Tom Sever - archeologist and remote sensing scientist - Interview

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THE MAIN WITH EYES IN THE SKY: A NASA ARCHAEOLOGIST USES SATELLITIES TO DISCOVER THE LOST HISTORIES OF ANCIENT CULTURES

As a teenager at boarding school, he began sneaking outdoors after lights out. "I fell in love with the sky," recalls Tom Sever, now NASA's archaeologist and a remote-sensing expert at the John C. Stennis Space Center in southwest Mississippi, "and I started inveting my own constellations." Two of his night-sky creation: a 1957 Chevy convertible, his first favorite car; and a San Francisco boxcar, like those that passed on a nearby railroad track. "I know the Greek constellations, and I've taught them," says the 45-year-old, "but even today, the most vivid ones in the sky are the ones I first created."

Sever's gift for envisioning new or subtle patterns has served him well. Pursuing his doctorate in anthropology/archaeology at the University of Colorado in the mid Seventies, he studied prehistoric architcture, astronomy, and calendar systems. In two summers with project scientists in the Southwest studying Anasazi astronomy, he stil searched for patterns. The work included taking measurements of kiva orientations and other Pueblo building structures, and hunting for the solstice and equinox positions that the ancient Anasazi used in their ceremonies.

In a 1977 filed trip into the Andes, he worked with Earthwatch Foundation archaeologists to investigate the Quenchuan Inca's astronomical ceque lines and architectural alignments outside the town of Cuzoco. A system of 41 lines emanates from the Temple of Gold, and along each line ae eight shrines called Wakas, which could be, among other things, caves with human bones. After a day's trek at an altitude near 9,000 feet, Sever sat on a mountainside at dusk watching the sun full behind the Andean high peaks and imagined a satellite flying overhead, its sensors collecting data from the vast mountainous region below.

In the last 15 years, Sever has realized his epiphany in the Andes by developing and refining remotesening technology. This includes optical light-gathering sensors that discriminate and identify surface objects by analzying reflected light, and microwave/radar imaging sensors that can pierce clouds, jungle canopy, sand, and soils. Mounted on satellites, space shuttles, airplanes, blimps, tethered ballons, and even truck-drawn sleds, these remote sensors "see" far beyond the narrow range of visible light (the band waves between ultraviolet and infrared frequencies) in the energy spectrum to which the human eyes is limited. And Sever plays a central role in choosing just what remote sensors will focus on and what their computer backup will analyze.

As we spoke in Sever's office at Stennis, NASA's premier rocket test site for 30 years, at one point a steady roar built, lasting several mintues. It was another static test firing of the space shuttle main engine, part of the program that surpassed 500,000 seconds of test time in one year alonge. Around the rocket-test stand, a variety of remote sensors collected and measured data streams generated from the engine's components, all to produce better and safer rocket engines. This same space-age sensor technology is helping archaeologists detect and record micro amounts of energy, whose pixels they shift and enhance to make the invisble visible, the hidden found. Tom Sever's work is allowing thousands of scientists and researchers to see for the first time.

Omni: What were your thoughts about the future of archaeology during that 1977 summer in the Andes?

Sever: After tracking the ancient Inca lines through the mountains for three months, we'd completed only two and a half of 41 lines. I became aware of just bow tedious and expensive most filed work can be, especially when you're working in demanding enviornments such as roadless mountain regions. Sitting on that hill, I though that even if I were to receive my research funding for years to come, I'd never know the answers, because there were 28 other sets of 41 lines througout South America. At that rate, it would take over 100 years to complete the survey. That meant with our current technology, I'd never understand how this ancient Inca calendar system worked. It bothered me a lot--not knowing, and perhaps never knowing. Then it dawnaed on me that my plight was that of all archaeologists, no matter where they worked. That's when I thought, Could NASA satellite technology be applied successfully to archaeology?

Omin: Once at Stennis, you quickly saw the advantage of airborne sensors? Sever: The high quality of airborne-sensor data and superior resolution made it the best way to test the application of remote sensing to archaeology and anthropology. Aircraft at this time flew much closer to the gound than satellites, so foar sensors mounted on aircraft, the resolution was 5 and 10 meters, versus 80 for satellites. At first there was no funding for archaeology, but I began to win over people working in agriculture, forestry, soil science, wetlands--all of which are relevant to archaeology. They'd then use the instrumentation to solve problems--often the same as archaeologists face.

Much archaeology research focused on site-specific information. Putting information on known, excavated sites into a database, researchers can develop a site profile. Such characteristics as elevation, distance from water, distances between sites or cities, corridors, and transportation routes can help predict potential archaeological sites.

As I began to explore the application of remote sensing, some scientitst expressed doubt. Many were skeptical because earlier airbone sensors were similar to a low-powered telescope unable to detect details on Mars or Juptier. And a satellite sensor's 80-meter resolution would let you see a prehistoric road or wall ruin in the data. Because it hadn't worked earlier, it was hard to convince these scientists it would work this time.

Omni: Where was your first opportunity to prove them wrong?

Severe: Chaco Canyon in northwestern New Mexico, near the Four Corners region. At first I thought about going to more exotic places like Stonehenge or the Pyramids in Egypt, but in the end it was the lab's modest funding that determined our choice. The Chaco Canyon Research Center had done aerial photography and ground survey and had begun a database. If our sensors found prehistoric roads, this would be proof that the technology could work for archaeology. And if we didn't find any roads, that would be an answer, too.

We flew the Thermal Infrared Multispectral Scanner [TIMS] for the first time over Chaco in the spring of 1982. It could resolve the ground down to a five-meter square. The TIMS also detects temperature differences to a tenth of a degree centrigrade on or near the ground. This enabled it to detect prehistoric roads of Chaco Canyon that date to 900 or 1000 A.D. Later, when I stood in Chaco Canyon and looked across the north mesa, holding computer-enhanced images in my hands, I could not see any features with my eyes that were there in the images. That's when the promise of this technology really hit me: how powerful it was, and what it could mean to me and archaeologists eveywhere. I walked out and studied the site because I simply could not believe how good this sensor already was.

Omin: Besides the importance of the thermal sensor, what else did you learn in New Mexico?

Sever: In three more flights over Chaco later in the Eighties, we found some 200 miles of a prehistoric road-way system extending south to Navajo Springs, Arizona, and into southeast Utah. Just how much farther this road-way system extends remains unkown. At one time, people belived Chaco Canyon was a center for redistribution. But the extent of the road system puts that theory in doubt. I see Chaco Canyon as a social and religious center. Pepole were coming in, exchanging ideas, practicing ritualistic activity, then returning to whence they came. It explains why we've found so few bodies in Chaco: They'd take their dead home to their respective pueblos.

We discovered parallel road segments, sometimes dual sets, making four roadways that would continue for a while and then merge into a single road-way. The myths chronicle the Pueblo's merging as one people, then separating, then merging again in the future.

Omin: What othe sites have you used to develop these sensors?

Sever: We've flown all our sensors over Poverty Point, Louisiana, one of the earliest and most sophisticated archaeological sites in North America. We've built a wonderful database using different types of sensors, optical and radar, from the site, which dates back from 1200 to 1000 B.C. to it's abandonment about 600 B.C. Actively studied and excavated in the Fifties, it has a central plaza surrounded by six concentric ridges, their purpose unknown.

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In the early Eightes, we used TIMS to detec a linear feature invisible from the ground that fan from the central plaza out across these ridges. It turned out to be a causeway or rampway coming into the site. Lying outside and due east of the plaza is a large bird-effigy mound that was once 110 feet high; these earthwoks date about 1000 B.C. That a lot of trade matreial was found there--copper from Michigan, flint material from the Ohio and Tennessee regions--indicates a large trade network existed, perhaps using the river system.

Omni: The project around Arenal Volcano, Costa Rica, provided the most dramatic proof of remote sensing's potential. How did it get started?

Sever: Jim Wiseman, chairman of archaeology at Boston University, recognized the importance of the technology and helped organize a conference that eventually brought 24 top people in various disciplines in Mississippi. An outshoot of the conference was choosing an aera and site to demonstrate the technology. That's when I met with Payson Sheets, an archaeologist from the University of Colorado who had a grant to exacavate prehistoric villages in Costa Rica. Devasted by ten volcanic eruption over the past 4,000 years, these villages were preserved to some extent under layers of ash.

After Sheets's team first surveyed this tropical rain forest region in 1984, NASA initiated two series of overflights using a specially equipped Learjet that flew about 1,000 miles high. When the second series of flights was completed in spring of 1985, our remote-sensing database included color and flase-color infrared photographs, thermal data from the TIMS, two bands of synthetic aperture rada data, and ligh-detection and ranging data. Later, seven spectral bands from the Landsat satellite's thematic-mapper [TM] instrument were also added, making this one of the most extensive remote-sensing databases constructed for archaeology.

Early in 1985, Payson and I were at the site, which is on the Continental Divide, 90 miles from San Jose, Costa Rica, studying the land-scape by foot. I saw a linear feature running through it and pointed it out to him. But he, lacking my computer experience, couldn't see it. As many remote sensors do, I was seeing from a different perspective--one that merges the aerial and ground information. Later on, Payson confessed that he was begining to wonder who NASA had sent him--this guy who throught he was seeing things everywhere.

Then I suggested we go back and look at the color-infrared photography to see if these features showed up there. Our field lab was a wooden shack in the little village of Tilaran, rented for 87 cents a day. We studied the images; lines appeared where I saw the featuers. Payson also saw them in the images and became a believer.

Omni: What did you think the linear features were?

Sever: I first though they were roadways, because they seemed to be several feet wide at the surface. Then we began didding trenches at the base of the cemetery where one of the linear features diverged. As the workers dug the first trench, Payson and I studied the volcanic layers of ash deposited over 4,000 years. As we excavated through the layers, a V pattern emerged, indicating erosion. When we finally got through the ash layers, Payson studied the base, which was only one or two feet wide, and said, "This isn't a road-way. It's a footpath." We were seeing prehistoric footpaths, literally walking in the footsteps of the ancients. In discovering the world's oldest known footpaths, we'd proven to the skeptics that remote sensing was important to the future of archaeology and anthropology.

Over the next few years, we put in 40 to 50 trenches, and with dating techniques, distinguished two different time frames for the footpaths. The earliest network, dated to about 500 B.C., was not as extensive as the later one. There were more footpaths connected to more sites, leading from villages to the cemetery on a high ridge of the Divide, where the people would commune with the departed spirits of loved ones. We can now know the daily movements of people more than 2,000 years ago.

Omni: Besides the infrared, what other remote sensors proved useful?

Sever: The faint lines indicating footpaths on infrared photography could be seen only in open pasture lands. Later, however, we used the TIMS to discriminate footpaths beneath thick forest. Landsat's mapper imagery also helped us find out if the Arenal area was a dryer forest environment during earlier time periods and if the present-day tropical forest grew over it. Satellite data on the Continental Divide shows one side, the dry Pacific as red, and the other, the lush wet Atlantic, as green. As we excavated villages, we found the soils there were oxidized, meaning they were receiving sunlight. But the footpath areas were not, meaning they were under a deep forest canopy. Prehistoric peoples were moving through the tropical forest and living in an environment similar to what we see today--even after all the volcanic eruptions over the centuries.

Omni: How important is remote-sensing technology to our well being?

Sever: More than most people realize. The stereotype has archaeologists just digging up spearheads and pottery and anthropologists just writing down the words of primitive tribes. But we're examining how people adapted to their environment throughout time, how they experienced environmental shift, why cultures come and go. Soils associated with artifacts are as important as the artifacts themselves--probably more relevant than the actual objects. Now more than ever, archaeological research is interdisciplinary: botany, forestry, soil science, hydrology--all contribute to a more complete understanding of the earth, climatic shifts, and how people adapt to large regions. This understanding is critical to decision making affecting the planet.

In Costa Rica, the culture survived repeated volancic explosions. Other cultures, like the advanced Maya societies, did not survive or recover from similar eruptions. Did it have to do with the size and violence of the eruption, the way they farmed their land over time, or territorial and political struggle?

Omni: Where did you fly next?

Sever: Guatemala has many unexplored areas in what was the old Maya Empire, including the Piedras Negras region and Usumacinta River Valley on the border of Mexico and Guatemala. Their inaccessibility and distance from any population center, plus leftist guerrilla activity, has also discouraged expeditions into this area. We joined forces with the National Geographic Society and a small research company in Mississippi. It began as a salvage project because of many rumors about a dam that would have flooded the Usumacinta River Valley, destroyed archaeological sites, caused tremendous environmental destruction, and uprooted the surviving Lacandon Maya.

Omni: Did you hope to change this dam-construction policy?

Sever: That was never the focus of our efforts. We just wanted to understand what was going on in the regio nso good decisions for preservation could be made in the future. In 1988, we produced a thematic-mapper image from Landsat [using several sensors to look at larger areas of terrain] of the Piedras Negras region, using three out of its seven bands for processing. To our surprise, it showed all the land on the Mexican side had been deforested, while in Guatemala, the forest thrived. These TM images were distributed in Guatemala; a copy was brought to the attention of Guatemala's President, Vinicio Cerezo, who immediately summoned the Mexican ambassador. Remotely sensed images of their borders was a factor eventually leading to the presidents of Guatemala and Mexico shaking hands for the first time in 150 years. As a result, the plans to build the dam were halted. A few years later, all seven presidents of Central America signed an agreement to work together on the environment.

Omni: What happens archaeologically when the land is burned?

Sever: The limestone used to build Mayan temples and other structures is also burned. Fire and rain can destroy them, and they can erode away in a few years. There's a constant race between preservation and looting.

Field work is extremely slow and painful. One hour on foot, one hour on a mule, hacking through the thick vegetation. So you must decide what will be the greatest return for the investment of field activity. On five field trips into the central Peten area since 1988, we've seen an incredible amount of looting and destruction--people, usually in groups of four and five, robbing tombs and stealing artifacts. Remore sensing gives us another way to beat the looters into the field, though generally they have beaten us. Looting can be even more dangerous than leftist guerrillas.

Omni: Have you had any close calls?

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Sever: Our group has never had a problem with looters, but we had a run-in with lelftist guerrillas during our second field season. Even though we took many precautions, including passing along our intentions to the villagers so the word would spread, some people weren't too happy that we were there. One morning, about 30 minutes into the field, we were ambushed and captured by leftists. At first there was a lot of yelling; then they rounded as up and kept us covered with their AK-47s.

We knew we were in trouble when they frisked us but let us keep our big machete and bowie knives. The knives were not threat to them. They took us through the woods to a clearing and surrounded us. That's when I thought it was really over and said to myself, "I guess this is it." But then our group had a chance to sit in a circle and talk for 15 minutes. We told each other things, like how we should avoid eye contact with our captors, not show any emotion, don't look mad. We were making it up as we went along.

The first quetion, in Spanish, was, "Who here works for NASA?" We have jokes about this. I claim they all pointed at me! They claim there was an incredible silence as we looked around at them. They held up the Global Positioning System TGPS] receiver. Even though I thought I had inspected it well and cleaned everything, they found a little NASA decal on it. A colleague, Jim Nations, told them none of us could speak Spanisgh, and they took him away. That was scary. We didn't know if we'd ever see him again.

After 45 minutes, they brought him back and said things would be all right. Their lieutenant was a man of honor. Then they interrogated each of us individually for about ten hours. All this time, they kept them guns on us. Finally, the lieutenant said that they represented the people of the Peten, that their concern was for the poor people, and that we were there without permission. He wanted the Americans to know this. Then he said we were free to go.

Omni: Would you go back again?

Sever: I'll do whatever has to be done, without undue risk, to further the work. Exciting history, loke the still-mysterious collapse of the Maya culture, waits to be discovered in the Peten. We did see some unrecorded temple ruins during other field trips there. A combination of moisture and vegetation bandwidths in the near-infrared range of Landsat's thematic mapper are revealing these pyramids. Because of the way vegetation grows around the Maya ruins, and because they are elevated features in a jungle area notorious for being flat, they stand out in the imagery. Sensors can see variation and help pinpoint the ruins. You can't see them from the air when you fly over, and if you're in the field, most likely you'll have to chop your way through the jungle to reach a specific site.

Stone monuments from the remote Piedras Negras area spotted on the black market may lead to other unrecorded sites. Glyphs on these monuments indicate that a great Maya center like Dos Pilas or Tikal, designated Site Q, once existed. Eight other cities mention it in their histories. Each city has its own emblem glyph. The Maya glyph, carved in stone, is not fully translated, but the epigraphers are continuing to help us decipher it.

Omni: Tell us about your work in Israel.

Sever: We're searching for an ancient fire-signal-towr system mentioned several times in the Bible that we believe extended from Jerusalem out into the Israelite Kingdom. We took GPS readings of 25 of the probable signal-tower sites and added these measurements to our geographic-information-system [GIS] database of the region. By digitizing the contour lines on topographic maps, we can make 3-D-like oblique images of that topography. Line-of-site computer imaging highlights such things as location and elevation. Then we take positions on hilltops that would be lines of communication between signal towers. This analysis will tell us the best way to communicate from point A to point B. Later, we'll go into the field again and excavate to verify the sites. If they prove to be towers, it may demonstrate these Iroin Age [circa 1000 B.C. to 100 A.D.] people were more mathematically and scientifically sophisticated than generally thought. The engineering for tower height alone would include such factors as the distance and elevations of the two closest signaling towers.

Omni: Do you have any projects in the United States.

Sever: The Army Corps of Engineers has asked us to the Wright-Patterson Air Force Base in Ohio to pinpoint the Wright brothers' 1910 hanger. They've narrowed it down to a ten-acre area. We anticipate thermal sensors will also define a roadbed, a launch rail, privies, perhaps even a runway or a corridor leading out from the hanger.

We may fly a new instrument now being developed: the ATLAS. it represents a new generation--it's lighter, more sensitive, and better all around than TIMS. It'll record nine bandwidth channels of the energy spectrum in the visible and ner infrared as well as the six narrow-band thermal channels currently in the TIMS. A single, compact ATLAS is capable of recording 15 electromagnetic bandwidths at once, whereas before, the same coverage required two sensors flying at different times.

Omni: If you could go anywhere with the best sensors, where would you go?

Sever: The unexplored areas of the Amazon on the eastern side of the Andes; the Rio Abiseo region in Peru; Siberia, northern China, and parts of Mangolia. The cultural resources, of Mongolia were damaged and some destroyed under communism; what's left must soon be preserved. While the tomb of Genghis Khan is an ultimate goal of many researchers, our investigations would focus more on the culture in its entirety. We're not lookig for specific treasure, but rather the history of an entire group of people.

Omni: Will this technology be available to people in the future?

Sever: You might put on a pair of special glasses and see much that's invisible to the human eye. With a little calculator in your pocket, you could change programs to create different filters on the lenses, enabling you to experience vision in the invisible portion of the electromagnetic spectrum. With one filter, you could walk across the landscape and see blighted trees and diseases in the grass. Turn to another bandwidth, and you'd see moist range, you could see subterranean pipelines. The precursor of such glasses is now being technology may be ableto restore vision to more than 60 percent of people considered legally blind but who have some light retention.

The same technologies can be adapted to reveal many portions of the electromagnetic spectrum. No bandwidth is better than any other. Each phenomenon or focus requires the part of the spectrum that best addresses that research question, be it finding Mayan pyramids or selecting hazardous-waste sites. Now that the GPS network gives us precise measurements to within a few meters, I've thought of several new projects. One is to see how occurately tenth- and eleventh-century Arab mosques are aligned toward Mecca.

Omni: What personal sacrifices have you made for your work?

Sever: Archaeologists traditionally maintain a stoic attitude toward hardships in the field. Sure, I've been thirsty, covered with ticks, bitten by snakes, stung by scorpions, captured by guerrillas. I've even caught malaria somewhere along the way. But many scientists and researchers go through similar if not worse hardships. It's unfortunate that people are attracted to this Indiana Jones--syndrome aspect of our work. It's the other side I'm in love with: the discovery, seeing things you've never seen or even thought about before, and testing hypotheses to sort the probable from the improbable.

Omni: Did you have any heroes as a young child?

Sever: They are teachers, colleagues, and friends. I admire these people for their uncompromising dedication to their work and because they maintain the highest standards of quality. It's discouraging when you see high standards being ignored. In myu mind twenties, I went t a lecture by Erich Von Daniken whose Chariots of the Gods was very popular then. The auditorium was sold out. I was astounded that 2,000 people could give Von Daniken this enthusiastic support when he was obviously wrong. I was scandalized by the lack of his knowledge of archaeology and astronomy. Even though I'd been actively interested in these subjects for just a few years, I could see through what he was telling people. It taught me to be careful and try to educate people.

Omni: What does the extension of human senses through remote-sensing technology mean for our future?

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Sever: As a species, we've been literally blind to the universe around us. If the known electromagnetic spectrum--from cosmic rays to visible light to huge seismic waves of the earth's interior--were scaled up to stretch around the planet's circumference, then the human eye and conventional film would see only the visible-light portion, equal to the diameter of a pencil! Our ability to build detectors that see where we can't see and computers that bring invisible information back to our eyesight will contribute to our survival on Earth and in space.

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