Fossil algae show a lake once existed on Lesotho's Mafadi summit, but it vanished about 150 years ago

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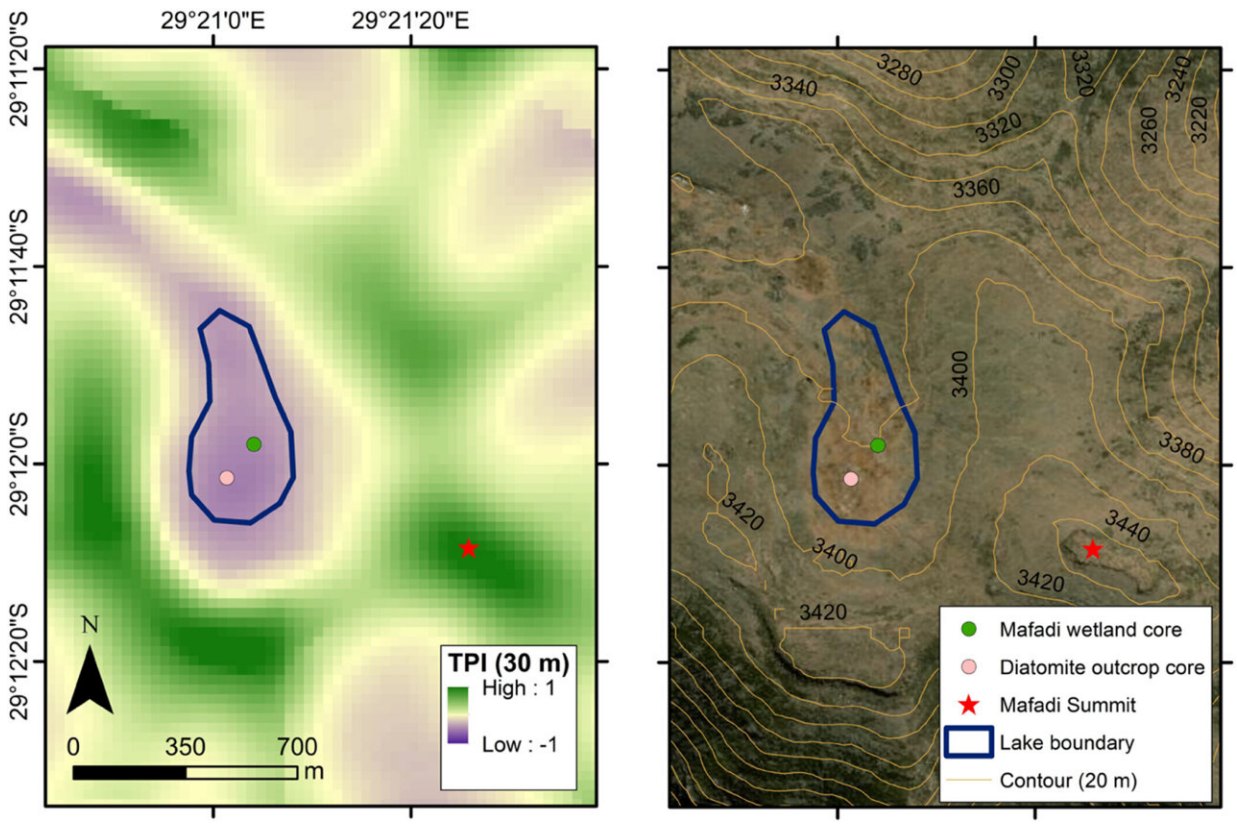

TPI plot and contour map indicating the probable position of the palaeolake demarcated by the blue boundary line. Credit: *Journal of Quaternary Science* (2024). DOI: 10.1002/jqs.3643

Lesotho is a small, land-locked, mountainous country located in the middle of South Africa. Its Eastern Lesotho Highlands are often referred to as the region's "water tower" because they receive some of the highest rainfall amounts in southern Africa, providing water to South Africa and electricity to Lesotho through the Lesotho Highlands Water Project.

Despite this abundance of rainfall, and although the country has many wetland habitats, there are surprisingly few natural lakes. Researchers aren't sure why—and our newly published study provides evidence that this may not always have been the case.

The research took place in a bowl shaped depression on the Mafadi summit, which is at 3,400m above sea level, high along the Great Escarpment in the eastern Lesotho highlands. Small white patches are visible across the landscape.

The patches are diatomite outcrops. Diatomites are consolidated sediments that consist mainly of the remains of fossilized algae called diatoms. These microscopic, single-celled algae are found in nearly all aquatic environments, and they preserve as well as fossils due to their glass-like shells made of silica. Their visible presence alone suggests that surface water systems were once more extensive than they are today.

We investigated the species of diatoms from one of the main diatomite outcrops just downslope from the Mafadi summit, detailing how these species have changed over time. Unlike studies of contemporary wetlands in the region, this core showed very little change until about 150 years ago.

Those changes represent the shift from a lake to the contemporary shallow wetland at the site, and understanding what might have driven them is useful today, since freshwater resources in southern Africa are precious and sensitive to environmental change. If natural lakes were

more extensive in the past in Lesotho, especially at altitude, this provides new important context for how freshwater ecosystems have developed over long timescales in this natural resource-rich mountainous country.

What the diatomite reveals

The diatomite we studied is situated along the slope of a bowl-shaped depression; the contemporary wetland situated at the bottom of this depression. The diatomite was characterized by species (such as Staurosirella pinnata, Staurosira construens and Aulacoseira ambigua) that thrive in persistent, surface waters such as lakes.

We then explored three further components: the contemporary topography of the landscape, the contemporary rainfall variability, and the geochemistry of the diatomite from the core, which was done alongside the diatom analysis.

Using the Topographic Position Index, an equation which compares the topography of a pixel to that of its neighbors using remote sensing, we confirmed that the bowl-shaped depression was sufficiently enclosed to feasibly have housed a small lake. Its depth would include the present-day diatomite outcrops. This topography would be necessary to explain how diatoms that have a preferred habitat of standing waters were in such high concentrations.

We also compared the contemporary rainfall at Mafadi to that at Lake Letšeng-la Letsie, a natural lake further south near the Ongeluksnek border with South Africa. It was dammed in the 1960s. This data confirmed that the Mafadi lake was hydrologically possible as there is currently more rainfall at Mafadi than at Letšeng-la Letsie.

Shifting patterns

So, how long was the lake around for? And where did it go?

We used radiocarbon to date the diatomite. The results indicate that the lake was present on the Mafadi summit from at least 4,000 years ago, until an estimated 150 years ago.

During this time, the diatom flora of the lake was rather stable. However, while the geochemistry of the lake was also stable for most of this time, there was a major geochemical change in the diatomite from around the year 1340 CE, indicative of changing nutrient availability, and perhaps the lake becoming shallower at this time. This shift occurred concurrently with regionally cooler temperatures linked to what's known as the Little Ice Age. Simply put, changes in climate may have played a role in changing environmental conditions on the summit.

We are unable to determine the exact date when the lake disappeared. But the reasons for its disappearance are likely complex.

Unfortunately, long-term precipitation records for the eastern Lesotho highlands are lacking. But we do know that the lake's disappearance about 150 years ago coincided with two major environmental changes. One was global climate change since the start of the Industrial Revolution. The other was regional landscape modification linked to the migration of herders and livestock into the higher reaches of the Maloti mountains, of which Mafadi is part, to find new grazing areas for their livestock.

Pastoralists' use of these mountain ecosystems over the past century through burning and grazing has led to widespread land degradation; soils and wetlands have been extensively eroded. Upland erosion has a negative impact on wetland hydrology. This, together with shifting precipitation patterns, may have led to the lake's final demise.

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