Student-at-work: Michael J. Krawczynski

“There is a crack, a crack in everything. It’s how the light gets in.” -- Leonard Cohen

Mike Krawczynski has been looking into cracks -- in the crust of the Earth, in glacial ice, on the Moon, and, soon, on Mars. Mike is a MIT/WHOI Joint Program graduate student in experimental petrology, pursuing a Ph.D. in Marine Geology and Geophysics, projected for 2010. The 25-year-old Massachusettsan (he’s from Northampton) is sharply focused on explosive situations, from the meteoric rise of his beloved Red Sox to the melt-and-freeze evolution of the Moon, from the buildup of upward pressure in magma under Mount Shasta to the downward pressure of lakes atop the West Greenland ice-sheet.

The cracks are just one aspect of the dramatic magmatic processes that intrigue Mike most. The center of his research is the effect of water on magma, the molten lava that forms the mantle of Earth -- and which has played a major role in the formation of other planets. “How do volcanoes evolve? What water is in the magma? What kind of eruption is needed to let it escape?” In other words, Mike feels that understanding plumbing -- cracks, flows, pressure, release -- is his key to understanding what flows through them, whether it’s water or magma. “I’m studying oceans, only they’re magma oceans,” he says. The MIT/WHOI program allows him just the crossover he needs. “I’ve tried to work on projects that have some relevance instead of quirky problems that only people who love scribbly equations would understand. The joint program is great for that. Everywhere you turn people are doing something interesting.”

At Brown, Mike majored in geochemistry and archaeology, a combo that led him to Colorado’s Fish Canyon, site of the biggest eruption of its kind in North America. “The eruption was five to six square kilometers of ash and pyroclastic deposits. In contrast, Mount St. Helens was .3 square kilometers. This was an explosive eruption, like Yellowstone, but twice as big. I fell in love.”

Mike’s work with Tim Grove at MIT’s Experimental Petrology Laboratory involves creating models of magmatic processes occurring not within continents, like Fish Canyon, but at subduction zones, such as the one California’s 14,000-foot Mount Shasta sits atop. Here, tectonic plates overlap. The high pressure and temperature in the Earth’s mantle releases water in the form of steam, which triggers melting in the overlying rock.

Why do some volcanoes seem to ooze while others explode? The answer lies in the viscosity (level of runniness) and the volatile content of the magma (how much gas, mainly from water and carbon dioxide, builds up inside it as it rises through the Earth’s crust). In less viscous magmas, bubbles rise and pop, so that the lava seems to boil, spurt, or shoot out gentle curtains or sprays of lava. But if the magma is more viscous -- thicker, gooier -- the bubbles can’t pop. Pressure builds up to the point where the force of the magma overcomes the rocks above it. You’ve guessed it: she’s gonna blow.

These pyroclastic surges (the “blow” or explosive eruption of a volcano) can travel as fast as 500 kilometers per hour. The result, at Mount Shasta, are chunks of basalt (solidified magma) roughly the size and shape of bricks, which indicates that they were blown into the air, then rained down onto the volcano’s sloping shoulders. Mike’s research at Mount Shasta involves clambering around with a pickaxe, collecting these bricks, called inclusions because they carry minerals carried up from deep inside the volcano. Mike uses the mass spectrometer at WHOI to learn the ages of his samples. “My goal is to get the youngest inclusions on Mount Shasta to study the time scale -- how quickly magma from below the plate can be transported through the crust.” He analyzes his samples at pressure to assess their composition, which clues him in to the amount of water present in the magma -- from which he can infer the temperature and pressure at the time of eruption. Mike studies some of the most explosive volcanic eruptions, including Krakatoa, Montserrat, the Moon, and beyond. His work requires machinery that can produce the pressure levels of different volcanic environments.

Mike traveled to a lab in Germany where he was able to do experiments with pressure vessels -- refitted World War II tank guns -- that mimicked the lower crustal levels of Mount Shasta. He found that the minerals in the inclusions found at Mount Shasta could only be produced at extremely wet melts at the lower crusts.

A visit to MIT finds Mike in a 12th floor lab overlooking the Charles River, where he is experimenting with “orange glass” from the Apollo 17 mission to the Moon. Earlier work included “red glass” from the Apollo 15 mission in 1971.   This glass is lunar basalt, the result of melting stages that may have lasted as long as a billion years. Astronauts Dave Scott and Jim Irwin used the lunar rover to explore the Sea of Rains, a basin created when lava flooded a crater 1123 km diameter. Among their finds was a 40-square-mile field of cinder cones, described by geologists as the first sure sign that the Moon’s surface had been shaped by exploding volcanoes, “one of the moon’s last belches.”

Back on Earth, Mike has turned his plumbing know-how to the question of how water melting atop glaciers reaches the bed underlying the ice sheet. Mike began work on his model of ice lake drainage in a class taught by his WHOI advisor, geophysicist Sarah Das, who is studying the West Greenland glacier. “Magma in the Earth fractures upward to make a volcano, while with ice the fracture propagates downwards. With the ice fracture model I turned the process upside down.” Mike’s formula showed that the quick drainage Das observed could indicate drainage to the ice bed.

Mike’s next work will take him (by way of his samples) to Mars, requiring the pressure levels that can be produced only by the five-ton multi-anvil chamber in the basement of the MIT lab. He dreams of being involved in research surrounding NASA’s next trip to the Moon, slated for 2018.