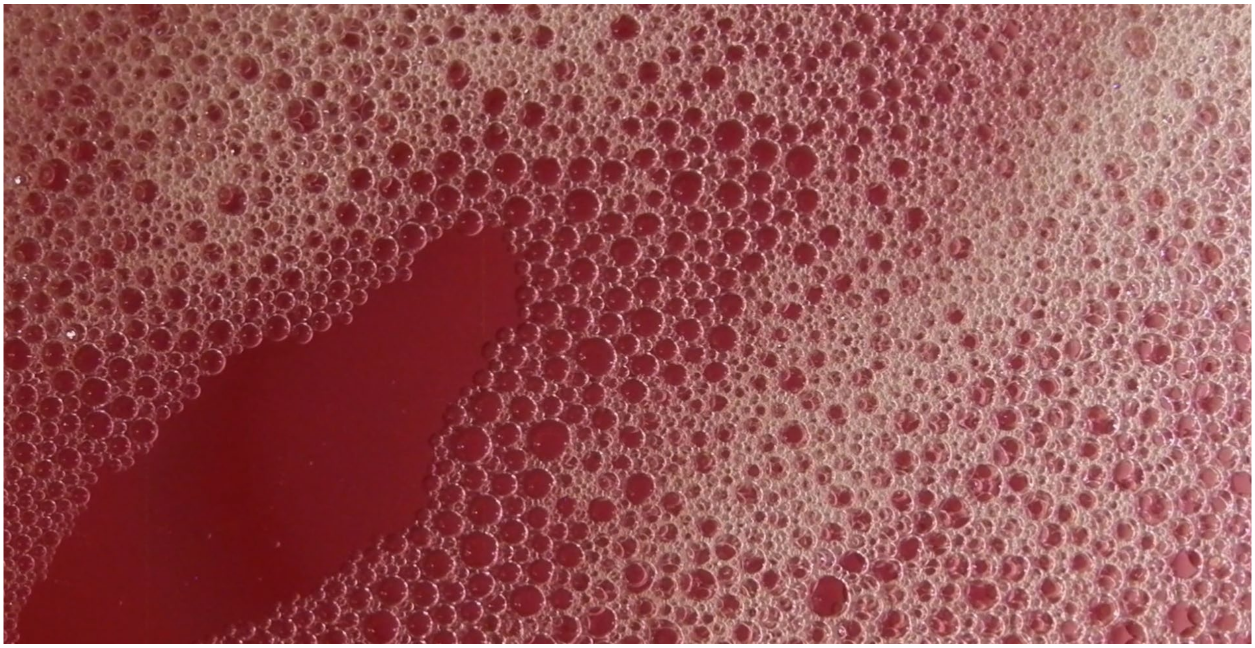

Team 3 Report: Bubble Rafts!

Kate French

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Flow Visualization Fall 2024

Assistance from: Sarah Hastings and Lia Cucuzzella

Note: See the Video!

Introduction:

In my materials science course, there was a unit about metallic solids' failure, which contained information about slip planes, close-packing of spheres, grain boundaries, and more. My professor showed us a little video about slip planes, with bubbles on the surface of a liquid used to mimic and show the behavior of close-packed metal atoms as they slip at 45 degree angles from the applied force. I was fascinated. Since then, I have wanted to recreate this experiment myself – pushing bubbles around on the surface of water and seeing how they slide by each other in the same way that metal atoms slide by each other within a metallic crystalline structure. Thus, my scientific intent was initially to produce and capture that phenomenon. As I tried things, however, more phenomena also became intriguing, both scientifically and artistically – blowing on the bubbles to get them down to more uniform sizes (having hand-mixed the bubbles, resulting in different sizes of bubbles) created fascinating effects of bubble popping, spreading, un-layering, and more. Artistically, I wanted to create a video which could capture this fluctuation and development, and having the human lungs in their variability as the blowing tool was chosen to add more dynamics and a sense of life (ebb and flow) into the process documented. I wanted to show how the bubbles behave when disturbed, and how they settle when given a brief respite.

Fluid Mechanics:

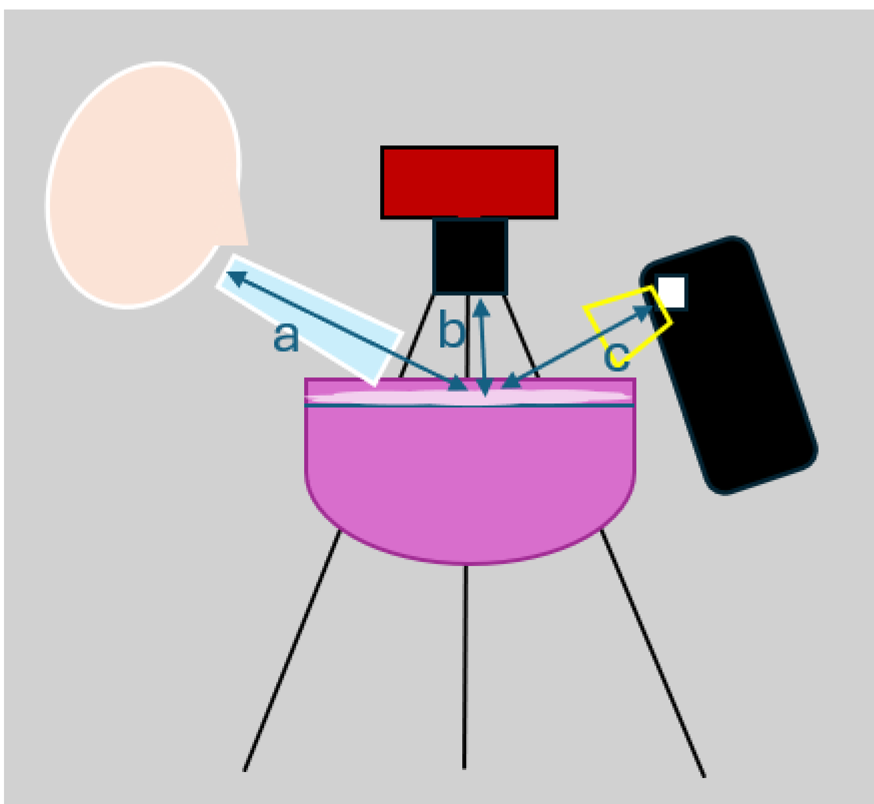

Figure 1. *Set-Up.*

As shown in Figure 1, the set-up consisted of a pink bowl, soapy water, a camera with a tripod, a phone flashlight, and a human with lungs.

The water was mixed with a squirt (not measured, but not a ton) of Dawn Ultra dish soap. When the soap was added first, followed by the water, the water hitting the bottom of the bowl through the soap caused the soap to create a large number of medium-small bubbles of near uniform sizes. When the water was added first, followed by hand-mixing (using one's hand like a fork when whisking eggs or other substances), the sizes of the bubbles was more varied. Both methods were used for different clips in the video.

After the bowl almost full of soapy water was bubbled and ready, it was placed on a counter with a camera facing down above its center, zoomed in enough that the edges of the bowl were not visible. The lights in the room were turned off, and a phone flashlight was held to the right of and above the bowl by one person, while another person blew on the bubble raft from above and to the left, as shown in the schematic.

When blown upon, the bubbles with more diverse sizes tended towards a more uniform size: the largest bubbles popped, the medium-sized bubbles spread out, and the tiny bubbles either disappeared around the medium-sized ones or merged into larger (medium-sized) bubbles.

The bubbles were moving a couple of inches per blow. They reconvened when allowed to settle. They clips do show slip planes,[1] as well as other phenomena. The slip planes are 45 degrees away from the direction of force application. As shown in the image below, the close-packed groupings of uniformly sized bubbles form hexagons with a seventh bubble in the center, and the bubbles slide next to each other in rows (any two adjacent bubbles form a possible line of slip).

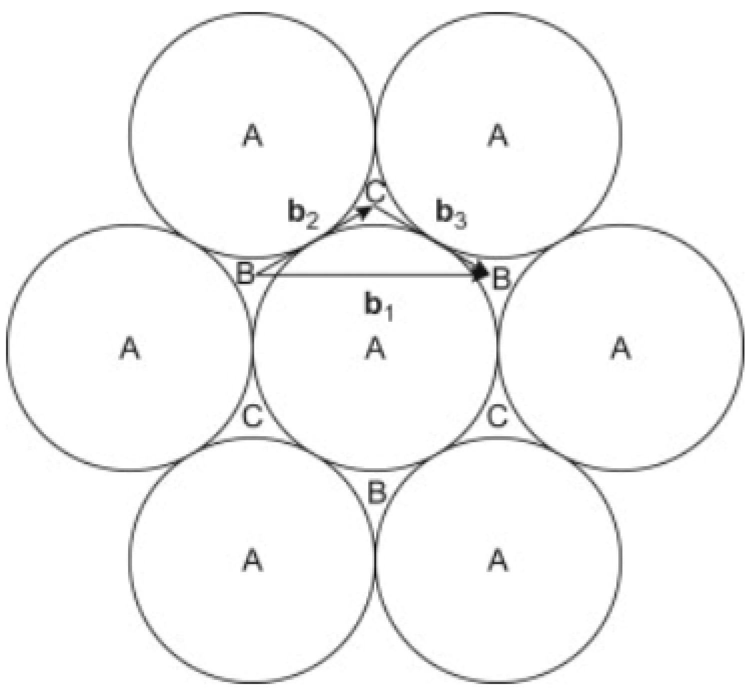

Figure 2. *Image of Close-Packed Spheres from Hull & Bacon*

The video shows this sliding at points where the bubbles are being blown or as they are settling back together between blows in the first two videos clips.

Photographic Procedure:

The various video clips were taken on a Nikon COOLPIX P500, a compact digital camera. The focal length was 9 mm, ISO 200, f-stop f/5.6, pixels 1920 x 1080, and frame rate 29.97 frames/second (for both recording and playback). The camera was held about 4 inches above the center of the bowl (distance b in the schematic), focused such that the bubbles were in focus, and zoomed such that the edges of the bowl were not visible. The camera was placed on a tripod to avoid any jittering during filming.

For lighting, a Samsung S22 Ultra's flashlight was held approximately 5 inches away from the center of the bowl, diagonally at an angle of 15-30 degrees above the raft surface (distance c in the schematic). The blowing took place from the opposite side from the flashlight, with a distance of 8-12 inches away, and an angle varying from 15 to 70 degrees from horizontal (distance a in the schematic). The distance, angle, and intensity of the blowing varied between the different clips; overall, the blowing was not very hard, because the goal was to show interesting motion, rather than destroy the bubble formation.

After filming, the many video clips were taken from the camera and edited using Animotica. The sharpness and contrast were both increased to make the bubbles pop a bit more (pun intended).

Below is an example of the unedited sharpness and contrast.

***Figure 2**. Example unedited image*

Conclusion:

Overall, I am pleased, even though I wound up capturing different content from what I had initially planned. After recording, it was suggested that I might have used a sponge to apply tensile or compressive load or shear stress to the bubbles to better demonstrate the slip plane phenomenon. This idea has merit, and I intend to make another pass at this video using that technique.

I like the impact of having the pink bowl. I initially tried using a white porcelain plate as the background, which, I found, required some sort of food dye or other visualization technique to make the bubbles more visible and the composition more interesting – so having a colored vessel solved that issue without as much fuss.

References:

[1] Hull, D, and Bacon, D.J. "Dislocations in Face-centered Cubic Metals." *Introduction to Dislocations,* 2011.