Soil Horizons

J. Morgan, contributing writer, Soil Science Society of America, Madison, WI.
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A
fter emerging sometime before 1000 BC, the ancient Mesoamerican culture of the Maya rose to become the most advanced Pre-Columbian society in the Americas. By 250 to 900 AD, the Maya were thriving in jungle cities—some larger than 40,000 people—where they erected grand temples, ball courts, and stepped pyramids, and made remarkable advances in language, art, mathematics, and astronomy. Their influence was felt throughout what are now the southern Mexican states of Chiapas, Tabasco, and the country’s Yucatán Peninsula, as well as in the present-day nations of Guatemala, Belize, northern El Salvador, and western Honduras.

And then, for reasons that are still debated despite decades of research, the civilization abandoned its core settlements of the Central Maya Lowlands—in what some call a collapse.

It’s a fascinating tale to archeologists, but one that’s not normally associated with the field of soil science. And yet the story documented in the soils of the Maya’s cities and settlements could hold the key to how they farmed, fed themselves, and treated the land, as well as why their society ultimately declined.

Archeologists have always been concerned with agriculture, notes Charles Golden, an archeological anthropologist at Brandeis University, “and that’s always been one of the great questions about the Maya: How did they manage to maintain these large cities in the rainforest?”

While the questions are enduring, how archeologists are now trying to answer them is not. In collaboration with soil scientists, they’re turning increasingly to the soil and the invisible artifacts it contains, such as chemical traces of food and crops. What they’re finding is that this substance—something archeologists literally used to brush aside—can be just as illuminating as more tangible artifacts.

“Invisible Artifacts: Uncovering Secrets of Ancient Maya Agriculture with Modern Soil Science

John Morgan

This temple in Tikal, labeled "Temple 1" by researchers, was built by the ancient Maya somewhere between 682 and 734 A.D. Source: Department of Biological Sciences, University of Cincinnati.

“I started this in ’97 and here I’m still working on it,” he says. “I can’t seem to get out of it!”

Of particular interest initially were the stucco floors of Maya houses and large plazas. Using a battery-operated spectrophotometer in a field laboratory, Terry and his colleagues identified spatial patterns of various chemicals on the floors, especially of phosphorus, which indicates the remains of food.

In homes, for example, they could distinguish sleeping areas and pathways, which were low in phosphorus, from kitchen and dining areas that contained high levels. They also discovered significant amounts of phosphorus along the edges of floors and household patios, indicating those areas had been swept clean, with food remains pushed to the sides.

But, more surprisingly, they also found phosphorus lining the edges of large, open plazas, which led to a new hypothesis.

The Maya and Markets

Golden is a long-time collaborator of Brigham Young University soil biogeochemist Richard Terry, who 15 years ago offered to add some more robust soil testing in the field to the spot testing that archeologists had done previously at some Maya sites. Terry had no real expectations for where the research would lead or if he’d even stick with it. But the soil chemistry, microbial life, and architecture of the ancient settlements soon captivated him.

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Richard Terry (left) and Fabian Fernandez, a former student of Terry’s at BYU, determine extractable phosphorus in samples of the palace floor at Aguateca, Guatemala. High phosphorus levels in the soil are indicative of ancient human activities related to food preparation and consumption.

“The thought is: Could the ancient Maya have conducted marketplace activity at the plazas?” Terry asks. Much like today, he explains, vendors in ancient times likely sold goods in public spaces during the day and then packed up and cleaned up in the evening.

As a result, no tangible evidence of their activities would be left behind, except potentially for geochemical residues of the food and crafts they marketed long ago. And if traces these items could be found in the plaza floors, they would help clear up what has always been a bit of a mystery to archeologists.

“The problem for the archaeologist is that they find these plazas all over the Maya world—in fact, all over the Americas—and they appear as empty spaces,” Terry says. “There are no artifacts. There’s just nothing remaining. But the soil chemistry is still there.”

And, in fact, at the same time this story line was emerging, another thread of research was suggesting that there was no way the large Maya cities of northern Yucatán could have sustained themselves solely by growing crops on the very poor soils of the region. A 2009 article in the Soil Science Society of America Journal, for example, summarized work at a site at Chunchucmil, Mexico. After analyzing the site’s soils, the researchers concluded that the Maya, previously thought to live in self-sustaining communities, could not have grown enough food there to survive, and must have traded and operated markets.

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Daniel Bair (left) and Chris Balszotti, graduate students at BYU, sample soils at the King’s Palace of Ceibal, Guatemala.

“At this site, the population was just gargantuan,” says Tim Beach, a Georgetown University geoscientist who collaborates with Terry and Golden. “I mean, if I were using modern agricultural technology, I could feed the people there, but it would be hard because the soils were extremely thin. And about half of this landscape had no soils at all.”

If the Maya didn’t grow all their food locally but also operated markets, this further suggested they were using a much larger area for agriculture than previously thought—including, potentially, steep uplands not really suited to farming. So the focus of the group has now shifted to understanding where exactly the food was grown, how the Maya grew it, and whether their practices were sustainable.

The last question is of particular interest today given climate instability and the increasing pressures on natural resources associated with population growth and emerging economies around the world. But these are also questions that archeologists have pondered for decades, Beach notes.

“Even in the 1930s, archaeologists and even some soil scientists found that the upland soils were very thin,” he says. “And they put that together with the fact that there were large ancient Maya populations and many, many Maya sites, and speculated that they must have truncated or eroded those soils.”

Were the Maya Living Sustainably?

If Maya agriculture did cause substantial erosion, Beach continues, the soil loss could eventually have undercut their ability to grow food. To find out whether this did indeed happen, the group has turned to new techniques, including a process that looks for a record of decomposed plant materials in soil layers. (And in many cases, the soil record is all the team has to go on because ancient farm fields are now often covered in rainforest vegetation in very remote areas.)
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mostly use another type, called C\(_3\). These two forms of photosynthesis further lead to measurable differences in the decomposed organic matter derived from the two groups of plants—allowing scientists to track whether only C\(_3\) plants (forest vegetation) once grew in a certain place or if C\(_4\) plants did as well, indicating the presence of ancient corn crops and farm fields.

For example, a paper in the November–December 2012 issue of the *Soil Science Society of America Journal* summarized their findings from a research site in Tikal, Guatemala, where they looked for traces of ancient agricultural activity in upland versus lowland soils. What they found was strong evidence for the past existence of maize—and thus, farming—in the lowland soils, where erosion is less likely and agriculture was presumably more sustainable.

However, they also discovered evidence of erosion in uplocale soils, suggesting that perhaps Maya farming did spread to steeper, less suitable soils over time.

So it remains an open question: Were these clever builders, astute mathematicians, and skilled farmers also living wisely and sustainably in the environment? Or were the Maya terrifically clever but also tragically shortsighted?

What soil scientists and archaeologists have found is both, Beach says: evidence of rampant soil erosion, but also of conservation—in agricultural terraces, for example, and in ingenious farming systems that in some cases adapted to past mismanagement. So, he concludes, “We still don’t know if the Maya transition a millennium ago was caused by environmental or other factors. But we do know there are ways to avoid their soil management mistakes and follow their successes.”

Learning those lessons is no mere archeological exercise. Soil erosion, sustainable farming practices, and feeding a booming population are all pressing issues for our own exceedingly clever society of today. Now, fortunately, the tools of soil science and the soil record are giving researchers quicker, more effective ways to understand how ancient civilizations like the Maya farmed and treated their soils and whether their practices contributed to their demise.

What’s more, both soil scientists and archeologists agree that as the field of archeology has grown more inter disciplinary, they’ve been pushed to become more fluent in each other’s research languages. And in doing so, Golden says, they’ve arrived at a point where they may not have *all* the answers, but they’re now asking, more than ever, the *right* questions.

“I think now you would be hard pressed to find an archaeologist who isn’t concerned with the question of the way the land is being used, the way food is being produced, and the way trees are being harvested,” Golden concludes. “It’s always in our mind now.”

“It opens things up to thinking about the world in ways that we haven’t thought of before,” Terry adds. “We have changed the paradigm amongst the archaeologists.”