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India joined with Asia 10 million years later than previously thought

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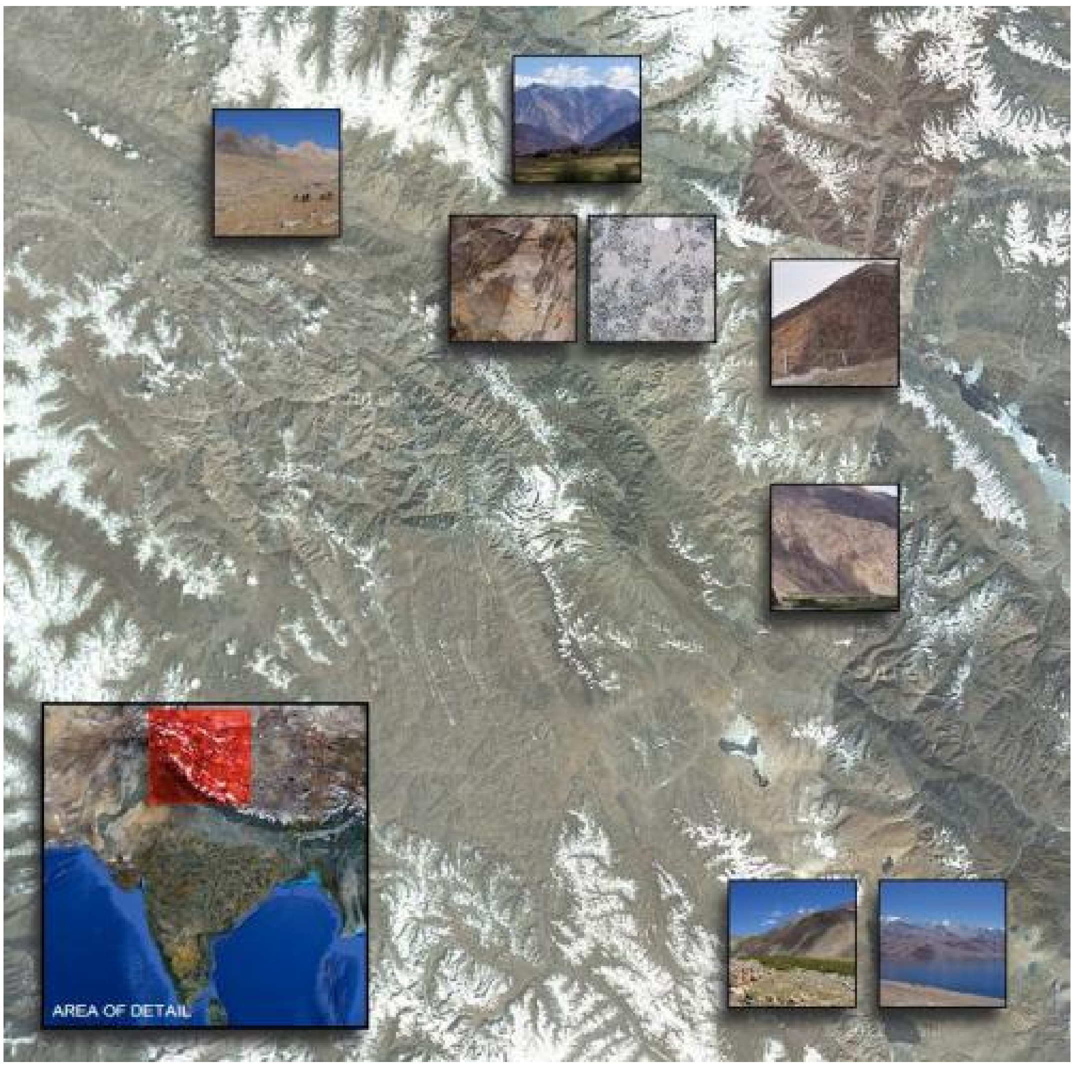

Credit: Pierre Bouilhol

The peaks of the Himalayas are a modern remnant of massive tectonic forces that fused India with Asia tens of millions of years ago. Previous estimates have suggested this collision occurred about 50 million years ago, as India, moving northward at a rapid pace, crushed up against Eurasia. The crumple zone between the two plates gave rise to the Himalayas, which today bear geologic traces of both India and Asia. Geologists have sought to characterize the rocks of the Himalayas in order to retrace one of the planet's most dramatic tectonic collisions.

Now researchers at MIT have found that the collision between India and Asia occurred only 40 million years ago—10 million years later than previously thought. The scientists analyzed the composition of rocks from two regions in the Himalayas, and discovered evidence of two separate collisional events: As India crept steadily northward, it first collided with a string of islands 50 million years ago, before plowing into the Eurasian continental plate 10 million years later.

Oliver Jagoutz, assistant professor of geology in MIT's Department of Earth, Atmospheric and Planetary Sciences, says the results, which will be published in Earth and Planetary Science Letters, change the timeline for a well-known tectonic story.

"India came running full speed at Asia and boom, they collided," says Jagoutz, an author of the paper. "But we actually don't think it was one collision … this changes dramatically the way we think the India/Asia collision works."

'How great was Greater India?'

In particular, Jagoutz says, the group's findings may change scientists' ideas about the size of India before it collided with Asia. At the time of collision, part of the ancient Indian plate—known as "Greater India"—slid underneath the Eurasian plate.

What we see of India's surface today is much smaller than it was 50 million years ago. It's not clear how much of India lies beneath Asia, but scientists believe the answer may come partly from knowing how fast the Indian plate migrates, and exactly when the continent collided with Asia.

"The real question is, 'How great was Greater India?'" Jagoutz says. "If you know when India hit, you know the size of Greater India."

By dating the Indian-Eurasian collision to 10 million years later than previous estimates, Jagoutz and his colleagues conclude that Greater India must have been much smaller than scientists have thought.

"India moved more than 10 centimeters a year," Jagoutz says. "Ten million years [later] is 1,000 kilometers less in convergence. That is a real difference."

Leafing through the literature

To pinpoint exactly when the Indian-Eurasian collision occurred, the team first looked to a similar but more recent tectonic example. Over the last 2 million years, the Australian continental plate slowly collided with a string of islands known as the Sunda Arc. Geologists have studied the region as an example of an early-stage continental collision.

Jagoutz and his colleagues reviewed the geologic literature on Oceania's rock composition. In particular, the team looked for telltale isotopes—chemical elements that morph depending on factors like time and tectonic deformation. The researchers identified two main isotopic systems in the region's rocks: one in which the element lutetium decays to hafnium, and another in which samarium decays to neodymium. From their analysis of the literature, the researchers found that rocks high in lutetium and samarium isotopes likely formed before Australia collided with the islands. Rocks high in neodymium and hafnium probably formed after the collision.

Heading to the Himalayas

Once the team identified the isotopic signatures for collision, it looked for similar signatures in rocks gathered from the Himalayas.

Since 2000, Jagoutz has trekked to the northwest corner of the Himalayas, a region of Pakistan and India called the Kohistan-Ladakh Arc. This block of mountains is thought to have been a string of islands that was sandwiched between the two continents as they collided. Jagoutz traversed the mountainous terrain with pack mules and sledgehammers, carving out rock samples from the region's northern and southern borders. His team has brought back three tons of rocks, which he and his colleagues analyzed for signature isotopes.

The researchers split the rocks, and separated out more than 3,000 zircons—100 to 200 micron-long crystals containing isotopic ratios. Jagoutz and his colleagues first determined the age of each zircon using another isotopic system, in which uranium turns slowly to lead with time. The team then measured the ratios of strontium to neodymium, and lutetium to hafnium, to determine the presence of a collision, keeping track of where each zircon was originally found (along the region's northern or southern border).

The team found a very clear signature: Rocks older than 50 million years contained exactly the same ratio of isotopes in both the northern and southern samples. However, Jagoutz found that rocks younger than 50 million years, along the southern boundary of the Kohistan-Ladakh Arc, suddenly exhibited a range of isotopic ratios, indicating a dramatic tectonic event. Along the arc's northern boundary, the same sudden change in isotopes occurs, but only in rocks younger than 40 million years.

Taken together, the evidence supports a new timeline of collisional events: Fifty million years ago, India collided with a string of islands, pushing the island arc northward. Ten million years later, India collided with the Eurasian plate, sandwiching the string of islands, now known as the Kohistan-Ladakh Arc, between the massive continents.

Peter Clift, a professor of petroleum geology at Louisiana State University, says it may take a while for his colleagues to embrace this new timeline of collisional events.

"This paper does a great deal to stir up the debate on the topic of the timing of collision," says Clift, who was not involved in the research. "I think that a lot of that evidence is already in existence, and that the paper will be seen as something quite fundamental a few years in the future."

"If you actually go back in the literature to the 1970s and '80s, people thought this was the right way," Jagoutz says. "Then somehow the literature went in another direction, and people largely forgot this possibility. Now this opens up a lot of new ideas."

More information:
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