CLUES FROM THE ASHES

Were the bodies of 43 missing Mexican students burned at a dumpsite? Fire investigator José Torero says the science doesn't add up

By **Lizzie Wade**, *in Mexico City*

On 12 July 2015, José Torero found himself standing in the municipal dump outside the town of Cocula in the Mexican state of Guerrero, tallying up everything he didn't see. Burn marks on the trees. Melted plastic. Anything that, to his trained eye, would indicate that 10 months before, the Cocula dump could have been the site of a massive fire that burned 43 bodies to ash.

Torero, who was born in Peru and now teaches at the University of Queensland (UQ), St. Lucia, in Brisbane, Australia, had come to investigate a crime that shocked the world: the disappearance of 43 students from the Ayotzinapa Normal School, a rural teacher's college near Tixtla, Guerrero. According to Mexico's attorney general (AG), the crime culminated in the students' bodies being incinerated at the Cocula dump.

But what Torero found—or rather, didn't find—at the alleged scene of the crime has threatened to unravel the government's story and has left the fate of the missing 43 even more mysterious than before. His investigation has also put a fresh spotlight on the forensic science of fire investigation, an area where Torero is seen as a world expert.

Although tens of thousands of fires are examined yearly around the world for arson, few investigations employ state-of-the-art science. Many are done by firefighters who rely on their own experience with how fire behaves, rather than scientific studies, says John Lentini, an independent fire investigator based in Islamorada, Florida. Lentini himself helped raise major doubts about the evidence used to convict Cameron Todd Willingham, a man executed in Texas for setting the fire that killed his family. "The field is not very advanced," Lentini says.

Fire encompasses "biology, chemistry, heat transfer, fluid mechanics, chemical combustion, behavior of structures, behav-

Difficult fire investigations are often highly politicized, José Torero says.

PHOTO: RICHARD COOK/BBC ARCHIVES

ior of materials. Scientifically speaking, it's a problem of enormous complexity," Torero says. Few investigations take into consideration state-of-the-art research in each of these fields. Worse, Lentini says, many investigators set out trying to prove an established theory of the crime, rather than ruling out hypotheses with the help of models and experiments, as Torero does.

TORERO GOT INTERESTED IN FIRE after he left Peru to study engineering at the University of California, Berkeley, where he met researchers working on fire safety problems for the International Space Station. "It was a combination of the NASA thing—it catches everybody's attention—and the fact that the problem in and of itself was incredibly complicated and unique."

During a postdoc with the European Space Agency, Torero's interests began to shift. "What really brought me into more 'down-to-earth' work," he says, was a 1999 fire in the tunnel under Mont Blanc in the French Alps that killed 38 people. In its wake, Torero dedicated himself to the intersection of fire safety and engineering, studying how disastrous fires start and spread as well as engineering strategies to prevent them. After teaching at the University of Maryland, College Park, and the University of Edinburgh, he became the head of the School of Civil Engineering at UQ in 2012.

When it comes to forensic work, Torero dedicates himself to cases "that have a significant social impact." In the aftermath of the 9/11 attacks, he studied the structural weaknesses that allowed fire to bring down the Twin Towers in hopes of improving skyscraper design. In 2011, he investigated a fire that killed 81 inmates in Chile's San Miguel prison. Guards had seen smoke but had failed to open the padlock that kept prisoners trapped in the burning cell. "They were blamed for not taking action and not being able to rescue the inmates," Torero remembers.

After recreating the blaze in the laboratory and using computer models to understand its behavior, his team concluded that by the time the guards saw smoke, the padlock was too hot to open and the prisoners were already dead. "They would never have had the time," Torero says. His conclusions refocused blame away from the individual guards and onto the overcrowded prison conditions that allowed the fire to endanger so many lives.

Tires or wood couldn't have provided the heat needed to completely burn 43 bodies at the Cocula dump, says Torero, who believes incineration in a crematorium is a more likely scenario.

Torero got involved in the Ayotzinapa case at the request of a group of five independent experts (known in Mexico as the Interdisciplinary Group of Independent Experts, or GIEI) convened by the Inter-American Commission on Human Rights to examine both the disappearances and how Mexico's AG has handled the investigation. The trouble began on the night of 26 September 2014, when students hijacked five commercial buses to transport them to a demonstration in Mexico City—an illegal but widely tolerated practice by students at Mexico's politically radical teachers' colleges. The students convened in the town of Iguala, where they came under gunfire by municipal and, allegedly, federal police. Some students escaped, others were killed while trying to flee, and 43 disappeared.

According to the AG, the missing students were kidnapped by the Guerreros Unidos drug cartel with help from the local police and under orders from Iguala's mayor, who had family ties to the gang. They were then executed and their bodies incinerated in the Cocula dump in the early hours of 27 September 2014, the AG says. The executioners gathered some of the remains into trash bags and allegedly dumped them into a nearby river, where they were later recovered; other remains were found in the dump itself.

The remains—mostly ash with a few bone fragments—were sent to a lab at the University of Innsbruck in Austria, where scientists have been able to make positive DNA identifications of two of the missing students. Still, doubts continued to swirl around the government's story, especially because no independent investigators were present when the remains were found, calling into question the chain of custody. The GIEI panel was asked to help resolve the doubts.

"A LOT of the more difficult [fire] cases are highly politicized," Torero says, and Ayotzinapa is no exception. "Politically, you need an answer, and you have to provide that answer now." In the case of Ayotzinapa, arrested cartel members had confessed —under torture, the GIEI suspects—to burning 43 bodies in the Cocula dump. "The [AG's] entire investigation was driven to try to prove or create evidence that what the testimonies were saying was correct," Torero says.

For example, the government's report presents rocks found in the Cocula dump that had been cracked from heat as evidence supporting the confessions. The problem, Torero says, is that "I could have gotten the same cracked rock with a small fire, with an old fire, in a number of different ways"—none of which the AG ruled out.

More things were amiss. Cartel members said they incinerated all 43 bodies at the same time on a pyre made of wood and tires. Past studies done with pig carcasses and human corpses revealed that when a body is burned on a pyre, the fat serves as fuel, but it doesn't provide enough heat to burn up all of the organic matter, Torero says. Yet the remains studied in Austria had virtually no organic matter left. (That's why the lab has been able to make only two DNA identifications so far.) "The only way you eliminate all that is if you have a source of heat that doesn't depend on the fat," Torero says.

Wood and tires could not have supplied so much heat: Torero calculated that the

PHOTO: REUTERS/HENRY ROMERO

perpetrators would have needed to burn 20,000 to 40,000 kilograms of wood or 9000 to 18,000 tires to provide the necessary energy. Instead, the state of the remains "is typical of incineration in a furnace," Torero says, such as those used in crematoriums. No crematoriums near Iguala have yet been investigated as possible crime scenes.

Then Torero went to the Cocula dump himself. He saw some partially burned tires and melted plastic, but they were more in line with what he would expect to see after a series of small fires. Most telling, in his view, were the trees. Leaves burned off in a fire can grow back in 10 months, but when a big fire scorches a tree trunk, that scar never goes away; scientists can even see burn scars centuries later in tree rings. None of the trees bordering the dump showed such damage.

Demonstrators marched in Mexico City on 26 December 2015 to demand justice for the 43 students, whose fate remains unclear.

TORERO ANNOUNCED his findings on 6 September 2015, when the GIEI released its full report: "The hypothesis that 43 bodies were burned in that dump is impossible." The Argentine Forensic Anthropology Team, which is monitoring the Ayotzinapa investigation on behalf of the victims' families, recently released its own report supporting Torero's assessment. And Lentini believes Torero "almost certainly came to the right conclusion."

AG Arely Gómez did not comment on Torero's findings but did open a second forensic investigation of the Cocula site. Several international fire science experts contacted for this story declined to comment because they are participating in that new inquiry. The AG's office told *Science* that it expects to release the results in early April.

Working 10 months after the fact with a questionable chain of custody, Torero knew he wasn't going to be able to reconstruct what happened at the dump. "It's like having three pieces of a 10,000-piece puzzle," he says. Still, for some families it was valuable to have their doubts about the government's story confirmed. "We're poor, but we're not stupid," a mother of one of the victims said at a press conference following Torero's announcement. "Our children weren't burned there!" For now, that's the only thing they can be sure about. ■

FORENSIC FRONTIERS

The microbial death clock

By **Kai Kupferschmidt**

When you die, a new life begins for the billions of microbes you carry with you. Unchecked by your immune system, waves of species start multiplying and breaking down your body. Microbes from the environment join in as well. Geneticist Jessica Metcalf of the University of Colorado, Boulder, hopes this macabre procession can provide a microbial clock that can help investigators tell the time of death more precisely than they can with current methods, which rely on body temperature, rigor mortis, and insects.

Early in the decay, for instance, bacteria from the Moraxellaceae family and the genus *Acinetobacter* begin gorging on dying human cells. Soon after, the Rhizobiaceae family, often involved in breaking down nitrogen sources, takes over. The gases produced by these bacteria cause the body to bloat and eventually rupture, allowing oxygen in and giving aerobic species the upper hand. Microscopic worms also start to multiply, probably feasting on the bacterial biomass now covering the corpse.

Metcalf first showed that she could use microbes, combined with a statistical model, to pinpoint the time of death of mice to within 3 days, even weeks after death. Then her team took samples from four human bodies at a so-called body farm, where cadavers are placed outside so that forensic scientists can study how they decompose. In a paper published in *Science* (8 January, p. 158), they reported that, again, the microbial dance was predictable enough to set a clock. "Over 25 days our error rate is about 2 to 4 days," says Rob Knight of the University of California, San Diego, who is collaborating with Metcalf. In a large new project, the researchers will expose 36 bodies, three at each of three different body farms, in all four seasons. That will help them further calibrate their clock further and tell them how it is affected by the environment. ■

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