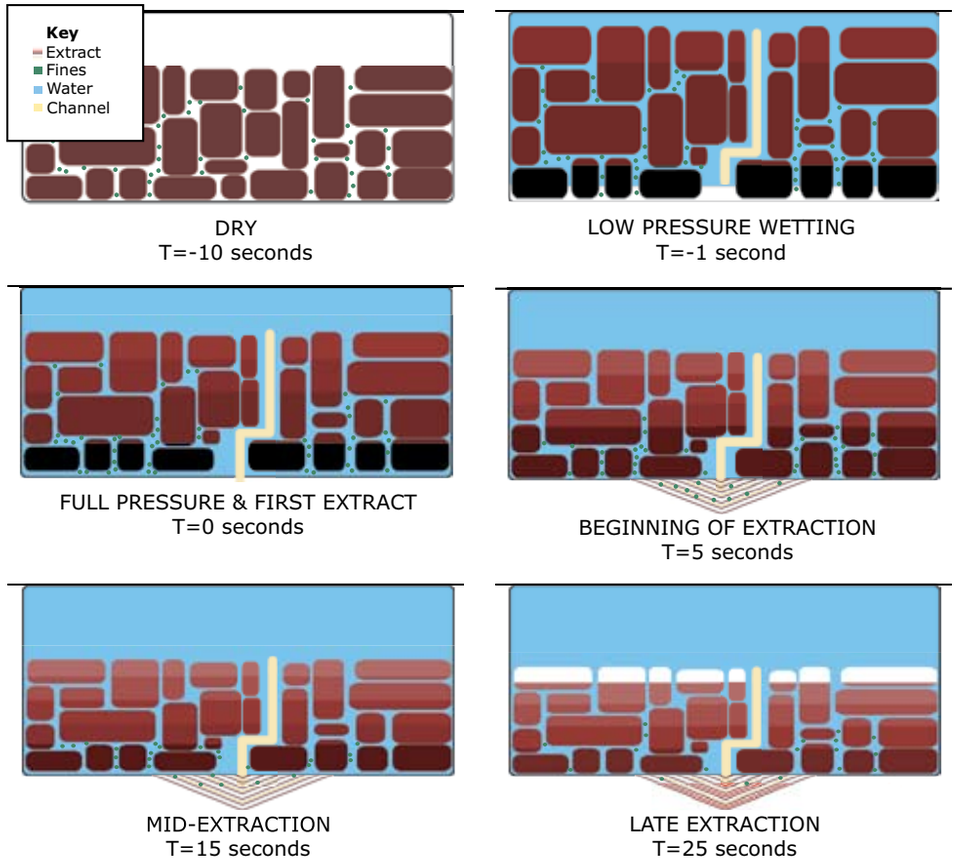
THE DYNAMICS OF ESPRESSO PERCOLATION AND EXTRACTION



The color of the grounds (represented by the stacked rectangles) in the first frame is deep red, indicating they are concentrated with coffee solids. The lighter reds in later frames represent lower solids concentrations.

T = -10 seconds: *The dry grounds just before the pump is engaged.* The grounds are packed with solids, and fines are scattered throughout the coffee bed.

T = -1 second: *The coffee bed near the end of preinfusion.* The water has percolated through almost all of the coffee bed but extraction has not yet begun. The grounds have absorbed water, swelling the coffee bed. A channel, represented by the yellow line, has formed through the middle of the coffee bed. The upper layers of the coffee bed have lost solids, while the lower coffee bed has gained solids. Fines have begun to migrate down the coffee bed.

T = 0 seconds: *The first extract appears.* The first extract appears at the outlet of the channel. Fines and solids have concentrated in the lower layers of the coffee bed. The coffee bed contracts as pressure increases.

T = 5 seconds: *Early extraction.* Solids and fines are rapidly removed from the coffee bed. The coffee bed is further compressed as full pump pressure is applied.

T = 15 seconds: *Mid-extraction.* The coffee bed shrinks as it loses mass. The upper layers of the bed are almost depleted of extractable solids. The bulk of fines and solids are concentrated in the lowest layers of the bed.

T = 25 seconds: *Final moments of extraction:* The upper layers of the bed are completely empty of extractable solids. The coffee bed has lost about 20% of its original dry mass.

According to the research done with large percolator columns, diffusion does not occur until coffee particles are:

1. "Satisfied with bound water." Coffee particles can hold up to about 15% of their dry weight as bound water.[16]
2. Saturated with free extracting liquid.[7]
3. Free of gases.[7]

The typical espresso extraction time is probably too short for all three preconditions of diffusion to be met. Therefore, it is likely that espresso extraction is accomplished entirely by the washing of solids from the outer surfaces of coffee particles, as well as by the emulsification* of oils.[9] Diffusion plays little, if any role.

Flow Progression

The initial extract from the flow of a well-prepared shot should be viscous and dark.‡ As the flow progresses the extract becomes more dilute and the color gradually lightens, eventually turning yellow. Cutting off the flow when it yellows, or

* The emulsification of oils seems to be enabled by the pressure of espresso brewing. It is arguable that the emulsion is the aspect of an espresso most responsible for differentiating it from a very concentrated cup of coffee.

‡ The color of the extract is believed to be darker when it has a higher concentration of caramelized solids or a lower concentration of CO_2, though there may be other factors that influence color.