Stable Isotope Geochemistry: A Window on the World

by Jacob Waldbauer '01

One of the most active areas of research in the Dartmouth Earth Sciences Department is stable isotope geochemistry. These laboratories, under the supervision of Professors C. Page Chamberlain and Xiahong Feng, apply one of the most versatile and powerful methods in earth science to a wide range of problems. Using a technique known as stable isotope ratio mass spectrometry, Chamberlain, Feng and their students have investigated problems from soluble contaminant transfer in streams to bird and salmon migrations. “These methods are valuable in studying almost any earth surface process,” says Chamberlain. One of the major applications of stable isotope geochemistry has been the study of global climate change. The method has proved so useful, in fact, that “in order to explain the climate record, you have to make reference to isotopes,” Feng says.

The key technique of stable isotope geochemistry is the measurement of isotope ratios. All elements naturally occur in several different isotopes, which means they can have varying numbers of neutrons in their nuclei. Stable isotope geochemists usually look at the elements which are the building blocks of many geologic and biologic materials: carbon, hydrogen, oxygen and nitrogen. The various isotopes of a given element naturally exist in certain proportions; for example, the average abundance of the two stable carbon isotopes is $98.9\%$ for $^{12}$C and $1.1\%$ for $^{13}$C. Many geologic, environmental and biologic processes (including plant and animal metabolism, mountain uplift, flooding and climate change) alter this ratio slightly from its global average, a phenomenon called fractionation. This fractionation can be detected using mass spectrometers, very precise instruments which can measure the ratio of one isotope to another in a sample. Using these tools, stable isotope geochemists can examine an enormous variety of research problems.

“This is a true interdisciplinary area of research,” says Chamberlain, “it grew out of geology, but is increasingly moving into biology and medicine.” An ongoing project in the Dartmouth group is a study of arsenic levels throughout New Hampshire, which was historically a major arsenic-producing region. Arsenic contamination of groundwater poses a major human health hazard, so tracing the origins of such contamination represents the application of a proven geologic tool to a problem involving geology, toxicology and public health. Other applications include detecting nutrition-related stress in anorexia and tracing the origin of illegal drugs, which can retain an isotopic signal indicative of their place of manufacture. Some studies have been more lighthearted, including an isotopic study of beer fermentation. The researchers found a shift in the isotopic signal in the carbon dioxide in the fermenting beer as the yeast moved from metabolizing simple sugars to end products.

Next year, the stable isotope geochemistry group will move to laboratories in the newly-renovated Steele building. While the group is well-equipped with sophisticated instruments, “getting enough technical support people has been a problem,” according to Chamberlain. Both Feng and Chamberlain actively involve undergraduates in their research, and the students work hands-on with mass spectrometry on a range of problems. Current undergraduate projects include a study of the soil water budget in Mink Brook and an investigation of the effect of fertilization and pesticides on water quality.

Do you work in an interesting lab or know someone that does? Contact the DUJS at dujs@dartmouth.edu to find out how to get your favorite lab into the lab spotlight.