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SKY LIGHTS:
A flash of
lightning over
Cape Town,
South Africa

EARTH SCIENCE: ATMOSPHERE

SUPER-CHARGED LIGHTNING

A burst of lightning is one of the most powerful naturally occurring phenomena on Earth. Even stronger is a rare, high-powered lightning strike called a *superbolt*. “Superbolts are 1,000 times more energetic than normal lightning,” says Robert Holzworth, an atmospheric scientist at the University of Washington.

Holzworth recently led a team that analyzed nine years of data from lightning-detecting sensors worldwide to learn more about superbolts. Though most lightning storms occur in the summer, Holzworth found that superbolts are most common in the winter. And unlike regular lightning, which usually strikes over land, superbolts strike mostly over the ocean. That makes your odds of seeing a superbolt extremely slim—even Holzworth has not witnessed one.

—Tara Bruno Trubela

HOW TYPICAL LIGHTNING FORMS

Most lightning occurs within clouds, but it can also occur between clouds and the ground. As negative charges reach downward from a cloud, positive charges reach upward from Earth. When they meet, BOOM!

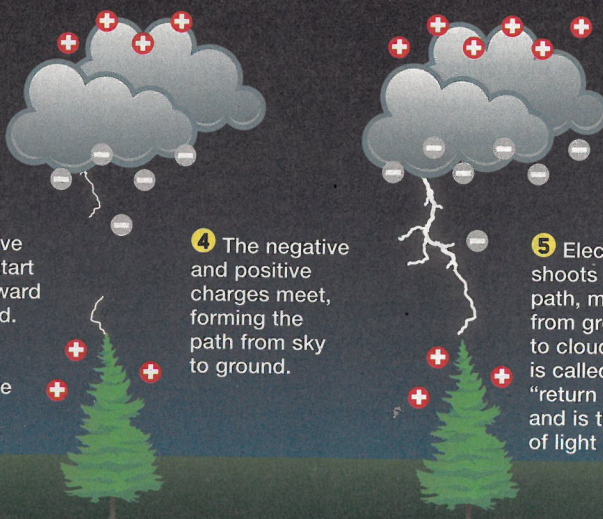
1 Positive charges form at the top of a cloud. Negative charges form at the bottom.

2 Negative charges start a path toward the ground.

3 Positive charges come up from the ground.

4 The negative and positive charges meet, forming the path from sky to ground.

5 Electricity shoots up the path, moving from ground to cloud. This is called the “return stroke” and is the flash of light we see.





FIGHT OVER POMPEII

Why two groups of scientists studying the ancient city of Pompeii and the volcano that destroyed it are at odds

AS YOU READ, THINK ABOUT how scientists might study the site of a past natural disaster to better understand what occurred there.

Nearly 2,000 years ago, the ancient Roman city of Pompeii was suddenly wiped off the map. It was the year 79 A.D., and the city's residents had been experiencing frequent mild earthquakes for months. Quakes are common on Italy's western coast, so people didn't pay them much attention.

Little did they know that the *seismic activity* was a warning. Mount Vesuvius—a large volcano east of the city—was about to blow its top. It would be one of the most violent eruptions in human history, killing an estimated 30,000 people.

Today, historians have a detailed account of what happened that fateful day, thanks to a Roman teenager named Pliny the Younger. The 17-year-old documented the eruption from the nearby city of Misenum. He described seeing a massive, gray cloud rising from Vesuvius's

peak. It reached 32 kilometers (20 miles) into the sky. Hours later, a *pyroclastic flow* of ash, rocks, and superheated gases rushed down the slopes of the volcano, engulfing the city. "It traveled at hurricane-like speeds and killed instantly," says Christopher Kilburn, a *volcanologist* from the University College London in England who studies the region.

In a matter of hours, the city was buried under 3 meters (10 feet) of ash and rock. Pompeii was accidentally rediscovered by construction workers in 1748. Since

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A CITY LOST: The ancient Roman city of Pompeii was destroyed by a volcanic eruption in about a day.

**WHAT WAS
POMPEII LIKE?**

Go to scholastic.com/scienceworld to watch a video about the lost city and how it was rediscovered.

then, scientists have flocked there to learn more about the city, which was preserved beneath the volcanic debris. *Archaeologists*, who study human history, continue to *excavate* the site to uncover the remains of Vesuvius's victims, their homes, and their belongings. Volcanologists also analyze the grounds surrounding the archaeological site. It contains layers of volcanic material from Vesuvius's past eruptions, shedding light on its violent history.

Recently, though, these two groups of scientists have been at



UNEARTHING HISTORY:
An archaeologist removes soil from Pompeii's ruins.

odds over Pompeii. To do their job, archaeologists dig to find ancient artifacts. But that disturbs the deposits volcanologists use to learn about the behavior of the still-active Vesuvius. Without this valuable soil, volcanologists say, they can't best study when this monster will unleash its wrath again.

TRAPPED IN TIME

So many scientists are interested in studying Pompeii because its ruins are unlike those of any other known ancient city, explains Steven Ellis. He's an archaeologist at the University of Cincinnati and a member of the scientific committee for the Great Pompeii Project. This organization aims to conserve Pompeii's remains and manage visitors to the site.



HIDDEN TREASURES: Archaeologists excavated this gold armband at Pompeii.

Most lost ancient cities suffered “a rise and a fall,” says Ellis. That means the cities grew until an event, such as a natural disaster, conflict, plague, or economic decline forced their populations to abandon

their homes. Buildings and items left behind slowly decayed, often becoming overgrown with vegetation, sometimes never to be found. Pompeii, though, was preserved during a period of prosperity. “It was a bustling, thriving city that was demolished overnight—quickly destroyed by an unimagined catastrophe,” says Ellis.

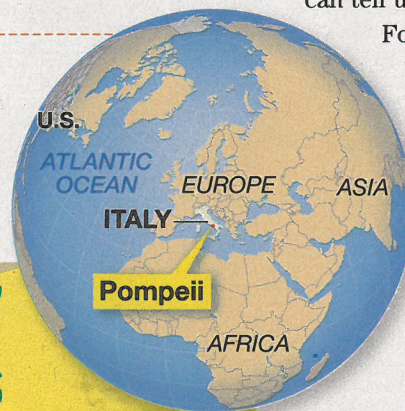
Since Pompeii's rediscovery, archaeologists like Ellis have been unearthing artifacts that tell stories about the city. They've learned that the city had roads paved with stone, restaurants, and indoor plumbing. Walls were adorned with beautifully detailed paintings. There was even graffiti promoting elections and gladiator fights.

“The real excitement comes from identifying an object that can tell us a story,” says Ellis.

For instance, “we'll find a kitchen and uncover a drain that leads out to the street. As we dig, we'll find bones from pigs and fish that tell us about what people ate—their last meals.”

BLAST AREA

The map below shows the yellow and red zones, at great and greater risk, respectively, when Vesuvius erupts. The green line depicts the 79 A.D. pyroclastic blasts that wiped out Pompeii and Herculaneum.



DEADLY CLUES

One of the most remarkable things archaeologists have found are body-shaped cavities in the ash that buried Pompeii. They formed as victims of the disaster slowly decomposed. Excavators preserve these body-shaped voids by pouring plaster into the holes. Once it dries and hardens, they chip away at the ash to reveal statue-like casts of the victims.

To archaeologists, Pompeii's true treasures are buried in the soil. But to volcanologists, the soil itself is worth more than gold. It holds the secrets of Vesuvius's eruptions. Without these deposits, volcanologists can't make discoveries that could help them understand when

FROZEN IN TIME: The plaster casts of some of Vesuvius's victims



the next big blast will occur—and how to protect those living in the volcano's shadow.

For example, scientists weren't sure exactly what killed Pompeii's citizens until recently. They theorized that most of the victims were either suffocated by volcanic gases and falling ash or pummeled by chunks of *pumice*. These small volcanic rocks formed when lava was ejected by Vesuvius.

Then in 2010, volcanologists created a computer simulation based on soil samples they'd analyzed. It identified six different pyroclastic waves released by Vesuvius during its 79 A.D. eruption. The researchers combined this information with a chemical analysis of victims' remains and artifacts. That helped them determine that the pyroclastic surges reached temperatures of 300°C (572°F)—hot enough to kill a person in a fraction of a second.

These waves left little evidence behind. Their deposits were only

TOUCH UP: A restorer cleans an ancient mural painted on a wall in Pompeii.



about 3 centimeters (1 inch) thick, hidden within other layers of volcanic soil. Without this evidence, we wouldn't know the dangers that modern-day populations could face during the next eruption.

SLEEPING GIANT

Vesuvius has erupted dozens of times since the destruction of the ancient city of Pompeii. It most

recently spewed an enormous mushroom cloud from its crater in 1944. "The eruption that destroyed Pompeii was about 100 times larger than the 1944 eruption," says Kilburn, the volcanologist. But the latter still caused damage and the deaths of 26 people.

"The fascinating thing about Vesuvius is that the type of eruption it produces varies from time to

**MOST RECENT
ERUPTION:** Vesuvius
last blew its top in 1944.



time,” says Kilburn. By examining layers of volcanic material deposited in the area around Vesuvius, scientists discovered a pattern: After a period of lava flows, the volcano slumbers. This allows a rock plug to form, trapping gases

inside. The gases build up, and so does the pressure inside the volcano. Eventually, like opening a shaken bottle of soda, the volcano goes KABOOM! This type of volcano, which alternately erupts flowing lava then clouds of ash is

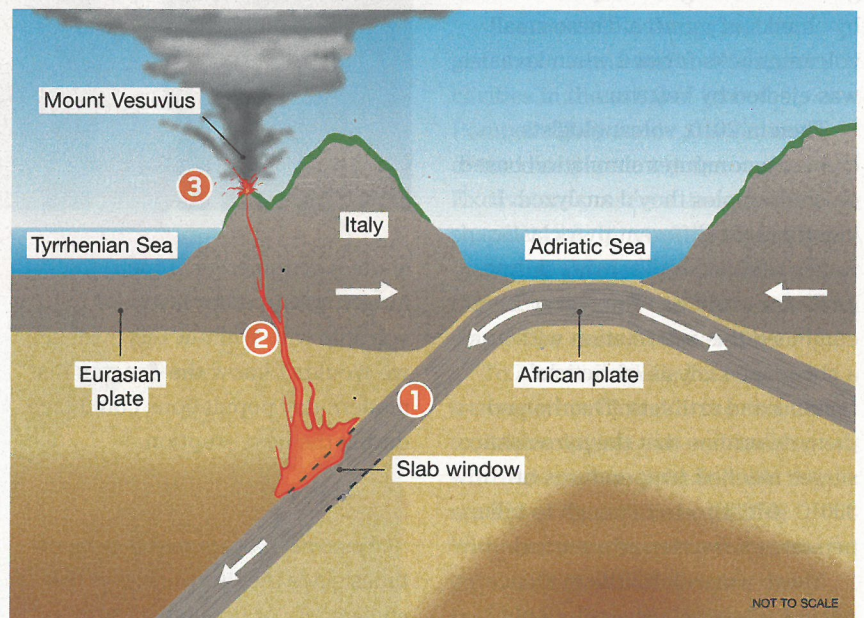
classified as a *stratovolcano* (see *How Vesuvius Formed*; below).

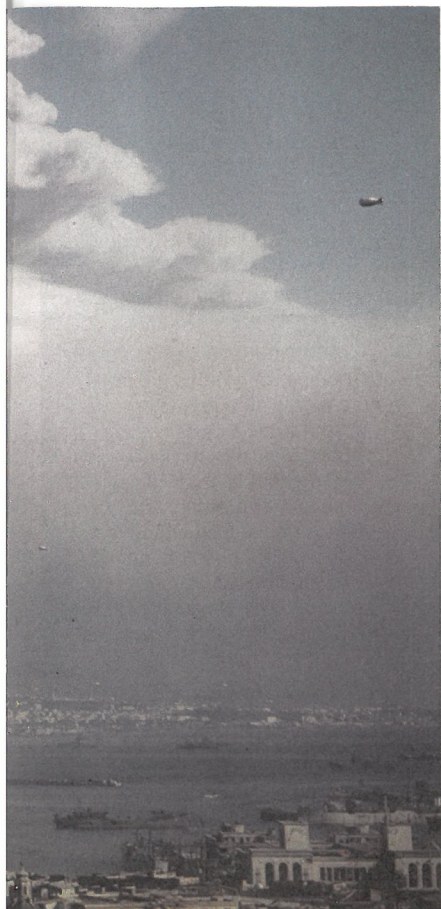
It's only a matter of time until Vesuvius erupts again. And if it turns out to be one of the volcano's more explosive eruptions, it could mean big trouble for the nearby city

HOW VESUVIUS FORMED

Italy is located near the edges of two *tectonic plates*—giant slabs of rock that make up Earth's *crust*, or outer layer. Mount Vesuvius formed over a *subduction zone*, where one plate dives below another.

- 1 The African plate has a tear in it, called a *slab window*. As this area descends, it melts when heated deep inside Earth.
- 2 This produces magma and volcanic gases that rise up beneath the volcano.
- 3 Once enough pressure builds, gases and lava erupt from the volcano.





of Naples. It lies just 12 km (7.5 mi) away from the foot of the volcano.

WARNING FROM THE PAST

Today, about 700,000 people live in Vesuvius's "red zone." This area is considered to be at greatest risk and would be the first to be evacuated when the volcano next shows signs of an eruption (see *Blast Area*, p. 24). A million more people live in the "yellow zone," with lesser risk.

Why would anyone decide to live so close to this ticking time bomb? Past eruptions have made the soil in the area extremely fertile, so it's ideal for farming. Tourists from around the world are also drawn to the beautiful region.

To help protect people visiting or living near Vesuvius, volcanologists analyze samples left behind by the eruption that destroyed Pompeii. By doing so, they can learn about the chemistry of rock spewed by the volcano. "That tells you what the *magma* [melted

rock below Earth's surface] must have been like before the eruption began," explains Kilburn. If scientists detect a similar makeup in Vesuvius's magma today, it might be a warning sign that the volcano is reawakening.

Studying the physical patterns and shapes of the deposits left behind by the deadly pyroclastic waves could reveal more about how they behaved as they rolled through the city. "To have this understanding, we need to be able to gather samples all the way through the volcanic deposits," says Kilburn. But, he adds, if the soil making up these deposits is removed by archaeologists to excavate artifacts, there will be nothing left for volcanologists to study.

CONFLICTING INTERESTS?

Last summer, a letter penned by a group of volcanologists, including Kilburn, was published in the scientific journal *Nature*. It criticized the Great Pompeii Project for removing soil that could be used to learn more about the region's past volcanic activity. "The volcanic deposits should be preserved and studied where they landed—otherwise, the information they contain about the eruption is lost," the authors wrote.

Removing the soil, Kilburn adds, also takes away the potential to study it in the future when new technologies might be available to learn more about the deposits. But Ellis, the archaeologist, argues that despite removal of soil from atop the city, plenty remains for volcanologists to study. "As big as the excavation [at Pompeii] is, it's still small compared with the amount of volcanic material that's still there," he says.

Currently, though, volcanologists don't have permission to work within Pompeii. Ellis says that's

because rules laid out by the Italian government gave the Great Pompeii Project the rights to manage the site. Right now, its main objective is to safeguard the city's remains from further damage after some of its ancient structures collapsed following years of exposure to the elements and poor maintenance.

Ellis explains that many scientists want access to Pompeii, making it increasingly difficult to make everyone happy. But, says Kilburn, "if we had more open collaboration, everyone would win." ❁

—Andrew Klein

WEIGHING THE EVIDENCE

Who do you think should have access to Pompeii? Gather evidence from the text to construct an argument. Use the following questions to help determine your stance and provide reasoning to support your claim.

- 1 What is the role of the Great Pompeii Project in protecting the uncovered city?
- 2 Do archaeologists and volcanologists have different goals when studying Pompeii? Do these goals overlap?
- 3 Should the fact that Vesuvius is an active volcano affect who should have access to the site?
- 4 Is there any way both sides could work together? Or does one or the other deserve to have a greater claim to the site?