Study shows the Sahara swung between lush and desert conditions every 20,000 years, in sync with monsoon activity

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A new analysis of African dust reveals the Sahara swung between green and desert conditions every 20,000 years, in sync with changes in the Earth's tilt. Credit: Massachusetts Institute of Technology

The Sahara desert is one of the harshest, most inhospitable places on the planet, covering much of North Africa in some 3.6 million square miles of rock and windswept dunes. But it wasn't always so desolate and parched. Primitive rock paintings and fossils excavated from the region suggest that the Sahara was once a relatively verdant oasis, where human settlements and a diversity of plants and animals thrived.

Now researchers at MIT have analyzed dust deposited off the coast of west Africa over the last 240,000 years, and found that the Sahara, and North Africa in general, has swung between wet and dry climates every 20,000 years. They say that this climatic pendulum is mainly driven by changes to the Earth's axis as the planet orbits the sun, which in turn affect the distribution of sunlight between seasons—every 20,000 years, the Earth swings from more sunlight in summer to less, and back again.

For North Africa, it is likely that, when the Earth is tilted to receive maximum summer sunlight with each orbit around the sun, this increased solar flux intensifies the region's monsoon activity, which in turn makes for a wetter, "greener" Sahara. When the planet's axis swings toward an angle that reduces the amount of incoming summer sunlight, monsoon activity weakens, producing a drier climate similar to what we see today.

"Our results suggest the story of North African climate is dominantly this 20,000-year beat, going back and forth between a green and dry Sahara," says David McGee, an associate professor in MIT's Department of Earth, Atmospheric and Planetary Sciences. "We feel this is a useful time series to examine in order to understand the history of the Sahara desert and what times could have been good for humans to settle the Sahara desert and cross it to disperse out of Africa, versus times that would be inhospitable like today."

McGee and his colleagues have published their results today in *Science*

Advances.

A puzzling pattern

Each year, winds from the northeast sweep up hundreds of millions of tons of Saharan dust, depositing much of this sediment into the Atlantic Ocean, off the coast of West Africa. Layers of this dust, built up over hundreds of thousands of years, can serve as a geologic chronicle of North Africa's climate history: Layers thick with dust may indicate arid periods, whereas those containing less dust may signal wetter eras.

Scientists have analyzed sediment cores dug up from the ocean bottom off the coast of West Africa, for clues to the Sahara's climate history. These cores contain layers of ancient sediment deposited over millions of years. Each layer can contain traces of Saharan dust as well as the remains of life forms, such as the tiny shells of plankton.

Past analyses of these sediment cores have unearthed a puzzling pattern: It would appear that the Sahara shifts between wet and dry periods every 100,000 years—a geologic beat that scientists have linked to the Earth's ice age cycles, which seem to also come and go every 100,000 years. Layers with a larger fraction of dust seem to coincide with periods when the Earth is covered in ice, whereas less dusty layers appear during interglacial periods, such as today, when ice has largely receded.

But McGee says this interpretation of the sediment cores chafes against climate models, which show that Saharan climate should be driven by the region's monsoon season, the strength of which is determined by the tilt of the Earth's axis and the amount of sunlight that can fuel monsoons in the summer.

"We were puzzled by the fact that this 20,000-year beat of local summer insolation seems like it should be the dominant thing controlling monsoon strength, and yet in dust records you see ice age cycles of 100,000 years," McGee says.

Beats in sync

To get to the bottom of this contradiction, the researchers used their own techniques to analyze a sediment core obtained off the coast of West Africa by colleagues from the University of Bordeaux—which was drilled only a few kilometers from cores in which others had previously identified a 100,000-year pattern.

The researchers, led by first author Charlotte Skonieczny, a former MIT postdoc and now a professor at Paris-Sud University, examined layers of sediment deposited over the last 240,000 years. They analyzed each layer for traces of dust and measured the concentrations of a rare isotope of thorium, to determine how rapidly dust was accumulating on the seafloor.

Thorium is produced at a constant rate in the ocean by very small amounts of radioactive uranium dissolved in seawater, and it quickly attaches itself to sinking sediments. As a result, scientists can use the concentration of thorium in the sediments to determine how quickly dust and other sediments were accumulating on the seafloor in the past: During times of slow accumulation, thorium is more concentrated, while at times of rapid accumulation, thorium is diluted. The pattern that emerged was very different from what others had found in the same sediment cores.

"What we found was that some of the peaks of dust in the cores were due to increases in dust deposition in the ocean, but other peaks were simply because of carbonate dissolution and the fact that during ice ages, in this region of the ocean, the ocean was more acidic and corrosive to calcium carbonate," McGee says. "It might look like there's more dust deposited in the ocean, when really, there isn't."

Once the researchers removed this confounding effect, they found that what emerged was primarily a new "beat," in which the Sahara vacillated between wet and dry climates every 20,000 years, in sync with the region's monsoon activity and the periodic tilting of the Earth.

"We can now produce a record that sees through the biases of these older records, and so doing, tells a different story," McGee says. "We've assumed that ice ages have been the key thing in making the Sahara dry versus wet. Now we show that it's primarily these cyclic changes in Earth's orbit that have driven wet versus dry periods. It seems like such an impenetrable, inhospitable landscape, and yet it's come and gone many times, and shifted between grasslands and a much wetter environment, and back to dry climates, even over the last quarter million years."

More information: "Monsoon-driven Saharan dust variability over the past 240,000 years" *Science Advances* (2019). advances.sciencemag.org/content/5/1/eaav1887

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