Sedimentary records link Himalayan erosion rates and monsoon intensity through time

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Throughout history, the changing fortunes of human societies in Asia have been linked to variations in the precipitation resulting from seasonal monsoons. A new paper published in the British journal *Nature Geoscience* suggests that variations in monsoon climate over longer time scales also influenced the evolution of the world's highest mountain chain, the Himalaya.

The climate over much of Asia is dominated by seasonal winds that carry moist air over the Pacific Ocean into East Asia and over the Indian Ocean into South Asia. The East and South Asian monsoons are responsible for most of the rainfall in these regions. Although the time when these monsoon patterns were first established is unknown, many lines of evidence suggest that they first came about at least 24 million years ago.

The new study uses geochemical data from an Ocean Drilling Project sediment core extracted from the seafloor of the South China Sea to establish a record of the East Asian monsoon climate over that time interval.

"Sediments in this core were eroded from the drainage area of the Pearl River system in China, and their chemistry records the relative intensity through time of chemical weathering in an area that received the bulk of its precipitation from East Asian monsoon storms," explains Peter Clift, lead author of the study and a professor of geology and petroleum geology at the University of Aberdeen in Scotland.

Many researchers believe that a geologically "abrupt" uplift of the Tibetan Plateau – the largest high-altitude region on Earth, with an average elevation of more than 4,000 meters (13,000 feet) – at 8 to10 million years ago caused a major intensification in the monsoon climate.

"South China Sea data do not support that interpretation," says Kip Hodges, a co-author of the paper and director of the School of Earth and Space Exploration in the College of Liberal Arts and Sciences at Arizona State University. "Other than a brief drop between about 17 and 15 million years ago, the pattern in the core suggests a steady increase in East Asian monsoon intensity from 23 to 10 million years ago, followed by a steady weakening until about 4 million years ago. After that, the intensity began to increase once more. The implication is that either the development of the plateau was not as abrupt as we might have thought, or that an abrupt uplift of the plateau at 8 to 10 million years caused a change in precipitation patterns that was not recorded in East Asia."

Another controversy surrounds the degree of coupling between the South and East Asian monsoons. Could one have varied in intensity differently from the other?

The team compared the South China Sea record with less-complete sedimentary records from the Arabian Sea and Bay of Bengal – which contain sediments that were eroded from the Himalaya, where the principal rainfall comes from South Asian monsoon storms – to argue for a linkage between the two monsoon systems over most of the past 23 million years.

"The really exciting moment in this research came when we began to compare patterns from one record to another and found broad agreement," says Clift.

The most interesting correlation was found when the team compared the sedimentary records to cooling age patterns in the Himalaya. Hodges and his students have spent years using isotopic dating techniques to determine the cooling ages of thousands of bedrock and sediment samples from all over the Himalaya.

"Most people are familiar with the use of such techniques to determine the crystallization ages of minerals and rocks," says Hodges. "They also can be used to determine when a mineral cooled through a certain temperature. The principal mechanism by which samples cool in mountainous regions is erosion, so a high frequency of minerals with the same cooling age generally means a high rate of erosion at that time."

Compilations of the cooling ages obtained by Hodges' group and other researchers show that the periods of high East Asian monsoon intensity matched well with high frequencies of cooling ages, implying a relationship between monsoon intensity and erosion in the Himalaya.

"While it makes sense intuitively that heavy rainfall should be correlated with more aggressive erosion, it is important to see such direct evidence of the coupling between the processes that define the evolution of mountain ranges and climatic processes," Hodges explains. "It implies, once again, that Earth is a complex system, and we cannot begin to fully understand mountain building without appreciating the roles of the hydrosphere and atmosphere in the evolution of mountain ranges."

But Hodges cautions that the results of this study are suggestive.

"It is important to confirm our interpretations by generating a more comprehensive cooling age dataset from regions of the Himalaya that have not yet been studied because of logistical constraints or political instability."

Adds Clift, "We really need more complete offshore sedimentary records from the Arabian Sea and Bengal Fan to make a solid case for linkages between the South and East Asian monsoon systems."

Source: Arizona State University

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