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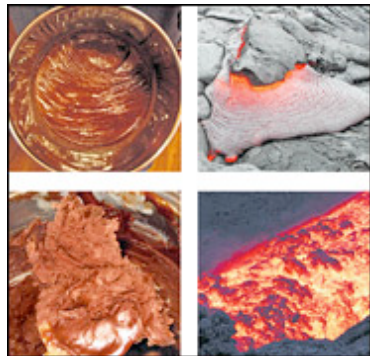
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Visual Lesson on Lava Spares No Calories

By [KENNETH CHANG](#)

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To learn about different types of lava, make a few batches of fudge.



Left, Heather Wright; Kathy Cashman

COOKING INCORRECTLY
When fudge is not stirred, above left, it resembles pahoehoe lava, top right, smooth and easy flowing. Overstirring fudge, bottom left, shears the sugar crystals, producing a rough, broken texture similar to 'a'a lava.

Or so an instructor in an upper-level volcanology class at the University of British Columbia told her students last semester.

Real lava is impractical to take into the classroom — not to mention searingly hot. So geology professors often look for more amenable materials to use for demonstrating geological concepts.

Various foodstuffs are a common choice.

"They're readily available," said the instructor, Alison Rust, a postdoctoral fellow at the University of British Columbia. "They're cheap.

Kenneth Chang will answer selected reader questions about this article. E-mail your questions to askscience@nytimes.com. His answers will be posted at nytimes.com/science on Friday.

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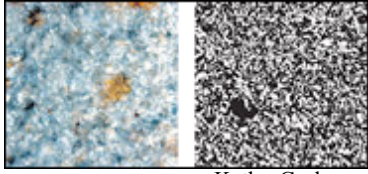
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Kathy Cashman

THROUGH A MICROSCOPE

Sugar crystals in thinly sliced fudge, left, look like the mineral crystals in basalt. Stirring and cooling affect the number and size of crystals.

They're nontoxic. I don't have to worry about spills."

All the students had to work on a project. Most opted for library research. But a group of four approached Dr. Rust and asked for a hands-on experiment. She told them to make fudge.

Fudge is like lava in that the crystallization of sugar is similar to the way minerals grow as lava cools. Basaltic lava, the type that erupts out

of Hawaiian volcanoes, contains relatively low amounts of silicate minerals, allowing it to flow quickly and smoothly over long distances.

Fudge, when stirred too little — the stirring induces the formation of crystals — resembles a type of lava called pahoehoe (pronounced pah-HOY-hoy). Its surface looks silky smooth, but its texture is unpleasantly gritty and coarse, because the sugar crystals, while few, have grown large.

When the fudge is stirred too long as it cools, the sugar crystals shear against one another. The end product tastes better, but it has a rough, broken surface that resembles another type of lava, 'a'a lava. (Pahoehoe and 'a'a, pronounced ah-ah, both come from Hawaiian words.) The students also made fudge with marshmallows and nuts to simulate rock fragments caught up in the lava.

They then cut slices of the fudge a fraction of an inch thick and looked at them under a microscope to examine the size and shape of the sugar crystals.

"Many of the results we got in the experiments were what is observed in real basaltic flows," a student, Concetta Gulluni, said.

Dr. Rust performed her own fudge experiments. In December, she and two other geologists, Kathy Cashman, Dr. Rust's doctoral adviser at the University of Oregon, and Heather Wright, one of Dr. Cashman's current graduate students, presented the experiments at a meeting of the

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American Geophysical Union in San Francisco. The poster session, which resembled a science fair for professional scientists, was dedicated to innovative lecture demonstrations.

The scientists found that adding extra corn syrup prevented crystals from forming at all, and the candy ended up more like taffy than fudge.

"I think it was the most rewarding poster I've ever done," Dr. Rust said. (If you want to do the fudge experiments yourself, a recipe and an explanation of how to vary it is available at [nytimes.com/science/](https://www.nytimes.com/science/).)

Dr. Rust said she had also experimented with cornstarch, corn syrup and applesauce. "It's not really out of the blue," she said. "We're using it for our serious research, too."

For her doctoral research at the University of Oregon, she ordered 1,200 pounds of corn syrup as an analog to the melted silicates found in basaltic lava. She blew bubbles into the syrup to study how gases trapped in magma changed how it flowed. Applesauce also turns out to share some properties with magma, and cornstarch mixed with water acts like a solid when hit with, say, a hammer, but also flows — much as rocks deep underground look solid, but are flowing slowly.

Nearby, at the same meeting session in December, Mark Jellinek, a colleague of Dr. Rust at the University of British Columbia, poured various liqueurs and other liquids into plastic cups to demonstrate the concept of convection. His poster title asked "The Earth: Kinda Like a Mai Tai?"

To onlookers, Dr. Jellinek, a professor of earth and ocean sciences and a former bartender, asked, "If you order two cocktails — one is a Coke with ice and the other is Scotch with ice — in which one does ice melt faster and why?"

After fielding guesses about carbonation and evaporation rates, Dr. Jellinek explained: "You have an ice cube, and the ice cube is in contact with water or alcohol. The first thing to realize is the ice is melting because there is heat transfer from the water to the ice."

Colder water is denser, so water from a melting cube sinks, stirring up warmer water, which causes the ice cube to continue melting. Alcohol, however, is less dense than water, so the water from the cube sinks faster in the Scotch,

stirring the water more vigorously and causing the ice cube to melt more quickly.

Dr. Jellinek then dropped two ice chips, roughly the same size, one into a cup of water, the other into Bell's Scotch Whiskey. "The main thing is what's coming off the bottom is superfast," Dr. Jellinek said, pointing to the ice and Scotch. "Just in the last 30 seconds, this guy is now 30 percent smaller than the one in the water."

Similar processes occur as crystals grow or melt in magmas, Dr. Jellinek said.

He poured some rum into another plastic cup followed by skim milk. A plume of lighter rum rose and spread out quickly over the surface, drawing up more rum from below. The liquids mixed quickly, causing the alcohol to evaporate.

Into another cup, he poured rum and half-and-half. In this cup, the plume of rising rum could not push the cream — clumped together by fat particles — out of the way.

"The motion stops at the edge of this white stuff," Dr. Jellinek said. "This is only stirring only as far as the cream lets it."

Dr. Jellinek performs this demonstration in teaching his geological fluid dynamics class to show how the composition of different materials affects their motions. "Plate tectonics is one good example," he said. "How do you break plates?"

When he was done, he handed the cups of cream and rum to one of the listeners.

"These taste good," Dr. Jellinek said.

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