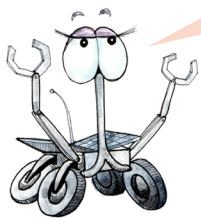


Humans and environments in the most arid place in the world: The Atacama Desert

María Eugenia de Porras, Eugenia M. Gayó, Mauricio Uribe and Antonio Maldonado

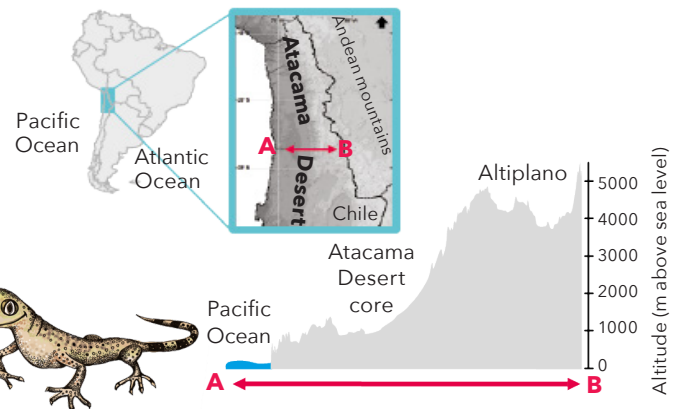
The Atacama Desert lies between the Pacific coast and the Andes in northern Chile. It is the largest desert in South America and the driest on Earth. Here, annual precipitation is almost zero. The little water that is available depends on the summer rainfall that falls on the Andean mountains. It reaches the desert by runoff and is found within some canyons or by the emergence of groundwater.

The presence of life in this extreme environment may seem unimaginable today; however, fossil and archaeological records reveal that plants, animals, and even humans lived in this region during various periods over the last 18,000 years.



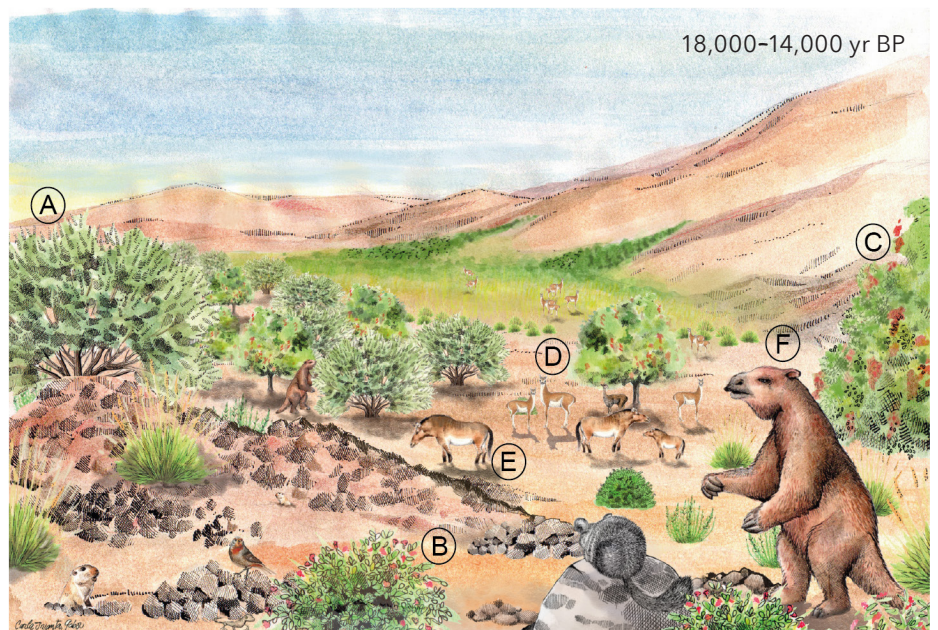
Wow! Really? The Atacama Desert is like the surface of Mars! Now I get why I was sent here to be trained for my mission! But has the desert ever hosted life? Hmmm, I'm wondering ... has it been less dry in the past?

Hey Zoë! Scientists working with paleoenvironmental archives have indeed found evidence that there were wetter periods several times in the Atacama Desert over the last 18,000 years.



Different **paleoenvironmental** records indicate that extensive **wetlands**, springs, shallow lakes, and several **perennial rivers** existed between 18,000 and 14,000 years ago in the core of the Atacama Desert. These landscape transformations are explained by higher precipitation over the Andes in the past (named the Central Andean Pluvial Event 1), that watered the core of the desert. This led to a flourishing of life, including several perennial native trees (*Prosopis tamarugo*^A, *Escallonia angustifolia*^B, *Schinus molle*^C) growing along rivers (riparian areas) and close to wetland **oases**.¹

Such a vegetated landscape also allowed many types of animals to live in this region, including rodents, birds, and South American camelids (guanacos^D), as well as some larger, now extinct, South American animals (megafauna) such as small horses^E and **ground sloths**.^{F,2} This wetter phase ended abruptly about 14,000 years ago,



leading to climatic and ecological conditions similar to today, which persisted over the following 1000 years.¹



Name: **Zoë**

Type: Solar- powered autonomous robot

Mission: Detect microorganisms and map the distribution of life in the Atacama Desert; perform tasks that could be used in future exploration of Mars.

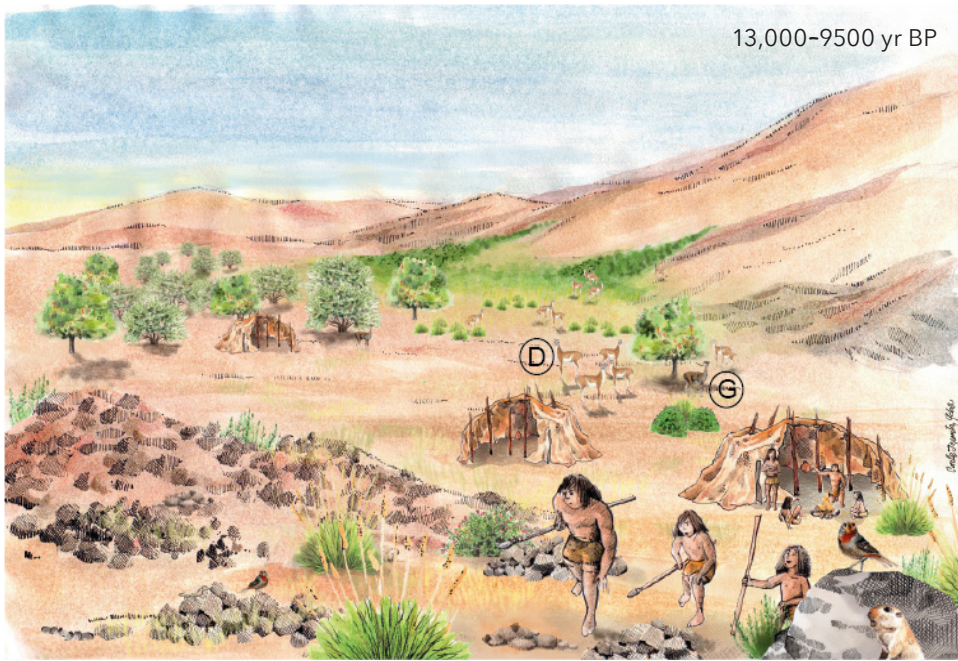


Name: **Gecko**

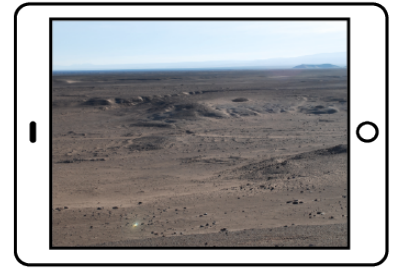
Scientific name: *Phyllodactylus gerrhopygus*

Where to find it: Northern Atacama Desert from the coast to the mountains up to 3500 m (11,500 ft) above sea level.

Fun fact: Each of its fingers has two touch pads and claws between them which allow Gecko to move on the hot surface of the desert.



13,000–9500 yr BP



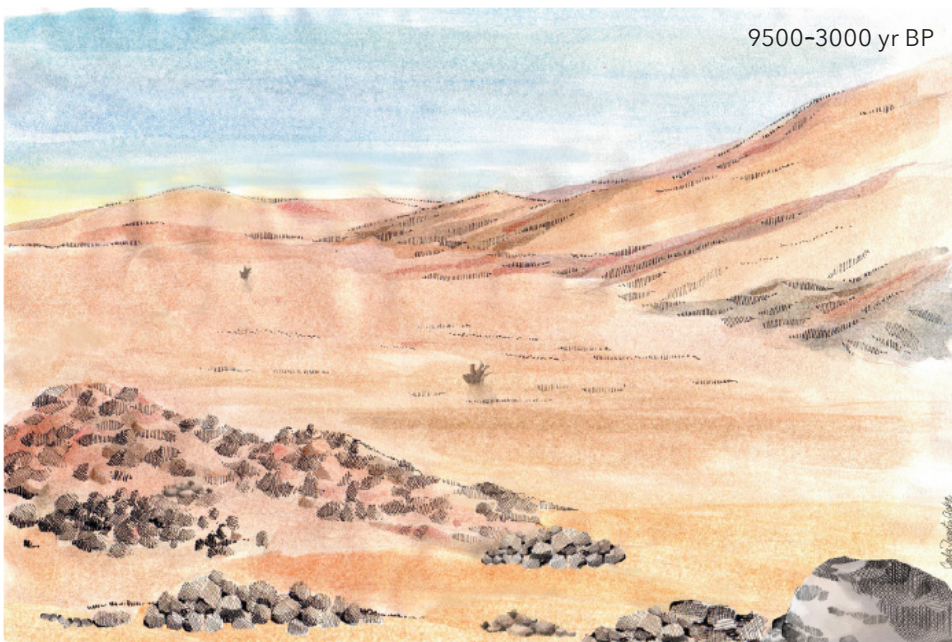
Earliest human sites at present



Projectile point

About 13,000 years ago, the desert once again became wet (Central Andean Pluvial Event 2), and freshwater oases with herbaceous vegetation and trees took root across the lowlands of the Atacama Desert.^{1,3,4} The megafauna was no longer part of the story, but small rodents, birds, and camelids such as guanacos^D and vicuñas^G became commonplace in these ecosystems. Humans also entered the scene during this period:

evidence indicates that the first settlers in the desert arrived about 12,800 years ago.^{3,4} Attracted by the availability of biotic and water resources, these hunter-gatherers established camps around wetlands and riparian areas. However, such residential bases were only intermittently occupied as environmental and ecological conditions varied, making a nomadic lifestyle necessary during various periods in the extreme inland Atacama.^{3,4}



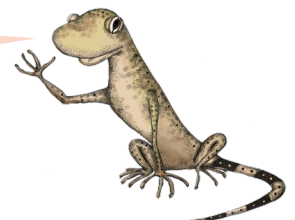
9500–3000 yr BP

The lack of paleoenvironmental and archaeological records dating between 9500 and 3000 years ago has led paleoecologists and archaeologists to infer that a huge 6000-year drought took place in the Atacama Desert core due to a decrease in rainfall over the Andes.^{1,3,4} The heavy decrease in water availability was hard for hunter-gatherer groups, who disappeared from the landscape. In fact, the previous environment full of water and biotic resources vanished, leaving a harsh habitat resembling the modern desert.

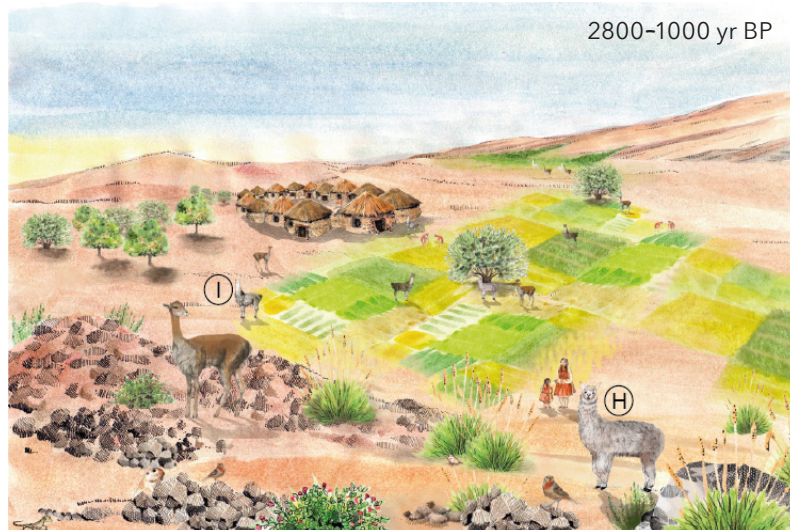


Oh noooo!!! Don't tell me that humans met the same fate as the megafauna!!! Did the humans in the Atacama Desert go extinct???? Dear Gecko, please, tell me more!!!!

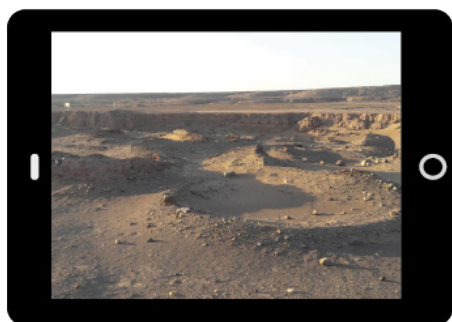
Fortunately they didn't! Archaeologists have found evidence that people moved to the few canyons within the desert that still had permanent water, or towards the Pacific coast and towards the Andean highlands.^{3,4}



Wet phases returned to the area about 3000 years ago, but these were only moderate in comparison to what had occurred before. **Paleoenvironmental** evidence indicates that two wet periods at 2500–2000 and 1600–1100 years ago led to increased runoff and local **water-table levels** across the Atacama Desert core. However, these were not enough to activate springs or **wetlands**, and the vegetation cover of native herbaceous and woody plants was scarce and mostly restricted to ravines.^{3,4} Humans re-occupied the low-elevation desert around 2800 years ago.⁵ Since then, people gradually adapted their traditional hunting and gathering system to an agricultural lifestyle, despite still foraging some wild resources (plants and animals). Population sizes increased when largely dispersed but concentrated villages with monumental public spaces (squares) and cemeteries were built, incorporating new forms of social organization with different economic and ritual activities. Local communities developed sophisticated technologies to manage surface water, including dams and irrigation canals for maintaining large and well-drained



cultivation plots on what are now arid floodplains. Domestic South American camelids (alpacas^H and llamas^I) usually hung around and herded around these fields where quinoa, gourd, and maize were cultivated, as well as algarrobos or mesquite trees (*Prosopis*).^{3,4,5}



Abandoned village with circular-shaped buildings



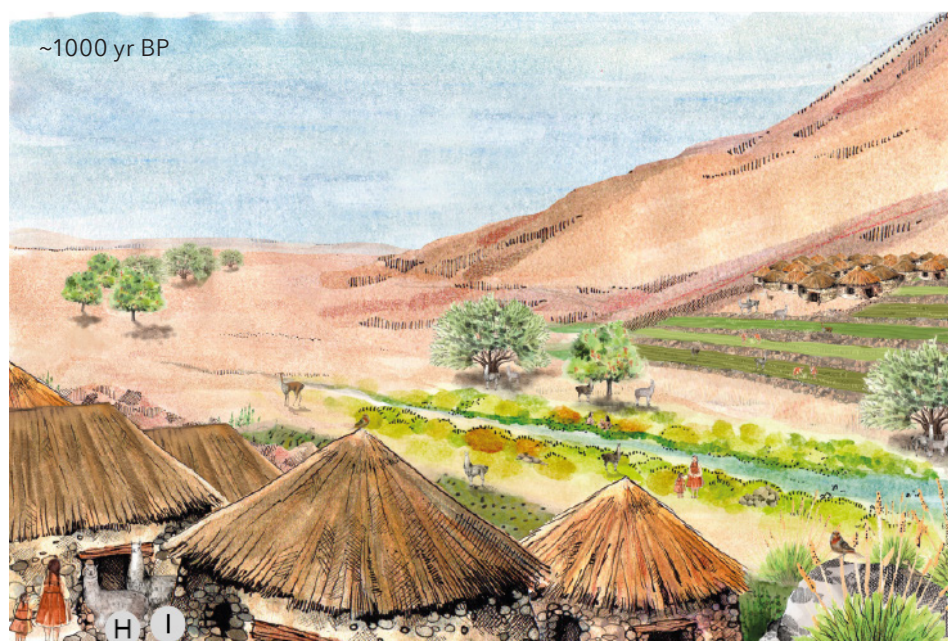
Ancient cultivation plots in the desert

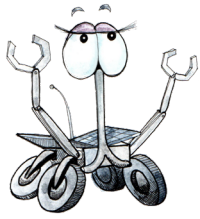


Cob associated with a cultivation plot

Arid conditions set into the area 1000 years ago.^{3,4} In order to face this scenario, people moved from the desert core to the Pacific coast or higher elevations (above 2400 m/7900 ft above sea level), where water

was much more abundant. That is, villages were now built following a vertical arrangement at upstream **oases** (canyons, **wetlands**) or in the Altiplano.⁶ Public spaces were separated from residential areas, located within or outside the villages. New systems of agriculture (arranged as terraced fields), defensive infrastructures (locally known as Pukaras) and land-use patterns emerged. Since this phase, the number of villages and the population density started to increase, and local communities intensified agricultural activities and the husbandry of alpacas^H and llamas^I within these circumscribed territories at high elevations.⁶ The Atacama lowlands become a space that served as a place for communication and exchange between people from Andean highlands and the Pacific coast (an internodal territory). Still, archaeologists have suggested that this landscape was used opportunistically by farmers after flashflood episodes that temporarily inundated the Atacama Desert core.



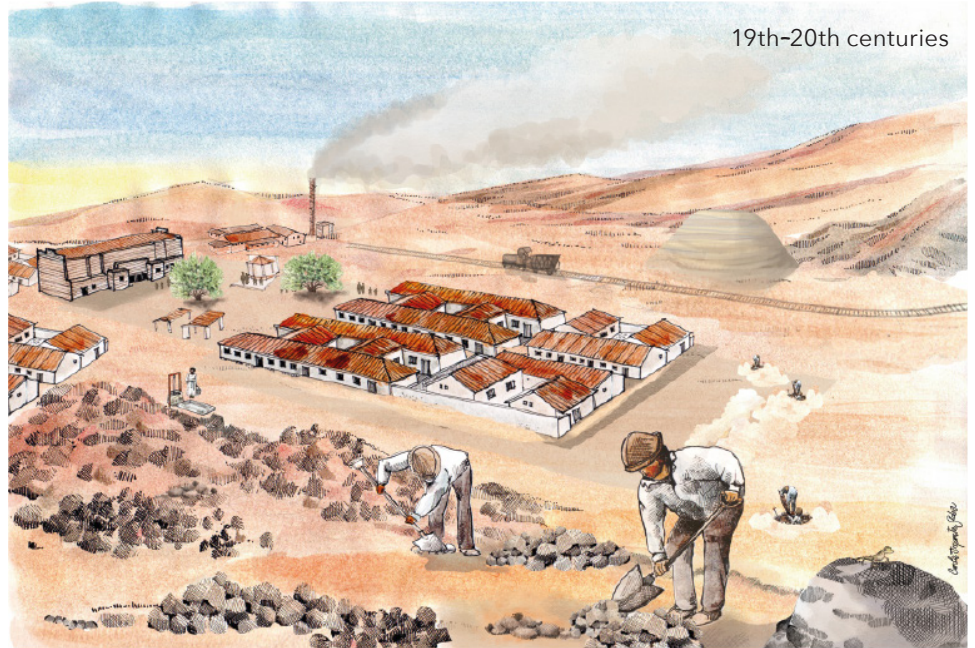


Let me guess, Gecko! Humans never settled long term in the desert core again!!!

Hmmm ... I'm afraid not. They have actually inhabited this landscape since the 15th century, but in a quite different way ...



During the last 700 years, climate has remained similar to present, even during very short (but decade-long) wet pulses.^{3,4} Despite this hostile environment, humans have continuously inhabited the core of the Atacama Desert since the European colonization (starting in 1533 CE).^{3,4,7} This has been achieved by a flexible lifestyle that involves the incorporation of new technologies and the large-scale exploitation of non-renewable natural resources. For example, modern urban centers have relied heavily on the groundwater stored within underground aquifers (fossil water) during past wet phases.^{3,4,7} The first profitable mining industry conducted between the 19th and 20th centuries in the Atacama Desert depended not only on the extraction of saltpeter but also on the use of logs of trees that grew in the core of the desert during both Central Andean Pluvial Events. Today, the Atacama Desert is the world's top producer of copper, which is a key raw material to manufacture a diverse array of



19th-20th centuries

devices that are part of our day-to-day life (e.g. computers, batteries, pipes, clothes, cars, electrical wires, and coins). Nevertheless, such extensive copper extraction to supply global technological needs will soon consume either the entire mineral reserve or a large volume of fossil water.



Old shovel used for saltpeter and fossil wood extraction

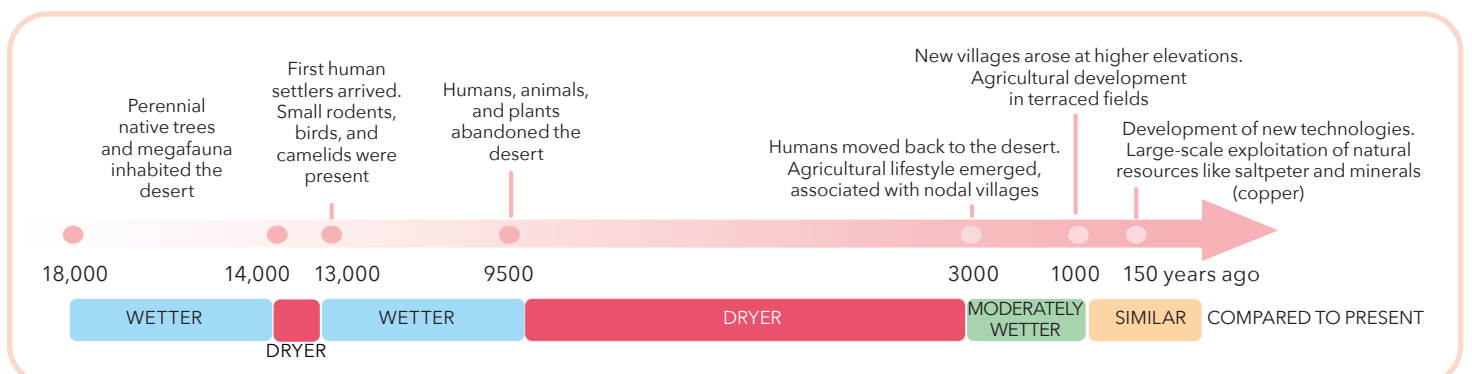


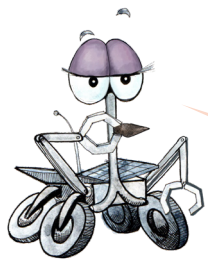
Ancient saltpeter/'caliche' processing plant



Salt peter village ruins at present

Major paleontological, archaeological, and environmental changes recorded in the Atacama Desert over the last 18,000 years





As you see, my dear Zoë, the Atacama Desert has a fascinating environmental history, and people have maintained a delicate balance for over 12,000 years, but the modern lifestyle has affected the balanced relationship that native societies used to have with the fragile Atacama Desert ecosystem ...



Absolutely! Now I feel a little bit ashamed since my circuits are made with Chilean copper ... building me consumed a lot of fossil water! Now I understand that the Atacama Desert is not a barren landscape ... its present ecosystems and archaeological heritage deserve to be protected and the extraction of fossil resources needs to be managed sustainably. I hope it is not too late ... 🔄

GLOSSARY

Extraction of saltpeter: Ancient, extensive economic activity performed during the 19th and 20th centuries to extract potassium nitrate (saltpeter/caliche) from the surface of the Atacama Desert to be used to cure meat and to produce fireworks, fertilizers, and toothpastes.

Ground sloth: Extinct large mammal directly related to modern sloths. It was an herbivore that lived in and around the riparian and wetland oases of the Atacama Desert.

Oases: Isolated areas in the desert where water is available.

Paleoenvironmental: Related to a certain environment of the geologic past.

Perennial rivers: Streams where water is found throughout the year.

Water-table level: Shallowest depth of the groundwater below the Earth's surface. This depth can change through time.

Wetlands: Areas in the desert where water reaches the surface most of the year, allowing plants to grow there or in the surrounding areas.

Exposed fossil wood and plant material

