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Earth and Space

How a fossil tree can picture the Peruvian Andes ten million years ago

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ABSTRACT

Fossil plants found in the Peruvian Andes revealed a dramatic tale of past environmental change. This transformation was a response of the rapid mountain uplift that occurred millions of years ago in this region. These findings underscore the fundamental role that the Andean uplift play shaping South American past, present and future climate.

Image credits: Edwin Cadena

If you have had the opportunity to climb up to the top of a tall mountain, you have probably noticed that as you go up the trees become smaller and smaller, until they disappear from the landscape, and only small shrubs, grasses and herbs fill the panorama. This is why in our fossil hunt fieldtrip to the highlands of Peru, we were pleasantly surprised when Floretino Tunquipa, a local villager, showed us an amazing discovery he excavated right outside of his house: a large fossilized tree that could has been as tall as a 10-story building when it was alive. When we saw it, we immediately, began to wonder: what kind of tree was it? Why was it there and how old was it?

In our field trip we specifically visited the Central Andean Plateau (or Altiplano), an extensive grassland ecosystem, called puna, located at almost 4000 m of elevation. When you first arrive there and walk a few blocks, you immediately realize that the air is so thin that it can be hard to breathe. The nights are freezing and the climate is windy and relatively dry for most of the year. All of these conditions together create an extreme environment to which not many organisms can adapt.

We decided to visit this region because we wanted to study the uplift of the Andes, and plateaus are often ideal settings to study fossils and rocks that track the changes occurred in the tectonic configuration.

The Andean uplift played a fundamental role shaping South American climate and species distribution. Using the plant fossil and geological record, we wanted to understand the relationships between the rise of the Andes, plant composition, and local climatic evolution.

In addition to the fossil tree, we were lucky enough to find other wood samples, dozens of fossil leaves, and almost five thousand records of pollen grains and spores. We dated the rocks in which the fossils were preserved and found two time-windows: one of Miocene age, from approximately eighteen to ten million years ago and a more recent one from Pliocene age, from about five million years ago. We then identified our fossil samples and related them with modern plants. Subsequently, based on the current distribution of the modern relatives of these fossils, we employed statistical models to define a shared climate range of the modern relatives and obtain climate estimation for both of the time-windows.

We found that the tree was around 10 million years old and belonged to the bean family, the most characteristic group of plants in the tropics today. At that time, the Central Andean Plateau had half the elevation it has today, around 2000 meters high. The climate was warmer and more humid. These conditions allowed a montane forest to develop, including tall trees, palms and tree ferns. Later, about five million years ago, the Central Andean Plateau reached the elevation it has today, and it underwent a profound transformation, from the forest we saw in the fossil record, to the puna grassland we see today. Climate also became much cooler and drier.

Seeing this past dramatic environmental change in such a short period (geologically speaking) supports previous hypotheses that the tectonic uplift of this region occurred in rapid pulses.

Separately, computer simulations of past Andean climate had predicted that by the time this tree was alive (approximately ten million years ago), this region should have been much drier than it is today. However, our fossil-based predictions showed exactly the opposite pattern: it was much wetter!

This underlines the important role of fossils in the study of climate change, as witness of our planet transformation. Understanding the discrepancies between fossil-based estimations and computer-based simulations can help us elucidate the driving forces controlling the climate of the Altiplano and ultimately the overall climate in South America.

According to climate models, in less than a decade the temperature and atmospheric carbon dioxide concentrations of our planet will be comparable with those experienced in the Miocene. Studying the interplay between the past and present climate of the Altiplano is fundamental to predicting what the future of this region will look like. Fossils and rocks also remind us about the long history of a planet that is under constant change.

The next time that you see a mountain, think of it as a dynamic structure that affects the climate and organisms living in it.