Profile of Katharine V. Cashman

Matthew Hardcastle, Science Writer

Katharine V. Cashman's career as a volcanologist has been punctuated by explosions. Mount St. Helens in Washington state erupted the year after she finished her Master's course in geology. She had just been invited to the University of Bristol in 2010 when the Eyjafjallajökull volcano erupted in Iceland, raining ash across Europe. In addition to Mount St. Helens in the Cascade Range, Cashman has worked with researchers at the US Geological Survey's Volcano Observatories in Hawaii (1) and Alaska (2). Her career has taken her to volcanoes on every continent. To study them, Cashman has helped pioneer an approach to examine the small-scale structures in samples of volcanic glass, ash, and crystals. Through chemical and physical analyses, laboratory experiments, and theoretical models, Cashman uncovers the properties of volcanic samples, reverse-engineering the processes that formed them within volcanoes. Cashman, who was elected to the National Academy of Sciences in 2016, is a professor of volcanology at the University of Oregon. In her Inaugural Article (3), she analyzes the physical properties of glass objects known as Prince Rupert's drops, hoping to gain insight into interactions between magma and water.

The Volcano Bug

Cashman grew up in Providence, Rhode Island. She was born into a family with multiple geologists, but she was not interested in becoming one herself. “I was trying to avoid it,” she says. Cashman enrolled at Middlebury College in Vermont and spent her freshman year deciding between majoring in biology or English literature. However, in her sophomore year, she began taking geology courses. She was won over in part by the fact that geology laboratories often took place outdoors, in contrast to the frequently malodorous biology laboratories. She was graduated in 1976 with degrees in biology and geology and one course short of earning a degree in English, as well.

Cashman's senior thesis involved field-mapping and structural geological analysis of the Thetford Mines ophiolite in Quebec, Canada. Ophiolites are sections of oceanic plates that have been pushed up over the edges of continental plates. Back then, it was early days for plate tectonics theory, which became widely accepted among geologists in the 1960s. After graduating, Cashman received a Fulbright scholarship to attend Victoria University of Wellington in New Zealand, where she was graduated with a Master's degree in geology in 1979. Her plan was to continue her study of ophiolites, but she became interested in New Zealand's relatively young volcanoes.

Cashman's growing interest in volcanology became solidified during a 4-month field study at Mount Erebus, an active volcano in Antarctica, unrelated to her thesis at the time. Even today, she considers the trip one of her most memorable experiences. “Antarctica’s an amazing place,” she says. “And when I was down there, there were very few women. They'd only been letting women go down for a few years. So it was quite an exciting time.” While attempting to retrieve gas samples from around an active lava lake within the summit crater of Mount Erebus, Cashman and her colleagues got caught in an eruption and had to make a hasty retreat as volcanic bombs of molten rock fell around them. “That’s where I got the active volcano bug,” she says.

After graduating, Cashman returned to the United States and began working for the US Geological Survey, initially at Woods Hole, Massachusetts. In 1980, Mount St. Helens erupted in Washington. “I begged and pleaded and got transferred to Mount St. Helens,” Cashman says. She was assigned as a public information scientist. “I had no training in public information, and I didn't know all that much volcanology, but I learned a lot on the fly.” As a point of contact for the media and community groups, Cashman needed to quickly get a handle on everything that was going on with the volcano. She went out into the field with monitoring groups, receiving a crash course in volcanology. Geologists from around the world flocked to the site, providing her with an opportunity to meet the larger research community. The experience motivated her to return to graduate school to learn more about volcanology.

Small-Scale Volcanology

Cashman received her doctorate in geology from The Johns Hopkins University in Maryland in 1986. For her thesis, she...
studied crystals in drill-core samples from solidified lava lakes in Hawaii (4). At the suggestion of her thesis advisor, Bruce Marsh, Cashman looked to commercial techniques used in industrial crystallization. “If an industry, for example, wants to grow salt that will fit through your salt shaker,” Cashman says, “they need to be able to control the size of the crystals.”

At the time, there were few laboratory experiments that could capture the processes of crystal formation within volcanoes. Cashman studied the theories used in industrial crystallization and inverted them, reverse-engineering the paths volcanic crystals took to the surface. This line of research is now known as experimental petrology, which is the study of small-scale structures within rocks. Throughout her career, Cashman has helped pioneer the application of petrology in the field of volcanology.

Cashman’s research has taken her all over the world. In contrast to the exciting encounter at Mount Erebus, most of her field research is unglamorous grunt work. “If you want to understand and interpret what happened in a past eruption,” Cashman says, “then you dig a lot of holes and carefully sample and analyze the material. Sampling from the bottom to the top of a deposit gives you samples through time from the beginning to the end of the eruption.”

Cashman collects samples of ash, tephra, pumice, and scoria, and brings them back to the laboratory for analysis. In the laboratory, Cashman’s main tools are electron microscopes, electron probe microanalyzers, and CT scanners. These tools help probe the physical and chemical properties of volcanic samples. She characterizes the size, shape, and surface textures of particles and analyzes their chemical compositions. Then, she incorporates these data into theoretical models to study the processes that formed them.

As an example, Cashman describes how magma deep below the surface contains dissolved gases, including water, CO₂, sulfur, and chlorine. As magma rises toward the surface, the dissolved gases expand and form bubbles, driving crystal formation. By studying the size and shape of the crystals, Cashman can determine the rate at which the magma cooled, which in turn reveals how fast the magma rose to the surface. The chemical composition of the crystals can also reveal the source of the magma that formed them.

After earning her doctorate, Cashman accepted her first faculty position at Princeton University in New Jersey. Her next position was at the University of Oregon, where she worked from 1991 to 2011 and recently returned in 2021. In 2010, she was invited to accept a research professorship at the University of Bristol in the United Kingdom. To fund her work in Bristol, Cashman applied for a research grant from the French insurance company AXA. At the time, AXA had funded only researchers in France and only in the fields of health and economics. Cashman began brainstorming proposals in March of 2010, with the deadline looming in May. Then, in April of 2010, Eyjafjallajökull began erupting in Iceland. “So,” Cashman says, “it became very clear how I’d write the proposal.” She used the grant to study the volcanic ash particles grounding airplanes across Europe to gain a better understanding of how different types of ash form. She also studied how ash spreads to forecast its movement through the atmosphere (5).

Prince Rupert’s Drops

In Cashman’s Inaugural Article (3), she analyzes the physical characteristics of Prince Rupert’s drops. Also called Bavarian tears, these glass objects, known since the 1600s, are formed when molten glass is dripped into water, causing it to rapidly cool into a tadpole-shaped glass bead. “The big head is extremely strong,” Cashman says. “You can hit it with a hammer, and it won’t break. But if you break the end of the tail, it will just shatter explosively.” Prince Rupert of England first brought the drops to England from Germany and enjoyed using them as explosive party favors. In 1661, King Charles II presented the drops to the recently formed Royal Society, and the objects have been the subject of scientific analysis ever since.

It is now known that the strong outer surface at the head of a Prince Rupert’s drop is formed by the rapid cooling of the molten glass when it hits the water, producing strong compressive forces that hold the drop together. In contrast, the interior of the drop cools more slowly and shrinks as it cools, often forming a vacuum within the drop. This mismatch in structural forces causes the drop to shatter explosively as soon as the brittle tail is broken.

Cashman was interested in studying Prince Rupert’s drops as a potential proxy for the interaction between magma and water. When a volcano erupts underwater, the rapid expansion of the heated water can significantly add to the explosive power of the eruption. This phenomenon was recently demonstrated by the incredibly powerful eruption in Tonga in January 2022. A process involved in meltdowns at nuclear power plants, called molten fuel coolant interaction, had previously been studied as a proxy, but Cashman and her colleagues felt a better analogy was needed.

Cashman partnered with the glass manufacturer Bristol Blue Glass in the United Kingdom for a steady supply of Prince Rupert’s drops. She broke the drops within containers to collect and analyze the sizes of the glass particles produced by the explosion. Cashman found that the medium in which Prince Rupert’s drops are broken affect the size of the particles formed. She broke drops in containers filled with air, water, and syrup. She attempted to
break drops encased in epoxy, but the material was too strong to allow the drops to shatter properly. Next, she tried hair gel, which allowed her to take detailed CT scans of the broken drops held in place by the gel and observe how the shape and size of the fragments from different locations within the drop varied. This insight about the medium is critical; magma from underwater volcanoes often first interacts with a slurry of seawater and sediments on the ocean floor, rather than pure seawater.

Because bubbles play a major role in volcanic eruptions, Cashman and her colleagues were also interested in the possibility of forming Prince Rupert’s drops out of bubbly molten glass. They hypothesized that bubbly glass melt would simply fragment when dripped into water, but they nevertheless asked Bristol Blue Glass to try making some. The foreman of the shop invited them over and prepared a fresh batch of bubbly molten glass. He repeatedly poured the bubbly melt into water where it shattered immediately. “We said, ‘Yes, we thought that would happen.’ And he looked at us and he said, ‘You did? I spent the whole weekend trying to make you a bubbly Prince Rupert’s drop and I couldn’t do it!’”

**Future Directions**

Cashman is now back in Oregon and interested in pursuing research around Mount Mazama, a volcano with a collapsed caldera, which formed Crater Lake. Volcanologists often focus on the immediate aftermath of major eruptions, but Cashman is interested in studying the volcanic hazards that follow the main event. For example, deposits from Mount Mazama suggest that large amounts of ash were produced during past eruptions. In a high desert environment like the western United States, volcanic ash and other fragmented material have a strong tendency to slide down slopes and get blown on the wind or swept along by rivers, producing widespread effects that could last for centuries. Cashman is also interested in studying the small cinder cones and lava flows distributed across Oregon, which have received less attention than large, iconic volcanoes. Throughout her career, Cashman has seen significant advances in the field of volcanology. Yet, she says, the question of when an eruption will occur is still difficult to answer.

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