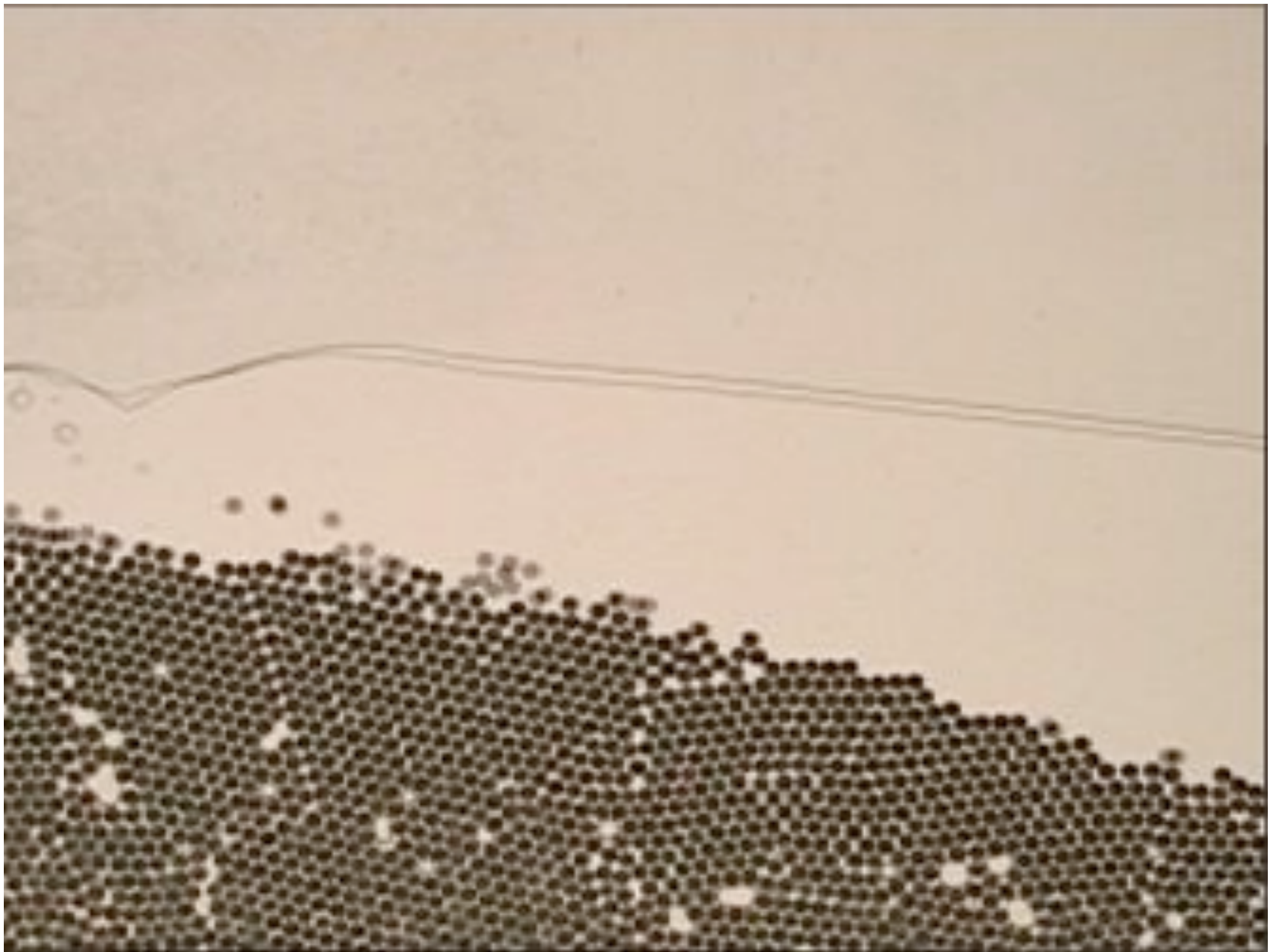


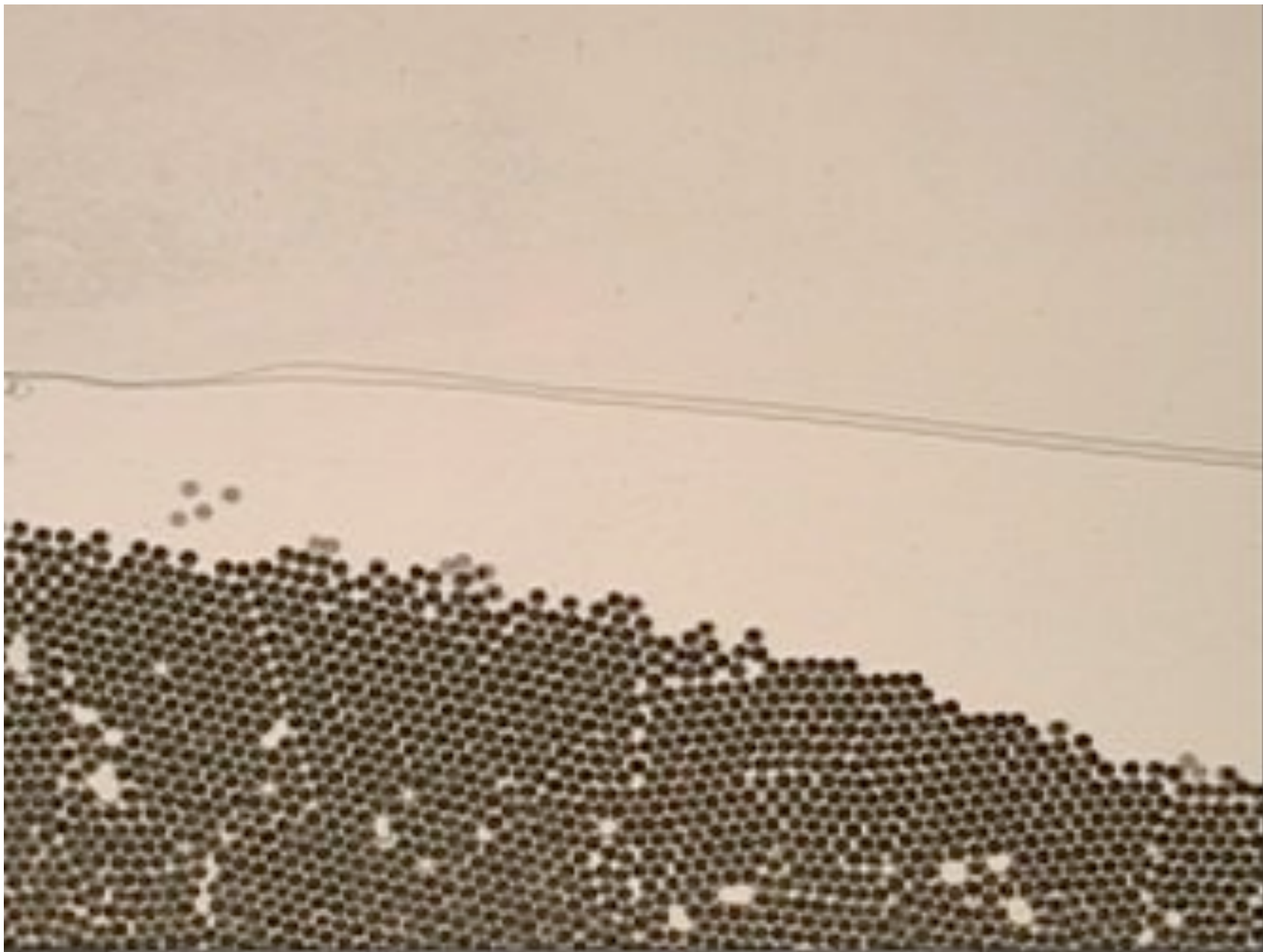




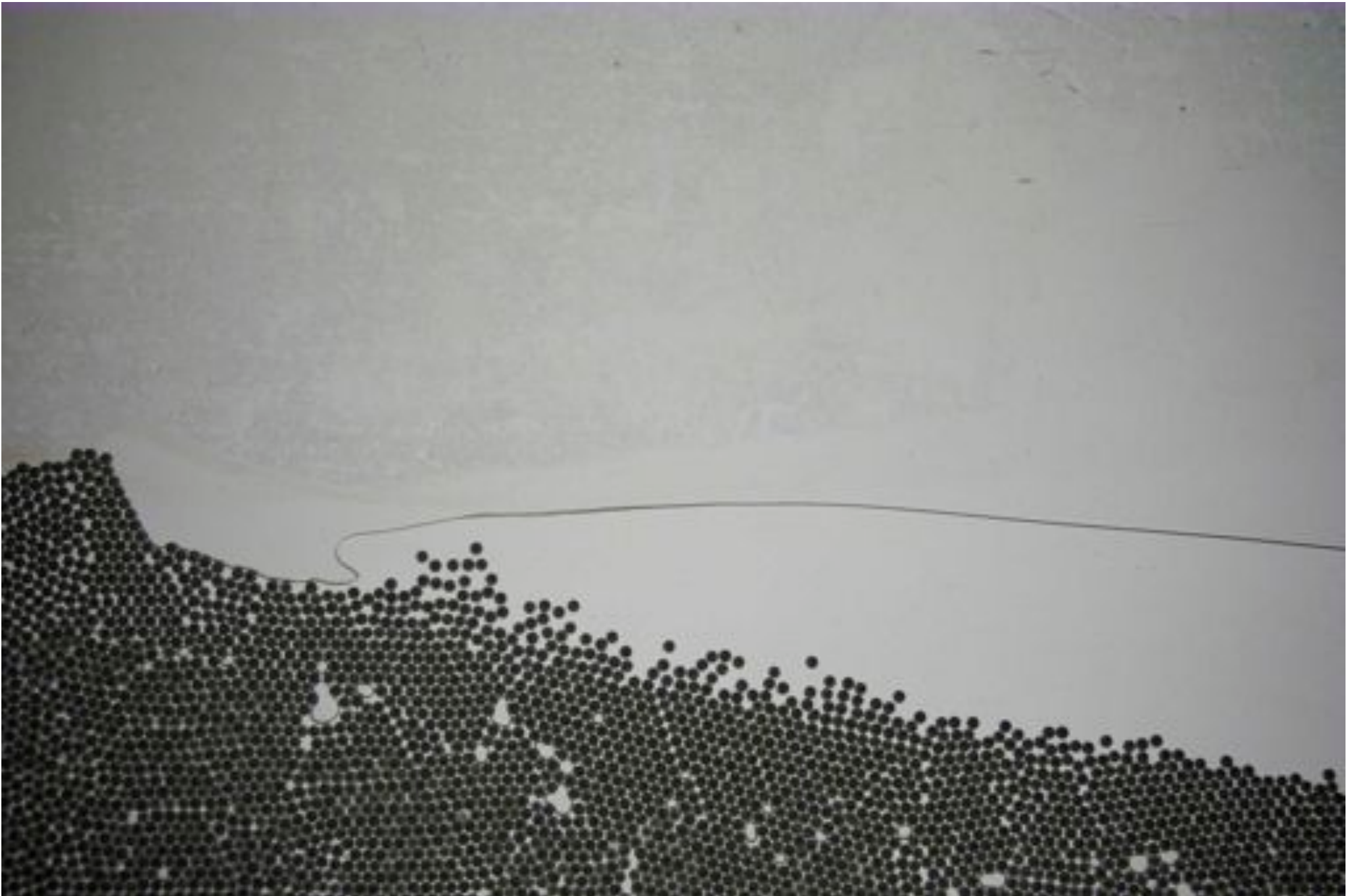




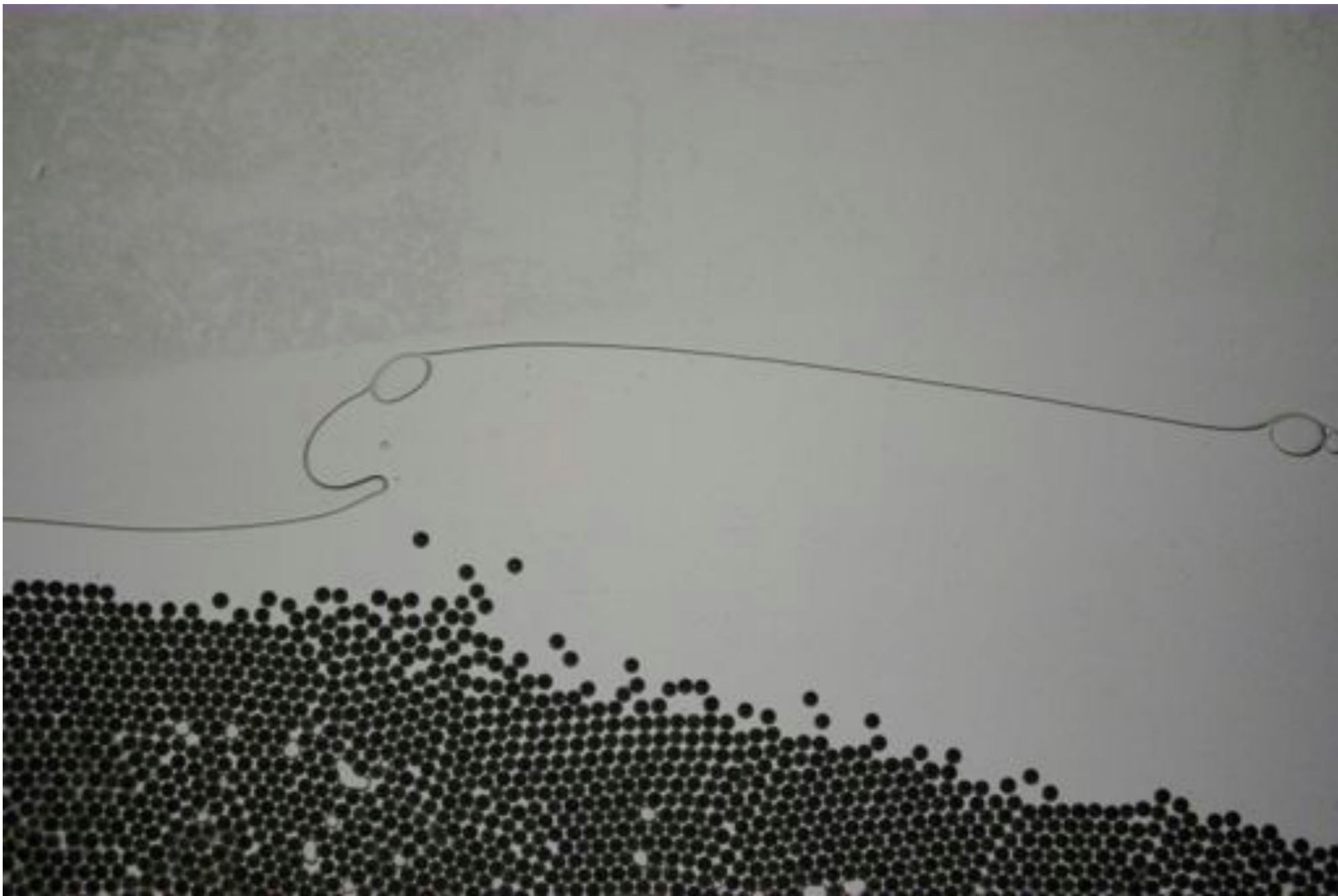




behind waves sand is swung upwardly



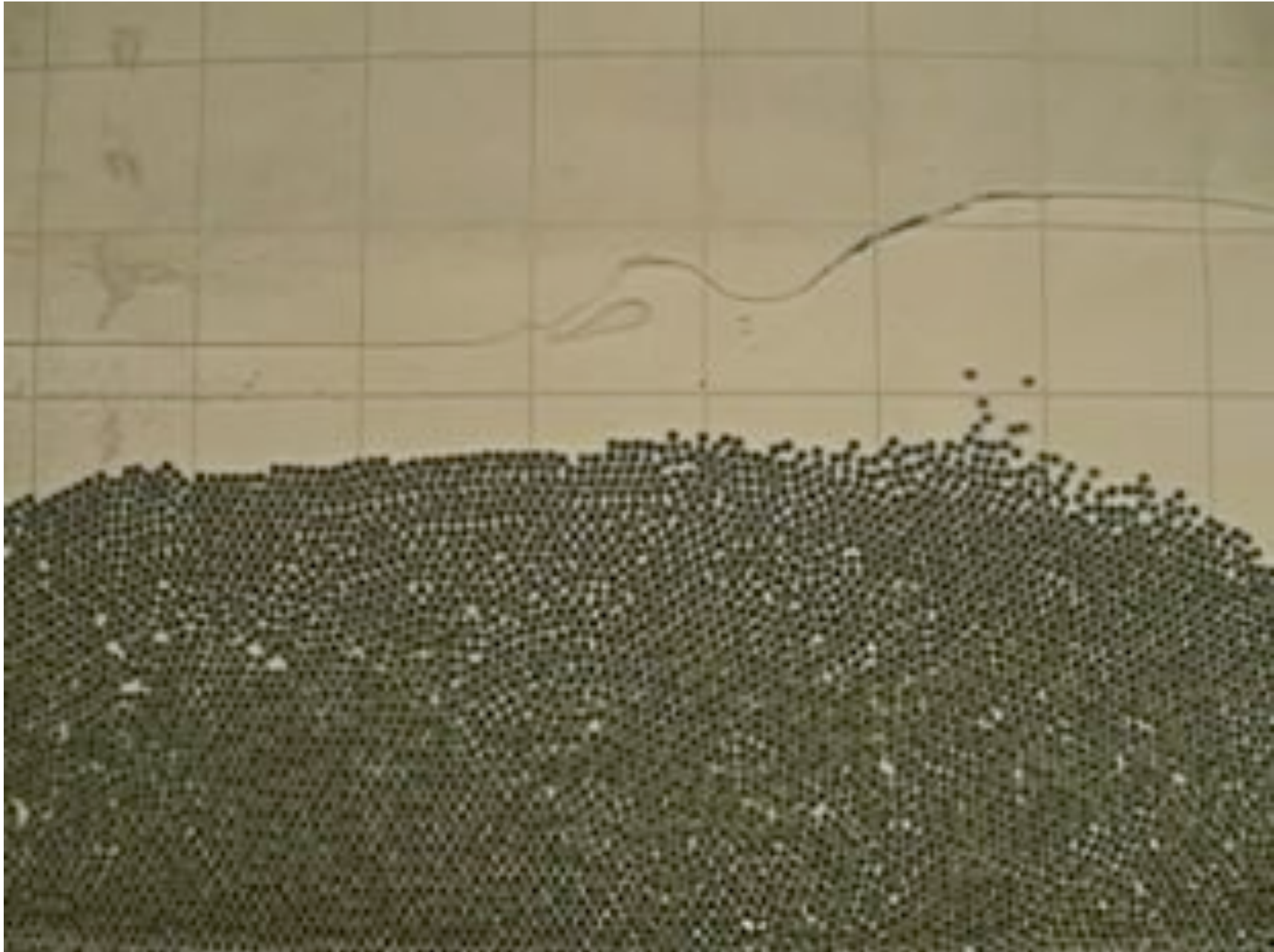
wave breaking: 1/750s stills



broken wave with enclosed bubble



close up Wave Breaking



Creation of a Beach

1. 30x faster; overview
2. 60x ...
3. 20x ...; zoom



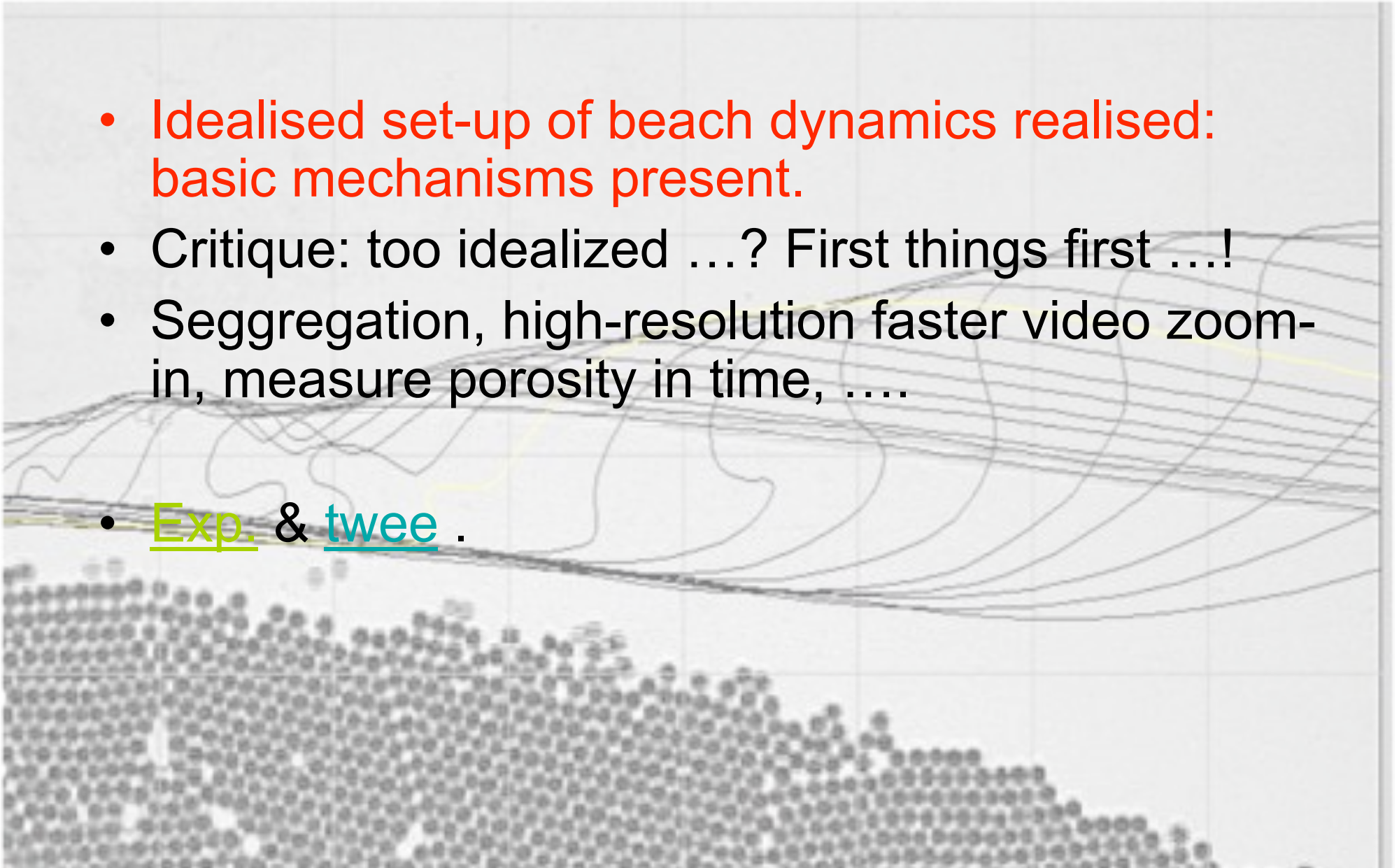
Qualitative Results

10 experiments (29-06 no films, new 100x30cm² set-up):

- **Minimum & maximum frequency** to form beach; more amplitude = better.
- 2 frequencies not as good.
- **Hypothesis**: beach forms because sea has energy in all frequencies; slow because only bit of correct frequency.
- Depth of beach set equal to height fixed beach; initially waves did not break, but as depth shallower get breaking waves.

Discussion

- Idealised set-up of beach dynamics realised: basic mechanisms present.
- Critique: too idealized ...? First things first ...!
- Segregation, high-resolution faster video zoom-in, measure porosity in time,
- Exp. & twee .



Outline Modelling

- ~Measure porosity to force hydrodynamics.
- Continuum modelling: shallow layers/
Boussinesq eqns/porous layer
Cotter&B, JEM'10; Klopman'10
- Discrete Particle Modelling with drag (layer/
entire) & 2.5D hydrodynamics ...
- Heterogeneous Multi-scale Modelling

References

- V. Zwart and B. 2010: *Fluid Fascinations*. Stichting Qua Art Qua Science,
<http://eprints.eemcs.utwente.nl/17393/>
- Images: <http://www.zw-artprojects.nl/fluidgallery.html>
- M. Kemp 2000: Visualizations. *The nature book of art and science*. Univ. California Press.
- Cotter & B. 2010: Water wave model ... Peregrine issue JEM.
- Klopman 2010: Ph.D. Thesis. Univ. Twente.