

Mountain ranges evolve and respond to Earth's climate, study shows

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Bering Glacier winds down from St. Elias Mountains eroding young thrust belt in mid-ground. Credit: Ken Ridgway, Purdue University

Ground-breaking new research has shown that erosion caused by glaciation during ice ages can, in the right circumstances, wear down

mountains faster than plate tectonics can build them.

The international study, including Dr Ian Bailey from the University of Exeter, has given a fascinating insight into how climate and tectonic forces influence mountain building over a prolonged period of time.

The research team attempted to measure all the material that left and entered the St Elias Mountain range, on the Alaskan coast, over the past five million years, using state-of-the-art seismic imaging equipment and marine coring.

They found that erosion accelerated sharply when global climate cooling triggered stronger and more persistent ice ages about one million years ago.

The pioneering new research, which is the product of the culmination more than a decade of field work, has shown that mountain ranges actively evolve with, and respond to, the Earth's climate, rather than being static, unyielding parts of the landscape.

The international study, conducted by the Integrated Ocean Drilling Program and led by scientists from The University of Texas at Austin, University of Florida and Oregon State University, is published in the *Proceedings of the National Academy of Sciences* on Monday, November 23.



Alaska's Yahtse Glacier transports a large volume of sediment from the St. Elias Mountains to the sea. Credit: Ken Ridgway, Purdue University

Dr Bailey, a Geology Lecturer from the Camborne School of Mines, based at the University of Exeter's Penryn Campus in Cornwall said: "Understanding precisely how the balance of climate and tectonic forces influences mountain building remains an outstanding unknown in Earth Sciences.

"A tremendous amount of important information has been gained by studying the onshore geology associated with the St Elias Mountain range.

"Our exciting findings, which add new insight to this important debate,

could only be made, however, by examining at the adjacent off-shore marine sediment record."

The study, conducted by a team of scientists from 10 countries, used seismic equipment to image and map a huge fan of sediment in the deep sea in the Gulf of Alaska caused by erosion of the St Elias Mountain range and took short sediment cores to understand the modern system.

They then determined when and how fast the fan accumulated by dating nearly four kilometres of marine cores collected from the gulf and the Alaskan continental shelf.



Scientific drilling vessel JOIDES Resolution in the Gulf of Alaska. Credit: Itsuki Suto, Nagoya University

Sean Gulick, lead author and co-chief scientist from the University of Texas Institute for Geophysics (UTIG), a unit of the Jackson School of Geosciences said: "It turned out most sediments were younger than we anticipated, and most rates of sediment production and thus erosion were higher than we anticipated.

"Since the big climate change during the mid-Pleistocene transition when we switched from short (about 40,000-year) ice ages to super long (about 100,000-year) ice ages, erosion became much greater. In fact, there was more erosion than tectonics has replaced."

"We were pleasantly surprised by how well we could establish ages of the sediment sequences as we were drilling, and the composition of the sediment gave clear evidence of when the glaciation started and then expanded, in synch with global climate trends over the past several million years," said co-author Alan Mix of Oregon State University. "Only by drilling the sea floor where the sediment accumulates could we see these details."

Mountain ranges form when tectonic plates thrust into one another over millions of years and scrunch up the Earth's outer crust. But even as mountains are built by these titanic forces, other agents—some combination of tectonic and climate processes—work to remove the accumulating crust.

Since the mid-Pleistocene, erosion rates have continued to beat tectonic inputs by 50 to 80 percent, demonstrating that climatic processes, such as the movement of glaciers, can outstrip mountain building over a span of a million years. The findings highlight the pivotal role climate fluctuations play in shaping Earth's landforms.

More information: Mid-Pleistocene climate transition drives net mass loss from rapidly uplifting St. Elias Mountains, Alaska, *PNAS*,

www.pnas.org/cgi/doi/10.1073/pnas.1512549112

Provided by University of Exeter

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