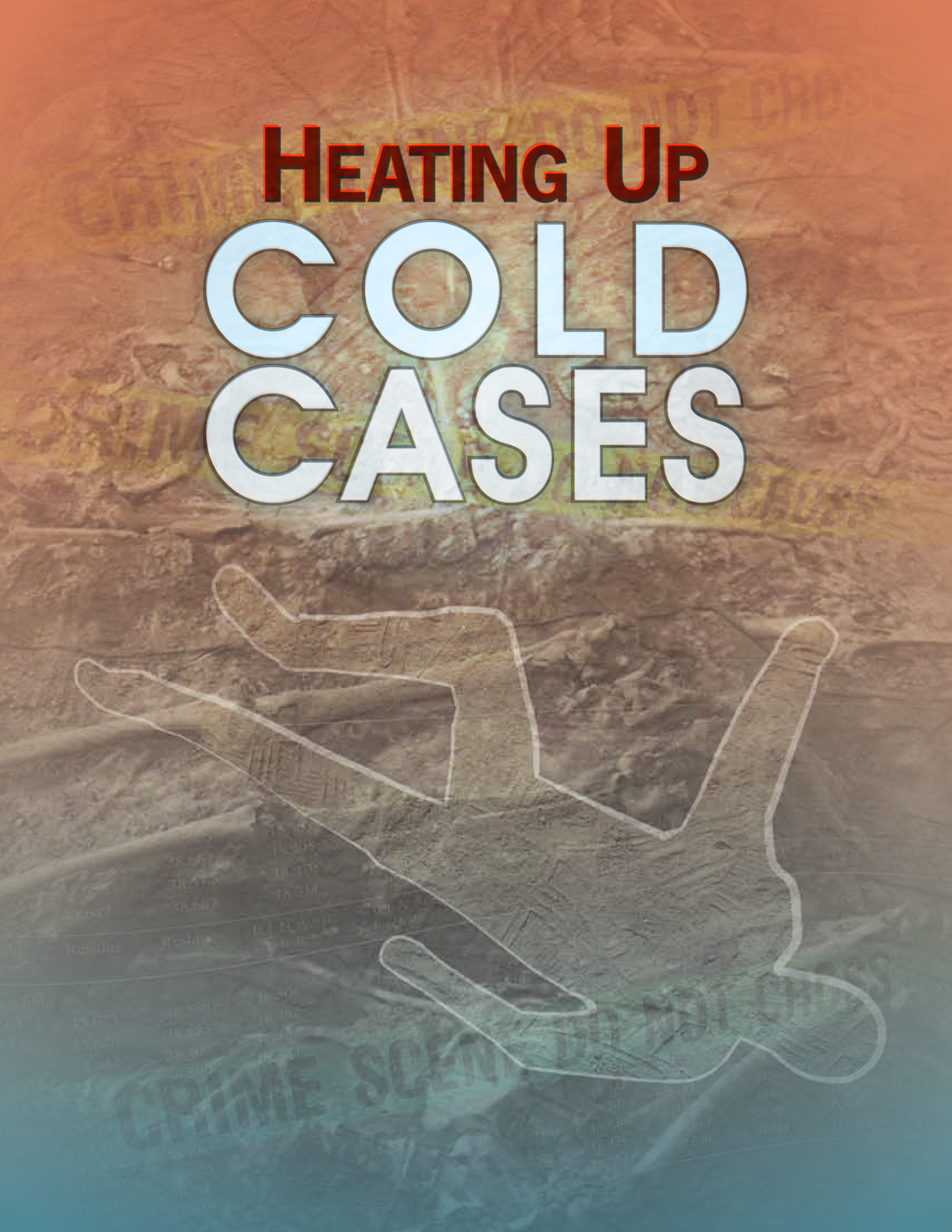
Heating Up Cold Cases



By Donna Hesterman

Investigators turn to a UF geologist for clues about unidentified human remains

NCIS, CSI, Bones. Turn on your television at almost any hour and you can find one of these perennial forensic crime lab shows.

Inevitably, a 30-something starlet in a lab coat stands over a stainless steel table of tea-stained human remains. She pinches a sliver of bone and holds it to the light, saying "I'll run it through the mass spec."

Moments later numbers are scrolling across her computer screen like a digitized Rolodex. Another few seconds and the numbers are replaced by a map glowing on the screen with a small patch of red blinking over the East Coast.

"We have a match," she declares triumphantly. "He's from Virginia."

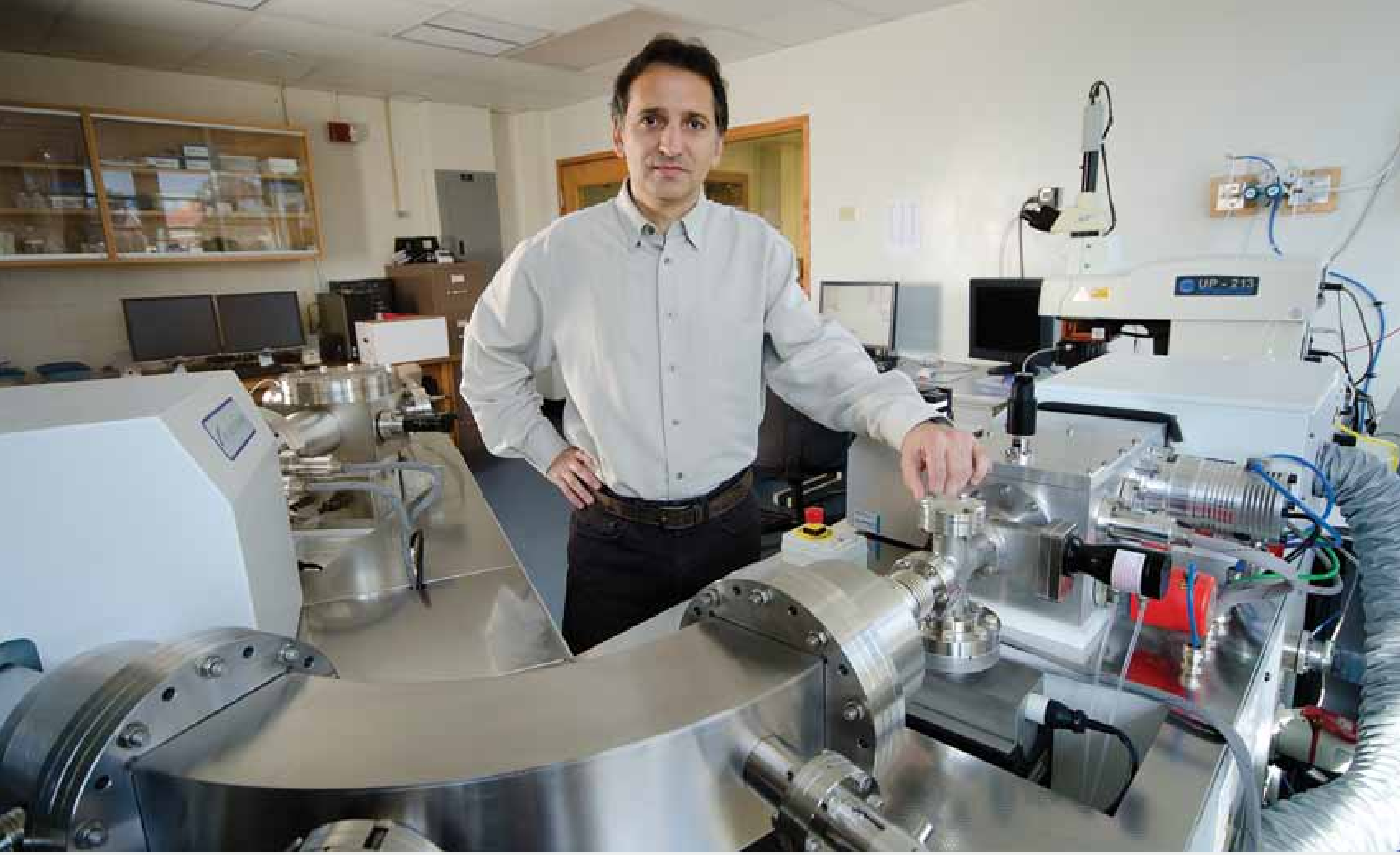
But that isn't how it works in reality.

Forensic scientists can't tell where a person lived simply by analyzing a sample of their bone. Not yet, anyway.

The elemental ingredients exposed by mass spectrometer analysis are meaningless without knowledge that links the elemental profile to a place. And, currently, there is no reference book or database that contains that information.

George Kamenov, a researcher in the University of Florida's Department of Geological Sciences, may be the closest thing investigators have to a database of Earth's elemental profiles. He's using his expertise to give detectives in the Hillsborough County Sheriff's Office a hand with some of their cold case files.

Marg Helgenberger (above) as Catherine Willows on the CBS drama CSI: Crime Scene Investigation.



Eric Zamora

Kamenov, like other geologists, studies the chemical makeup of the Earth's crust for clues about how tectonic plates have moved and shifted over time. He uses a mass spectrometer to break samples of rock and soil into their elemental ingredients, or isotopes — variant forms of an element that differ by the number of neutrons present in the nuclei.

The isotopes function as sort of an "inorganic DNA" that he uses to trace the movements of continents and tectonic plates since the breakup of Pangaea hundreds of millions of years ago.

"Different regions have different isotopic profiles because the processes that have created the Earth's mountain ranges, rivers and prairies leave distinct chemical markers in the soil," Kamenov says.

He uses lead isotope analysis for cold case work because elemental lead is found practically everywhere and in a variety of stable isotopes that remain chemically the same over hundreds of thousands of years.

Kamenov, through his experience as a geologist, has become familiar with the mosaic of isotopic profiles that characterize many regions. He's analyzed samples of lava rock, sedimentary stone and soil from sites in Europe, North and South America, Africa and even the Caribbean and Pacific Islands.

But it was his research for a 2008 environmental study that first revealed how people living in a particular region absorb isotopic signals from the soil into their bodies. The air people breathe and the food and water they consume are conduits for elements to enter their bodies. The isotopes they ingest become a record of their past environment.

A friend who had become a dentist back in Kamenov's native Bulgaria sent him his first samples for the study – 20 or so teeth removed during normal dental procedures from patients living in Sofia, Bulgaria.

In the same laboratory at UF where Kamenov had analyzed isotopic data to answer questions in geology, he began to examine human tooth enamel to see if various lead isotopes in the soil were finding their way into human bodies in the same ratios that they appeared in the soil.

They were.

He found that lead isotopes in tooth enamel matched natural sources of lead

George Kamenov (above) in the UF geology department's Inductively Coupled Mass Spectrometry Laboratory. The instrument can heat samples to 18,000 degrees, vaporizing them so the range of isotopes can be identified.

Tiny bone fragments (opposite page) serve as time capsules that hold clues about a person's past environment.

Eric Zamora

Kamenov found that lead isotopes in tooth enamel matched natural sources of lead in the ancient mountains surrounding Sofia. He also found that some of the isotopes matched the black sooty deposits encrusting tailpipes of leaded-gas burning cars around the city.

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"Tooth enamel starts forming when we are babies and keeps building until we are around 10 years of age," Kamenov says. During those early years, babies put a lot of things in their mouth that are covered in dust. Young children inhale dust as they run and play outside. Both activities are excellent pathways for local sources of lead to enter the body. The developing tooth enamel absorbs the local pattern of lead isotopes in the soil.

At the time, Kamenov was trying to trace lead pollution back to its source. He was not looking for a way to tie human remains to a geological region. But that is exactly what he found.

Archaeologists took note of the study and saw the technique as an opportunity to find new clues in what could be called the coldest of cold cases. Bethany Lynn Turner-Livermore, an assistant professor of anthropology at Georgia State University, approached Kamenov for help in tracing the origins of a population of people unearthed by researchers at an ancient Incan site in Peru.

"I wanted to add lead isotope analysis to my study of these well-preserved skeletons at Machu Picchu because it could tell me where these people came from," says Turner-Livermore. Archaeologists in the past have relied on jewelry, pottery and other personal effects to glean information about past cultures. Turner-Livermore is one of a new breed of bio-archaeologists who analyze the chemistry of human remains to gain insight into ancient civilizations.

The Incans were known to have enslaved people from throughout their empire for labor, she says, but archaeologists couldn't tell from the material evidence if laborers were all

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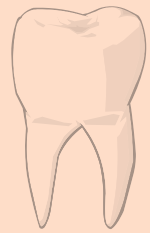
Isotopic Tracking



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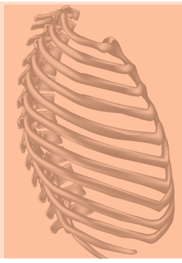

While tooth enamel stops forming in our teenage years, ribs keep remodeling and growing throughout our lives. They maintain an isotopic record of where we have lived the most recent 7-10 years of life.

taken from the same place or if the rulers were plucking individuals from various regions to fill the ranks. It’s the sort of population dynamics question at the heart of many anthropological and archaeological queries.

“You go to Kamenov for that,” Turner-Livermore says. “He has the right equipment to analyze heavy elements like lead but, more importantly, he can translate his geological knowledge into an archaeological context.”

The lead isotope analysis clearly indicated that the Incans were pulling individuals from distant homelands to populate their labor colonies.

Erin Kimmerle, an assistant professor of anthropology at the University of South Florida, heard about Kamenov’s work also and quickly realized he might be able to contribute to the Tampa Cold Case Project she leads.

The project is a collaboration between USF’s Forensic Anthropology Laboratory and local law enforcement that helps detectives in the Hillsborough County Sheriff’s Department identify remains of John and Jane Doe’s who have met an untimely demise in the Tampa area.

Crime drama enthusiasts could easily mistake the USF Forensic Anthropology Laboratory for one of the sets depicted on television. Kimmerle’s team provides DNA testing, and has the technology to perform trauma analysis, facial reconstruction and clandestine grave searches. But sometimes, even that isn’t enough.

“Facial reconstruction or DNA may tell us, for example, that a person is of Asian descent,” says Kimmerle, “but that doesn’t necessarily tell us where they are from.” It helps if detectives can focus their investigation on a specific region. A facial reconstruction or physical description is more likely to be recognized if it is posted in the area where the victim was from.

Kimmerle and her team have been extracting tiny samples of teeth and bone from unidentified cadavers to send to Kamenov since early 2011. Some samples are in support of her work with the Hillsborough County Sheriff’s Department, and some are from other projects. She and Kamenov are also examining forensic cases from Nigeria to build a database of the isotopic profiles that typify people from different regions in that country. The information will eventually be used to identify remains of what are presumed to be victims of genocide from the late 1960s.

The samples arrive unceremoniously in Kamenov’s office — a cardboard box filled with Ziploc baggies containing chips of human bone and teeth.

So far, only two of the 10 Hillsborough County cases analyzed by Kamenov turned out to be the bodies of local “Floridians.” Most of the remains seem to be those of visitors who came to Florida from locales ranging from Kentucky to South Korea. Kamenov recognized the familiar signal of leaded gasoline from Europe in one victim’s tooth enamel.

“Gasoline refiners in Europe and the U.S. used different sources of lead back when automobiles were burning leaded fuel,” Kamenov says. The isotopes in the enamel matched the type of leaded fuel burned in Europe until the 1990s. The lead isotopes in the man’s ribs, however, indicated that he had lived in the Caribbean prior to his arrival in Florida.

“While tooth enamel stops forming in our teenage years,” Kamenov says, “ribs keep remodeling and growing throughout your life.” They maintain

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Aimee Blodgett / USF

Erin Kimmerle applies tools used in biological anthropology to unravel mysteries from local homicides to international cases of human rights abuse.

an isotopic record of where you have lived the most recent 7-10 years of life. The same man had a surgical plate in his knee, and detectives had been busily combing Florida and U.S. databases looking for its serial number until Kamenov's analysis put them on a new path.

Kamenov gives all the credit to the $600,000 contraption that occupies a quarter of the 300-square-foot Inductively Coupled Mass Spectrometry Laboratory in UF's geology department. Unlike other mass spectrometers, the plasma component of this instrument can heat a sample to a vaporizing 18,000 degrees.

The extreme heat sends the sample's molecules and atoms into an excited state, explains Kamenov. An accelerator then propels the particles down a long steel tube until an opportunely placed magnet slows them back down, sorts them according to atomic mass and identifies the range of isotopes present in the sample.

The machine is definitely part of the story. Not every university has a mass spectrometer with its particular range of capabilities. But even if forensic labs around the world had access to this instrument, it is unlikely they would know what to make of the information that comes from heavy isotope analyses. The printed graph of dots and numbers means nothing without a means to link the data to a place.

"It would be great if we had a database like that," says Kimmerle.

She and Kamenov have been working on a database of sorts that will map the most prominent features in Florida's lead isotopic profile. But there's no shortcut. The information required to populate a map like that is unearthed one geological study at a time.

"The database will definitely help out with the Florida cold case files," she says.

Indeed, if geologists like Kamenov could put together a similar database to map the world's distribution of elemental isotopes, it could very nearly put actual forensic scientists on footing with the Abby's and Angela's working in television's forensic labs.

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http://icfahr.usf.edu/coldcase/