

For Delphic Oracle, Fumes and Visions

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For at least 12 centuries, the oracle at Delphi spoke on behalf of the gods, advising rulers, citizens and philosophers on everything from their sex lives to affairs of state. The oracle was always a woman, her divine utterances made in response to a petitioner's request. In a trance, at times in a frenzy, she would answer questions, give orders and make prophecies.

Modern scholarship long ago dismissed as false the explanation that the ancient Greeks gave for the oracle's inspiration, vapors rising from the temple's floor. They found no underlying fissure or possible source of intoxicants. Experts concluded that the vapors were mythical, like much else about the site.

Now, however, a geologist, an archaeologist, a chemist and a toxicologist have teamed up to produce a wealth of evidence suggesting the ancients had it exactly right. The region's underlying rocks turn out to be composed of oily limestone fractured by two hidden faults that cross exactly under the ruined temple, creating a path by which petrochemical fumes could rise to the surface to help induce visions.

In particular, the team found that the oracle probably came under the influence of ethylene -- a sweet-smelling gas once used as an anesthetic. In light doses, it produces feelings of aloof euphoria.

"What we set out to do was simple: to see if there was geological truth to the testimony of Plutarch and the others," said Dr. Jelle Zeilinga de Boer, a geologist at Wesleyan University, who began the Delphic investigations more than two decades ago.

As is often the case in science, the find was rooted in serendipity, hard work and productive dreaming. At one point, not unlike the oracle herself, the scientists were stimulated in their musings by a bottle of Dão, a Portuguese red wine.

The team's work was described last year in *Geology*, a publication of the Geological Society of America, and at the annual meeting in January of the Archaeological Institute of America. It will also be reported in the April issue of *Clinical Toxicology*.

Over the years, scholarly doubt about the thesis has given way to wide acceptance and praise.

"I was very, very skeptical at first," said Dr. Andrew Szegedy-Maszak, a Wesleyan colleague and classicist, who specializes in Greek studies. "But they seem to have it nailed. I came to scoff but stayed to pray."

Near the Gulf of Corinth on the slopes of Mount Parnassus, the religious shrine was founded before 1200 B.C. and the temple eventually built there became the most sacred sanctuary for the ancient Greeks. They considered it the center of the world, marking the site with a large conical stone, the omphalos (meaning navel or center).

Originally a shrine to Gaea, the earth goddess, the temple at Delphi by the eighth century B.C. was dedicated to Apollo, the god of prophecy. His oracle spoke out, often deliriously, and exerted wide influence. One of her admired pronouncements named Socrates the wisest of men.

Before a prophetic session, the oracle would descend into a basement cell and breathe in the sacred fumes. Some scholars say her divine communications were then interpreted and written down by male priests, often in ambiguous verse. But others say the oracle communicated directly with petitioners.

With the rise of Christianity, the temple decayed. The Roman emperor Julian the Apostate tried to restore it in the fourth century A.D., but the oracle wailed that her powers had vanished.

French archaeologists began excavating the ruins in 1892, in time digging down to the temple's foundations. No cleft or large fissure was found. By 1904, a visiting English scholar, A. P. Oppé, declared that ancient beliefs in temple fumes were the result of myth, mistake or fraud.

The Oxford Classical Dictionary in 1948 voiced the prevailing view: "Excavation has rendered improbable the postclassical theory of a chasm with mephitic vapours."

Another round of myth-busting came in 1950 when Pierre Amandry, the French archaeologist who helped lead the temple excavations, declared in a book on Delphi that the region had no volcanism and that the ground was thus unable to produce intoxicating vapors.

Three decades later, in 1981, Dr. de Boer went to Delphi not to study old puzzles but to help the Greek government assess the region's suitability for building nuclear reactors. His main work was searching out hidden faults and judging the likelihood of tremors and earthquakes.

"A lucky thing happened," he recalled. Heavy tour traffic had prompted the government to carve in the hills east of Delphi a wide spot in the road where buses could turn around, exposing "a beautiful fault," he said. It looked young and active.

On foot, Dr. de Boer traced it for days, moving east to west over miles of mountainous terrain, around thorny bushes. The fault was plainly visible, rising as much as 30 feet. West of Delphi, he found that it linked up to a known fault. In the middle, however, it was hidden by rocky debris. Yet the fault appeared to run right under the temple.

"I had read Plutarch and the Greek stories," Dr. de Boer recalled. "And I started thinking, 'Hey, this could have been the fracture along which these fumes rose.' "

Dr. de Boer put the idea aside. Knowing little of the archaeological literature, he assumed that someone else must have made the same observation years earlier and come to the same conclusion.

In 1995, he discovered his mistake. While visiting a Roman ruin in Portugal, he met Dr. John R. Hale, an archaeologist from the University of Louisville, who was studying the Portuguese site. At sunset, the two men shared a bottle of wine, and the geologist began telling the archaeologist of the Delphi fault.

"I said, 'There is no such fault,' " Dr. Hale recalled. But Dr. de Boer convinced him otherwise. He cited both Plutarch, a Greek philosopher who served as a priest at Delphi, and Strabo, an ancient geographer. Each told of geologic fumes that inspired divine frenzies, with Plutarch noting that the gases had a sweet smell. By the end of the evening, the geologist and archaeologist had decided to work together to find the truth.

Back in the United States, Dr. Hale tracked down the original French reports on the temple excavation and discovered to his surprise notations that the bedrock on which the temple was built was "fissured by the action of the waters."

The French archaeologists, expecting a yawning chasm, had apparently overlooked the importance of the small cracks.

"What I had been taught was wrong," Dr. Hale recalled. "The French had not ruled it out."

By 1996, the two men had traveled to Greece to resurvey the fault at Delphi and study the regional maps of Greek geologists. These revealed that underlying strata were bituminous limestone containing up to 20 percent blackish oils.

"I remember him throwing the map at me," Dr. Hale said of Dr. de Boer. " 'It's petrochemicals!' " No volcanism was needed, contrary to the previous speculation. Simple geologic action, Dr. de Boer insisted, could heat the bitumen, releasing chemicals into temple ground waters.

During a field trip in 1998, the vent notion grew more plausible still as the two men discovered a

second fault, which they named Kerna after a well-known spring, going north-south under the temple. The intersecting faults now marked a provocative X.

As intriguing, the second fault appeared to be aligned with a series of ancient dry and modern wet springs, one directly beneath the temple.

The scientists found that the dry springs were coated with travertine, a rocky clue suggesting that the waters had come from deep below. When hot water seeps through limestone, it leaches out calcium carbonate that stays in solution until it rises to the surface and cools quickly. The calcium carbonate can then precipitate to form rocky layers of travertine.

Increasingly excited, the two men won permission from the Greek authorities to sample the travertine.

At this point, Dr. Jeffrey P. Chanton, a geochemist at Florida State University, joined the team. He analyzed the travertine samples gathered from dry springs near the temple and in its foundation, finding methane and ethane. Each can produce altered mental states. But a better candidate soon arose.

"A small light went off in my mind," Dr. de Boer recalled. Perhaps, he speculated, ethylene had been there as well.

Ethylene is significantly less stable than ethane and methane, so its absence in old rocks was understandable. Yet psychoactively, ethylene is quite potent, more so than ethane, methane or even nitrous oxide. From the 1930's to the 1970's, it was used for general anesthesia.

Dr. Chanton went to Greece, sampling an active spring near the temple.

The team waited. Days passed. Then his call came in. He had found ethylene, as well as methane and ethane. To all appearances, the ancient riddle had been solved.

In late 2000, Dr. Henry A. Spiller, the toxicologist who directs the Kentucky Regional Poison Center, joined the team to help with the pharmacological analysis.

"There's a fair amount of data on the effects of ethylene," Dr. Spiller said. "In the first stages, it produces disembodied euphoria, an altered mental status and a pleasant sensation. It's what street people would call getting high. The greater the dose, the deeper you go." Once a person stops breathing ethylene, he added, the effects wear off quickly.

Modern teenagers know of such intoxicants, including ones that in overdoses can kill. Experts say that youths who breathe fumes from gas, glue, paint thinner and other petrochemicals are toying

with hydrocarbon gases.

Of late, Dr. Hale has been widening his focus, investigating other ancient Greek temples that he believes were built intentionally on geologically active sites.

And Dr. de Boer, now 67, is still concentrating on Delphi. On March 9, he and some students left for Greece to drill out rocky samples from the fault zones and illuminate them under a special light to try to establish dates of seismic activity.

Such geologic shocks, he said, may have influenced fume production over the ages, causing the intoxicating gases to wax and wane.

"You never know if it will work," he said of any research project shortly before the Delphi trip. "With the fumes, it did. With this, we don't know. But it's worth a try."

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