Geologists search for prehistoric high

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Not all areas of the Tibetan Plateau rose at the same time, according to researchers who are determining the past elevation of plateau locations by studying the remains of terrestrial plants that once grew there.

"The Tibetan Plateau is responsible for the monsoons in India," says Dr. Pratigya J. Polissar, postdoctoral fellow in geosciences, Penn State. "People have documented ecological changes around the edge of the plateau that may indicate when it was high, but we do not really know when the plateau rose and so we do not know when the monsoon circulation began."

Elevation is a key factor in forces in the Earth's circulation and climate and often large land masses influence climate far beyond the local geographical and geological region. Polissar; Katherine H. Freeman, professor of geosciences, Penn State; and David B. Rowley, professor of geophysical sciences, University of Chicago, looked at lipids preserved in ancient lake sediment that originated in plants growing in the surrounding watershed. The lipids were once part of the waxy coating found on leaves that grew during the late Eocene about 35 million years ago and the early Miocene, 8 to 6 million years ago. These lipids are biomarkers for the plants that generated them.

"We are really interested in the hydrogen in these lipids," says Polissar. "Hydrogen is preserved in the molecules and the hydrogen isotopic composition is preserved."

The researchers are interested in the ratio found between regular

hydrogen and deuterium, hydrogen that contains both a proton and neutron in its nucleus and is heavier than normal hydrogen. This hydrogen ratio can disclose where the plants were growing because as air masses rise on the side of a mountain, water, which contains hydrogen, rains out of the air. A proportionally larger amount of deuterium rains out leaving air at higher elevations with a higher percentage of normal hydrogen. The composition of the water that plants take up from the ground is a reflection of the rainwater that falls in that area, so the hydrogen incorporated into the plants can tell us the hydrogen ratio of the rainwater.

By looking at the hydrogen isotope ratios of plants growing at various elevations today and the hydrogen isotope ratios in the water, the correlation between elevation and hydrogen isotope ratio can be established.

However, there are a number of things to consider. The types of plants that grew in the past must be the same as those studied in the present. The researchers used pollen analysis on the ancient samples to determine the composition of the plant population.

They also must consider that plants use hydrogen isotopes in different ways, with some preferring more of one isotope than the other. This preferential uptake can skew the results if it is ignored.

To check their approach, the researchers used a set of three samples from two locations on the Tibetan Plateau. In one location, a pair of samples came from the Miocene and a much earlier time in the Eocene. In the other location, a Miocene sample was paired with previous results by other scientists on Eocene rocks. Two of these samples had elevations previously assigned, using similar analysis of oxygen isotopes taken from carbonates like limestone. The third, a Miocene sample, had an unknown elevation. The two known elevation samples allowed the researchers to

test the accuracy of their method.

"No one has done this before on vegetation remains," says Polissar. "Sediments that preserve organic material do not typically contain carbonates. This method would allow us to determine elevations at locations with only organic material."

When the researchers compared the results from their two samples to the elevations derived from carbonate oxygen isotope testing, they found that the organic hydrogen isotope approach worked well. The third sample, from the Miocene, showed an elevation that was much higher than the matching sample from the Eocene.

"This shows that the basin was rising between these two sample dates," says Polissar. "Everywhere else at this time was already high, but this area was low. The whole plateau did not rise at the same time, but the northern portion rose later."

Knowing that the northern portion of the plateau rose later can help climatologists who try to model ancient climate. This knowledge can also help those who model the ancient biological world because different plant communities grow at different elevations because of the differing rainfall and temperatures.

Source: Penn State