

Testimony from the iceman: the 5,000-plus-year-old Neolithic man discovered a decade ago is telling scientists how he lived--and died

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The city of Bolzano, in northern Italy, has many things of which it can boast. It has a scenic location, wedged into a narrow valley between the gray, craggy escarpments of the Dolomites. It has an old central district, closed to automobiles, with streets dotted by small squares and fountains and lined with shops and cafes. The balconies, balustrades and cobblestones of this neighborhood can, in the evening light, induce a visitor to imagine that Romeo and Mercutio might at any moment come swaggering around a corner.

But the most remarkable sight in Bolzano is on the second floor of the old Banca d'Italia building, a short walk from the city's outdoor vegetable market. I first saw it one evening in the company of Dr. Eduard Egarter Vigl, the chief of pathology at the city's hospital.

Dr. Egarter asked me to put on hospital scrubs. He opened a heavy, insulated door and walked into the antechamber of a multiroom new vault built in the center of the building. It was brightly lit, and the temperature within was a degree or two below freezing. Egarter then opened a door to one of the two inner rooms in which the temperature is kept at a constant 20.3 degrees Fahrenheit and the relative humidity hovers between 95 and 98 percent. Inside one of the inner rooms a tray held a body, faceup. Egarter pushed a gurney up to the tray, slid the tray onto it, then rolled the gurney out into the refrigerated antechamber.

The body looks like a skeleton wrapped tightly in hairless skin--skin the brown of a roasted turkey. It gleams with a glaze of ice that is left undefrosted to protect it. It is 1.60 meters tall--about 5 feet 3 inches--and weighs 13.78 kilograms, or a carefully monitored 30.32 pounds. Black lines on its back and ankles appear to be tattoos. Its mouth is frozen in an expression that displays a few worn, chipped teeth. This body, which is roughly 5,300 years old and best known as the Iceman, is perhaps the most spectacular archaeological discovery of the late 20th century.

Egarter is its caretaker. He is a stocky, genial, balding man of 53, with a salt-and-pepper mustache, which, if it were waxed and curled, would give him a slight resemblance to David Suchet's TV version of Agatha Christie's detective, Hercule Poirot. That would be appropriate, because Egarter has become, in addition to the body's conservator, a

sleuth.

More than a decade after the Iceman's discovery, Egarter is still trying to unravel the mysteries of the body on the tray. Along with its clothing and tools, the body was originally perceived as a kind of snapshot of the past, a specimen snatched from the Neolithic era to be analyzed and understood by the science of the present. Developing that snapshot has not proved as simple as was first assumed.

The body on the tray has a nickname, Otzi (it rhymes with "tootsie"), after an area of the Alps called the Otztal. In September 1991, a pair of hikers saw Otzi's head and shoulders protruding from the melting ice in a pass known as the Tisenjoch, some 35 miles northwest of Bolzano. Otzi became a sensation. He made the cover of Time. He was the subject of several books and countless articles. In retrospect, many of the books and articles were partially mistaken.

Otzi began to befuddle people almost as soon as he was found. He was first thought to be just another Alpine fatality. Not realizing the age of their discovery, the rescue workers who came to the scene treated the body less than gently as they tried to pull it from the ice. A jackhammer tore chunks of flesh from Otzi's left hip and damaged his thigh. The unfinished bow that he carried was broken into two pieces, and the frame of his backpack was ripped apart.

Only when an archaeologist from the University of Innsbruck, Dr. Konrad Spindler, saw the copper ax found with Otzi and estimated it to be 4,000 years old--a relic of the Neolithic age--did anyone begin to comprehend what an astonishing discovery had been made on the Tisenjoch. The Neolithic era was the transitional age when stone tools began to give way to metal and when agriculture was supplanting hunting and gathering. Until Otzi, archaeologists had been required to reconstruct Neolithic civilization from skeletal remains, flint tools and arrowheads, bits of pottery and the beginnings of metallurgy. The glacier's damp, freezing temperature had preserved not only Otzi himself but also a trove of organic artifacts--clothing, wooden handles for tools and weapons, feathered arrows--never before seen by modern eyes. Some of the artifacts, however, were inadvertently damaged or destroyed as the body was pried from the ice.

"A lot was lost," says Dr. Markus Egg, an archaeologist at the Roman-Germanic Central Museum in Mainz, Germany, who supervised the restoration of Otzi's belongings. "For example, we don't know how the backpack was worn--over the head or over the shoulder. And the quiver has no strap to indicate how it was carried." Nevertheless, the study of the artifacts that did survive the extraction changed our understanding of the Neolithic world. The radiocarbon dating of Otzi's ax blade forced a revision in the generally accepted date for the advent of copper smelting in the Alpine region. The

feathers on two of his arrows showed that Neolithic man understood the ballistic principles that make an arrow rotate and fly more accurately. The embers that he carried, wrapped in maple leaves in a birch-bark container, suggested how Neolithic people transported fire from place to place.

There had been an assumption, of course, that people of that era wore clothing of some sort. But, save for some jewelry and buttons, there had been no examples until Otzi. From him, archaeologists learned that Neolithic people in central Europe had leggings to protect them from the cold. But they evidently had few woven textiles; all of Otzi's clothing came from animal hides. Despite its primitive appearance, his gear was functional. He had shoes made of leather and bast (plant fiber), stuffed with grass for insulation. When researchers made copies of the shoes, they found them quite practical for hiking in the snow. "Everything we know about clothing from the Neolithic age in Europe is from him," Egg says. "There is nothing to compare. He is alone."

Scientists who worked on the Otzi project produced some elegant results with just specks of evidence. Some researchers, looking at the structure of the body's damaged thighbone, analyzed the secondary osteons--concentric arrangements of bone matrix that increase as a person ages--and estimated that Otzi was in his 40s when he died.

Dr. Klaus Oeggl of the Institute of Botany in Innsbruck received about 40 milligrams of material from Otzi's colon. Laboriously analyzing every milligram, Oeggl found remnants of cooked bread made from einkorn, a primitive variety of wheat. This suggested that Otzi's society had the beginnings of agriculture. Oeggl also found pollen from a plant called the hop hornbeam. Examining it carefully, he found that the cell content within the pollen's outer shell was intact. This told him that the pollen was fresh, since the inner cellular material of pollen from the hop hornbeam decays within a few days or weeks of falling to the ground. From this, Oeggl deduced that Otzi had died in late spring, when the plant sheds its pollen. He also determined that Otzi came from a village on the Italian side of the Tisenjoch, since analysis of sediment layers showed that the hop hornbeam did not grow on the north, or Austrian, side in Otzi's time.

The research on the clothing, the tools and the intestinal contents, however, yielded more information than did research on the state of the body and the cause of Otzi's death. Dr. Werner Platzer, chief of the Department of Anatomy at the University of Innsbruck, was the man initially in charge of conserving the body. His first priority was to make certain it did not decay. Platzer surmised that the best way would be to try to replicate the conditions within the snow and ice of the Tisenjoch. He kept the body packed in crushed ice, stored in a refrigerated vault, and allowed examinations infrequently and for only 30 minutes at a time.

There was sufficient evidence to indicate that the body was male, although in one of

their first publications on Otzi, the Austrian group said the genitals seemed to be missing. They speculated that they might have been torn off during the extraction from the ice. This prompted a German journalist to publish a book claiming that the entire discovery was a fraud and that Otzi was nothing more than a castrated Egyptian mummy, planted in the mountains to stimulate tourism. Only when that book was published in 1993 did the Innsbruck scientists pull the body from the vault, unwrap it and take a closer look. When they did, they discovered that contrary to their earlier supposition, Otzi's genitals were intact.

The major question was how he came to die 10,000 feet up in the Alps. Much of the responsibility for answering it fell to a team of specialists under the supervision of Dr. Dieter zur Nedden, chief of one of the radiology departments at the University of Innsbruck. Zur Nedden scanned the body five times during the six years it was in Innsbruck. The first pictures were made with conventional x-rays. Then there were digital x-rays. There were a total of three examinations with computer tomography. One apparatus even made three-dimensional plastic models of the skull and organs. Zur Nedden worked with a select, international team of experts to assess the findings. They found signs of arteriosclerosis, a possible stroke and osteoarthritis, and they determined that Otzi had suffered a serious injury--broken ribs on his right side. But they could not be certain whether the ribs had been broken before Otzi's death or after, when pressure from the snow and ice might have crushed them.

The broken ribs figured prominently in the death scenario published in 1993 by Spindler, the chief archaeologist on the Innsbruck research team. In his best-selling *The Man in the Ice*, Spindler hypothesized that Otzi had been involved in some catastrophic event, most likely a battle. His ribs had been broken. He fled the scene, leaving his bow and arrows behind, which forced him to start work on a new bow. But the pain of the rib injury was too great to bear at extreme altitudes. Exhausted, he lay down and died.

No one had disproved that theory when the body was brought to Italy in 1998. Though the first police and rescue workers to respond to the news of a body in the ice were Austrian and they had taken it to Innsbruck, a survey made two weeks after the discovery determined that Otzi had actually been found in Italy, about 100 yards from the Austrian border. Italy quickly claimed permanent custody, but did not assume it until six years later, when the specially designed refrigerated vault had been installed in the old bank building in Bolzano (renamed the South Tirol Museum of Archaeology), after repeated testing of the refrigeration technique on another mummified body.

Otzi's transfer was ostensibly friendly, primarily because the ties between Austria and Italy's South Tirol are old and strong. Even today, about 70 percent of the province's population is of German origin. It enjoys a degree of autonomy within Italy, and all of the towns and highway signs have names in both Italian and German. But there was an undercurrent of tension to the transfer, something Egarter expressed in a conversation

before he showed Otzi to me. "Sometimes the Austrians believe that the South Tiroleans are a small country living on tourism and agriculture and they are a little bit--not stupid, but not sophisticated like the university people in Innsbruck," he said. "People here in South Tirol sometimes have an inferiority complex."

Sophisticated or not, the South Tiroleans found themselves responsible for one of the world's archaeological treasures. Egarter was cast in a central role, given the task of preserving the body. He had no credentials in archaeology. His career had been spent managing a staff of 65 people in the local hospital's pathology department, analyzing tissue samples sent by other doctors and doing autopsies. He might, for instance, be asked by an insurance company to determine whether a driver pulled from a car wreck had died from the collision or had perhaps had a heart attack that led to the crash. "Dr. Bruno Hosp, the minister of culture for South Tirol, called me in and told me they had been looking for a conservator for Otzi in South Tirol and had become convinced that I was the man who had the most to do with death," Egarter said, explaining his appointment.

For a couple of years, Egarter confined himself to monitoring Otzi's weight and the condition of his skin, looking for signs of decomposition. He did no research, assuming that all the major questions had been answered in Innsbruck. Then, in June 2001, zur Nedden called. In a joint effort with Wake Forest University in North Carolina, zur Nedden wanted to test a bit of the broken right rib to determine whether the break had occurred before or after Otzi's death. He asked Egarter if he would remove a sliver of bone.

"I went to Innsbruck and asked zur Nedden to show me the position of the fracture, because I had to make coordinates for the extraction," Egarter recalled. "He gave me one picture and said, 'Here is the fracture, it shouldn't be a problem. Open the chest here and take out the piece. It should only take 20 minutes.'"

Not satisfied with zur Nedden's instructions, Egarter enlisted the aid of a Bolzano radiologist, Dr. Paul Gostner. Together they pulled Otzi out of his display vault and into the chilled anteroom, where Egarter felt it was safe to work for the hour or more the procedure might take without risk of defrosting the body. There they took a series of x-rays of Otzi's chest cavity.

"The next day, Dr. Gostner came to me and said he was sorry, but he couldn't see any rib fractures," Egarter continued. "And he asked if I had any old x-rays of the body." Egarter pulled some out and gave them to Gostner, who smiled and said, "OK, I am happy." He was happy because the older pictures proved that his new pictures were accurate, not marred by some error. Like the new pictures, the old x-rays showed a dense, triangular mass in Otzi's left shoulder. It was, Gostner estimated, five times as

dense as bone. It was stone. It looked like an arrowhead. He found it hard to believe that the Innsbruck team could have missed it.

That night, Egarter and Gostner went to the museum and removed the body from its display vault. They saw a dark spot under the left shoulder blade. With his hands, Egarter defrosted the icy glaze that normally covers the body's skin. He found a wound, small but unmistakable, puncturing the skin. He could see that something had created a small channel going through the skin and muscles toward the bone.

This confirmed what the x-rays suggested--that Otzi had been shot in the back. (Presumably, before dying, he had reached back and yanked the arrow shaft from his body. It has not been recovered.) When Egarter reported his discovery, the Austrians went back to their x-rays and CAT scans and found the arrowhead as well. They even made a plastic model of it. "We missed the arrowhead," zur Nedden said in a recent interview. In the x-rays and CAT scans they had made, he explained, "we saw there was a structure. It was very dense and we said, 'Later we'll look at what this structure means.' But we forgot to do it, because we found lots of other things--fractures, calcifications, arthritis and so on."

But they had not, according to Egarter, actually found a rib fracture. The x-rays Gostner and Egarter made showed that what zur Nedden read as a fracture was likely the result of compression, presumably from the weight of snow and ice pressing on the body. In the pictures made in Innsbruck, Egarter explained, Otzi's sixth and seventh ribs on the right side are lying over each other. "This overlapping can give the image of a rib fracture," he said. "It looks like one rib that's been fractured instead of two ribs overlapping. Dr. Gostner made pictures from different angles. If you look from this angle"--he pointed to a spot about six inches under his own armpit--"you can see that you have two ribs and not a fracture."

Nor were those the last changes that the pathologist from Bolzano would make to the scientific record on Otzi. Soon thereafter, Brando Quilici, a filmmaker from Rome who is working on his second film about Otzi for the Discovery Channel (scheduled to air next fall), interviewed Alois Pirpamer, a mountain guide from Vent, on the Austrian side of the Alps, who assisted in the recovery of the body. He told Quilici that when he first saw Otzi, he thought he saw an object clenched in Otzi's right hand, an object that had lodged between two rocks and contributed to the difficulty of the extraction. When the body was finally extricated, film made at the time showed that a rescue worker reached into the slush, removed an artifact and tossed it off to one side. Fortunately, the cameraman zoomed in on the discarded object, which was retrieved and taken to Innsbruck, along with the body and other artifacts. Quilici tracked down that original film footage, which revealed that the "discarded" artifact was in fact a dagger with a flint blade and a wooden handle.

Early in 2002, Egarter, alerted by Quilici, decided to investigate further. He defrosted Otzi's right hand and examined it under a microscope. He found a small cut running from the palm of the right hand, just below the index finger, over to the top side of the hand. It was, in total, about 3.5 centimeters (1.4 inches) long. When he probed, he found he could gently push a scalpel blade to a depth of five or six millimeters. He saw discoloration along the edges of the cut, which suggested to him that it was not made during the extraction of the body. It had been made while Otzi's blood still flowed, before he died. "I think that the wound was very painful," Egarter says. "Two fingers are nearly immobilized."

This wound, too, had not been noticed in Austria. Egarter asked Gostner to make close-up x-rays of the body's right hand. Gostner found two bone lesions--one under the cut and a second on the right wrist. They were consistent with the sort of lesion that a woodworker might suffer if he cut his hand on the blade of a saw. This suggested that Otzi might have sustained the wound fending off an attacker's blade.

Egarter is still not sure how this new evidence fits into a comprehensive theory that would explain how Otzi came to die where he did. He hopes to investigate further. He would like to do an endoscopic examination of Otzi's chest cavity. Then he would like to get permission from the scientific committee of the museum that controls research on Otzi to defrost the body and remove the arrowhead. Doing that would enable him to determine whether the arrow severed any nerves, arteries or veins. Severed arteries would indicate that Otzi died of blood loss shortly after the arrow hit him. If veins were damaged, he might have lasted considerably longer before the loss of blood killed him. If no blood vessels were damaged, he might have survived the wound for several days. While further tests await, Egarter continues to look for other clues. "It was my work, my responsibility at first," he said. "But it has become my hobby." I had the sense that if his command of English were more certain, Egarter would have used the word "passion" instead of "hobby."

I tagged along with Egarter, mountain guide Pirpamer and Quilici one day last summer when they helicoptered up to the Tisenjoch to have a look around. Clouds wafting down from the mountain above hid the sun, melding with the snow and ice that covered much of the ground. Rocks that in sunlight glint with the faint golden color of pyrite looked black and foreboding. It was cold; we could see our exhalations in front of us as we hiked through the snow toward the place where Otzi was discovered.

Egarter, dressed in a parka, red cap, jeans and gaiters, made observations as he walked. "A man would burn a thousand calories an hour in conditions like this," he said, looking around. He scuffed his feet in the snow, trying to get a sense of the footing Otzi had for his final steps. He looked at the mist, mist in which a man could, perhaps,

disappear.

At 65, Pirpamer still has the light, sure step of an experienced mountain guide, though his hair and beard are as white as the flowers of the mountain avens that grow on the slopes below. He led the way to a stone obelisk that marks the site of the discovery. The obelisk's precise placement was dictated primarily by the desire to make it visible to tourists in the valley below. The actual site of the find is about 75 yards away, marked by a splotch of red paint on a boulder.

It was easy to speculate about how Otzi had come to this place and died. Perhaps he was a shepherd returning to a village in the valley below from winter pastures. Maybe another village had raided his home. Maybe another man had taken his wife during his absence. He could have encountered a battle. He could have lost his bow and arrows and fled with only his dagger and copper ax. He might have stopped somewhere to cut another bow and new arrows. His enemies might have pursued him, forcing him to seek refuge higher up, in summer pastures. As he fled upward through forests of larch and pine, he might have sipped water from one of the many rivulets flowing from the glacier above as he passed beyond the tree line, then beyond the vegetation line, where the grass and wildflowers disappear. Somewhere he would have been shot in the back, presumably from below, because the entry wound is beneath the position of the arrowhead.

But no scenario answers all the questions raised by the evidence. If someone shot and killed him, why did the assailant leave a valuable ax with the body? If Otzi had a disabling cut in his right hand, why was he clutching his dagger in it? Egarter does not pretend to know. "My only hypothesis," he tells me later, "is that for whatever reason, Otzi thought he would be safer on the mountain than he was in the valley."

It may be that Egarter will unravel some of this mystery with new tests. The investigation of the man in the ice has revealed a great deal about the Neolithic era. But it has also, unexpectedly, revealed the fallibility of our own science. There are many things about Otzi, I suspect, that we are fated never to know.

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