

Questioning the Delphic Oracle

When science meets religion at this ancient Greek site, the two turn out to be on better terms than scholars had originally thought

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Figure 1 View from the theatre to the Temple of Apollo (the oracle)

Overview

An intoxicating Tale

- For the past century, scholars have discounted as myth the traditional explanation that vapors rising out of the earth intoxicated, and inspired, the prophesying priestesses at Delphi.
- Recent scientific findings show that this description was, in fact, extraordinarily accurate.
- In particular, the authors have identified two geologic faults that intersect precisely under the site of the oracle.
- Furthermore, the petrochemical-rich layers in the limestone formations of the region most likely produced ethylene, a gas that induces a trancelike state and that could have risen through fissures created by the faults.

Introduction

The temple of Apollo, cradled in the spectacular mountainscape at Delphi, was the most important religious site of the ancient Greek world, for it housed the powerful oracle. Generals sought the oracle's advice on strategy. Colonists asked for guidance before they set sail for Italy, Spain and Africa. Private citizens inquired about health problems and investments. The oracle's advice figures prominently in the myths. When Orestes asked whether he should seek vengeance on his mother for murdering his father, the oracle encouraged him. Oedipus, warned by the oracle that he would murder his father and marry his mother, strove, with famous lack of success, to avoid his fate.



The oracle of Delphi functioned in a specific place, the *adyton**, or "no entry" area of the temple's core, and through a specific person, the Pythia, who was chosen to speak, as a possessed medium, for Apollo, the god of prophecy. Extraordinarily for misogynist Greece,

* ἄδυτον *the innermost sanctuary*, Liddell and Scott. *An Intermediate Greek-English Lexicon*. Oxford. Clarendon Press. 1889.

the Pythia was a woman. And unlike most Greek priests and priestesses, the Pythia did not inherit her office through noble family connections. Although the Pythia had to be from Delphi, she could be old or young, rich or poor, well educated or illiterate. She went through a long and intense period of conditioning, supported by a sisterhood of Delphic women who tended the eternal sacred fire in the temple.



**Figure 2 King Aigeus consults the pythia called Themis*,
Attic vase of about 440 BCE**

* Still without a male heir, Aegeus asked the Oracle at Delphi for advice. Her cryptic words were "Do not loosen the bulging mouth of the wineskin until you have reached the height of Athens, lest you die of grief."

Aegeus (king of Athens) went to Troezena and met with Aethra, daughter of Troezena's king Pittheus. Pittheus understood the prophesy and introduced Aegeas to his daughter, Aethra, when he was drunk. They had sex and when she

The Classical Explanation

Tradition attributed the prophetic inspiration of the powerful oracle to geologic phenomena: a chasm in the earth, a vapor that rose from it, and a spring. Roughly a century ago scholars rejected this explanation when archaeologists digging at the site could find no chasm and detect no gases. The ancient testimony, however, is widespread, and it comes from a variety of sources: historians such as Pliny and Diodorus, philosophers such as Plato, the poets Aeschylus and Cicero, the geographer Strabo, the travel writer Pausanias, and even a priest of Apollo who served at Delphi, the famous essayist and biographer Plutarch.

fell pregnant, Aegeus decided to go back to Athens. Before leaving, he covered his sandals, shield and sword under a huge rock and told her that when their son grew up, he should move the rock and bring the weapons back.

In Troezen, Theseus grew up and became a brave young man. He managed to move the rock and took his father's arms. His mother then told him the truth about who his father was and how he should take the weapons back to him. Theseus decided to go to Athens.

When Theseus arrived, he did not reveal his true identity. He was welcomed by Aegeus, who was suspicious about the stranger who came to Athens. But Aegeus eventually recognized the sandals, shield and sword. Father and son were reunited.



Figure 3 Strabo's *Geographia*, printed by Aldus Minutius, Venice, 1577

Strabo (64 B.C.-A.D. 25) wrote:

"They say that the seat of the oracle is a cavern hollowed deep down in the earth, with a rather narrow mouth, from which rises a *pneuma* [gas, vapor, breath; hence our words "pneumatic" and "pneumonia"] that produces divine possession. A tripod is set above this cleft, mounting which, the Pythia inhales the vapor and prophesies."

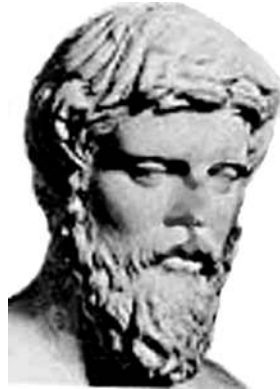


Figure 4 Mestrius Plutarchus (46-127)

Plutarch (A.D. 46-120) left an extended eyewitness account of the workings of the oracle. He described the relationships among god, woman and gas by likening Apollo to a musician, the woman to his instrument and the *pneuma* to the plectrum with which he touched her to make her speak. But Plutarch emphasized that the *pneuma* was only a trigger. It was really the preconditioning and purification (certainly including sexual abstinence, possibly including fasting) of the chosen woman that made her capable of responding to exposure to the *pneuma*. An ordinary person could detect the smell of the gas without passing into an oracular trance.

Plutarch also recorded a number of physical characteristics about the *pneuma*. It smelled like sweet perfume. It was emitted "as if from a spring" in the *adyton* where the Pythia sat, but priests and consultants could on some occasions smell it in the antechamber where they waited for her responses. It could rise either as a free gas or in water. In Plutarch's day the emission had become weak and irregular, the cause, in his opinion, of the weakening influence of the Delphic oracle in world affairs. He suggested that either the vital essence had run out or that heavy rains had diluted it or a great earth-

quake more than four centuries earlier had partially blocked its vent. Maybe, he continued, the vapor had found a new outlet. Plutarch's theories about the lessening of the emission make it clear that he believed it originated in the rock below the temple.

A traveler in the next generation, Pausanias, echoes Plutarch's mention of the *pneuma* rising in water. Pausanias wrote that he saw on the slope above the temple a spring called Kassotis, which he had heard plunged underground and then emerged again in the *adyton*, where its waters made the women prophetic.

Plutarch and other sources indicate that during normal sessions the woman who served as Pythia was in a mild trance. She was able to sit upright on the tripod and might spend a considerable amount of time there (although when the line of consultants was long, a second and even a third Pythia might have to relieve her). She could hear the questions and gave intelligible answers. During the oracular sessions, the Pythia spoke in an altered voice and tended to chant her responses, indulging in wordplay and puns. Afterward, according to Plutarch, she was like a runner after a race or a dancer after an ecstatic dance.

On one occasion, which either Plutarch himself or one of his colleagues witnessed, temple authorities forced the Pythia to prophesy on an inauspicious day to please the members of an important embassy. She went down to the subterranean *adyton* unwillingly and at once was seized by a powerful and malignant spirit. In this state of possession, instead of speaking or chanting as she normally did, the Pythia groaned and shrieked, threw herself about violently and eventually rushed at the doors, where she collapsed. The frightened consultants and priests at first ran away, but they later came back and picked her up. She died after a few days.

The New Tradition

Generations of scholars accepted these accounts. Then, in about 1900, a young English classicist named Adolphe Paul Oppé visited excavations being carried out by French archaeologists at Delphi. He failed to see any chasm or to hear reports of any gases, and he published an influential article in which he made three critical claims.

- First, no chasm or gaseous emission had ever existed in the temple at Delphi.
- Second, even if it had, no natural gas could produce a state resembling spiritual possession.
- Third, Plutarch's account of a Pythia who had a violent frenzy and died shortly afterward was inconsistent with the customary description of a Pythia sitting on the tripod and chanting her prophecies.

Oppé concluded that all the ancient testimony could be explained away.

Oppé's debunking took the academic world by storm. His opinions were so strongly expressed that his theory became the new orthodoxy. The absence of the wide opening that the French archaeologists had expected seemed to prove his argument.



Figure 5 Prof. dr. Pierre Alfred Amandry

Additional support for Oppé's theory came in 1950, when French archaeologist Pierre Amandry added the further negative that only a volcanic area, which Delphi was not, could have produced a gas such as the one described in the classical sources. The case seemed closed. The original tradition of the Greek and Latin authors lived on only in popular books and in the words of local guides, which, in Oppé's opinion, had been the source of the chasm and vapor myth in the first place.

The situation changed in the 1980s, when a United Nations Development Project undertook a survey in Greece of active faults (those along which earthquakes have been generated in the past few hundred years). As a member of that survey, one of us (de Boer, who is a geologist) noted exposed fault faces both east and west of the sanctuary. He interpreted them as marking the line of a fault that ran along the south slope of Mount Parnassus and under the site of the oracle. But being aware of the classical tradition and unaware of the modern skepticism and debunking, he attributed no special importance to his observation.

More than a decade later de Boer met another of us (Hale) at an archaeological site in Portugal where Hale, who is an archaeologist, sought de Boer's geological opinion on the evidence for earthquake damage at an ancient Roman villa. Over a bottle of wine, de Boer mentioned that he had seen the fault that ran under the temple at Delphi. Hale, who had learned the approved view as an undergraduate, contradicted him. But in the lively conversation that en-

sued, de Boer converted him with his description of the fault, his account of how faults could bring gases to the surface and his references to the classical authors. Realizing the importance of the observation for the interpretation of the ancient accounts, the two decided to form a team for further exploration of the site.



Figure 6 Dr. John Hale and Prof. Jelle de Boer

The Classical Explanation Revisited

During our first field trip, in 1996, the two of us conducted geological surveys and examined the temple foundations that the French archaeologists had exposed. The temple has a number of anomalous features that would call for some special interpretation of its function even if the reports of Plutarch and others had not been preserved.

- First, the inner sanctum is sunken, lying two to four meters below the level of the surrounding floor.
- Second, it is asymmetrical: a break in the internal colonnade accommodates some now vanished structure or feature.
- Third, built directly into the foundations next to the recessed area is an elaborate drain for spring water, along with other subterranean passages.

Thus, the temple of Apollo seemed designed to enclose a particular piece of terrain that included a water source, rather than to provide a house for the image of the god, the normal function of a temple building.

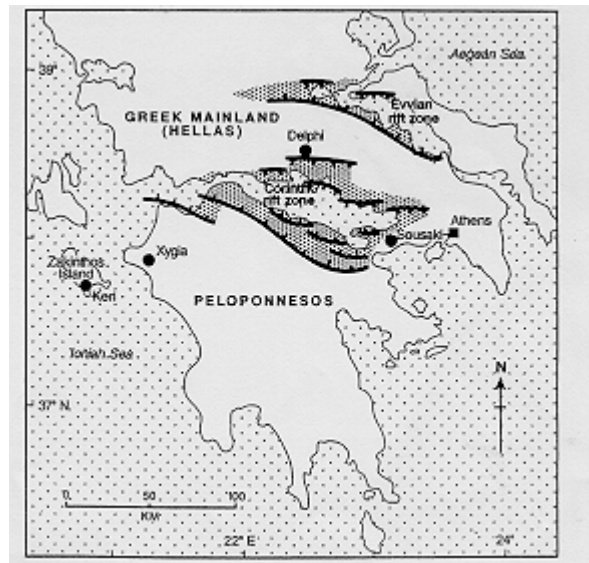


Figure 7 Tectonic Setting of Delphi and schematic representation of Corinth and Evvian rift zones.

During that first exploration, we traced the major east-west fault line, called the Delphi fault, that de Boer had observed during the earlier survey. Later we were to discover the exposed face of a second fault in a ravine above the temple. This second line, which we named the Kerna fault, ran northwest-southeast and cut across the Delphi fault at the oracle site. A line of springs that ran through the sanctuary and intersected the temple marked the location of the Kerna fault below the ancient terracing and the accumulated debris from rockslides.

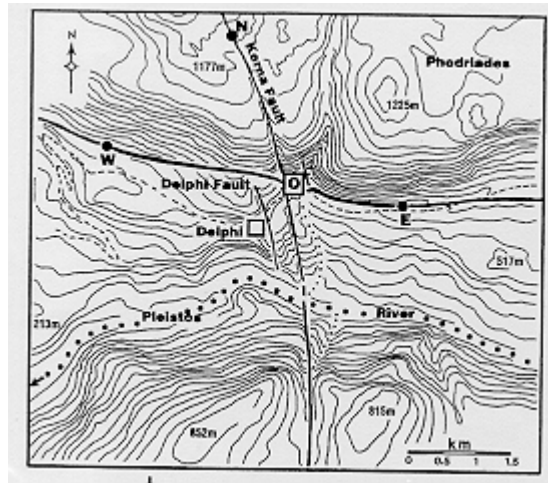


Figure 8 Topographic map of Delphi area and location of Kerna and Delphi faults.

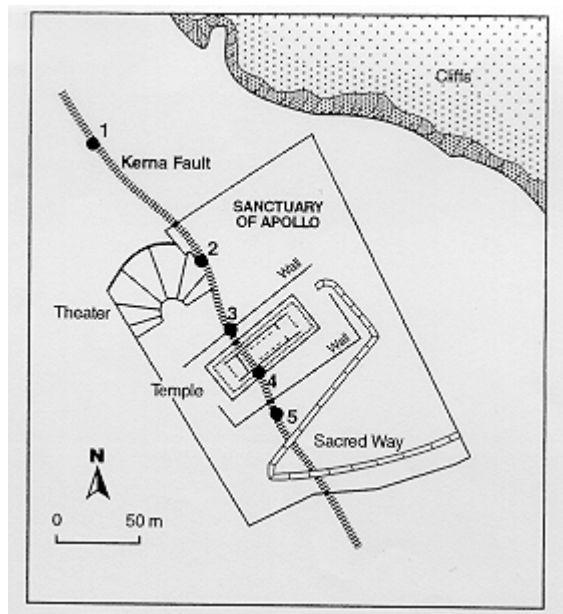


Figure 9 Trace of Kerna fault as outlined by line of five springs or related features in and directly outside sanctuary of Apollo.*

* 1-Kerna Spring, 2-Theater Spring House, 3-travertine coating on Ischegaon retaining wall, 4-spring in temple foundation, near *adyton*, 5-former spring below sanctuary of Ge. Only Kerna Spring is active today.

That same year a father-and-son archaeological and geological team, Michael D. Higgins and Reynold Higgins, published a book that suggested we were on the right track. In their *Geological Companion to Greece and the Aegean*, they noted that the line of springs did indeed suggest the presence of a "steep fault" running northwest-southeast through the sanctuary. They also pointed out that no geological reason necessitates rejecting the ancient tradition.

Higgins and Higgins theorized that the gas emitted might have been carbon dioxide. A decade earlier a different scientific team had detected such an emission at another temple of Apollo, the one at Hierapolis (modern Pamukkale) in Asia Minor (now Turkey, and home to the ruins of many great Greek cities). Following the lead of Strabo, modern researchers have discovered that the Apollo temple at Hierapolis had been deliberately sited over a vent of toxic gases, which in the finished temple emerged from a grotto in the building's foundations.

The temple at Hierapolis was not a place of prophecy, and the carbon dioxide was not so much intoxicating as toxic, claiming the lives of sacrificial animals, from sparrows to bulls. Even today the gas, which is emitted irregularly, kills sparrows that perch on the wire fence intended to keep people out. Other temples of Apollo in Turkey, however, were oracular, and they were built over active springs, such as those at Didyma and Claros. A link clearly seemed to be emerging between temples of Apollo and sites of geologic activity.

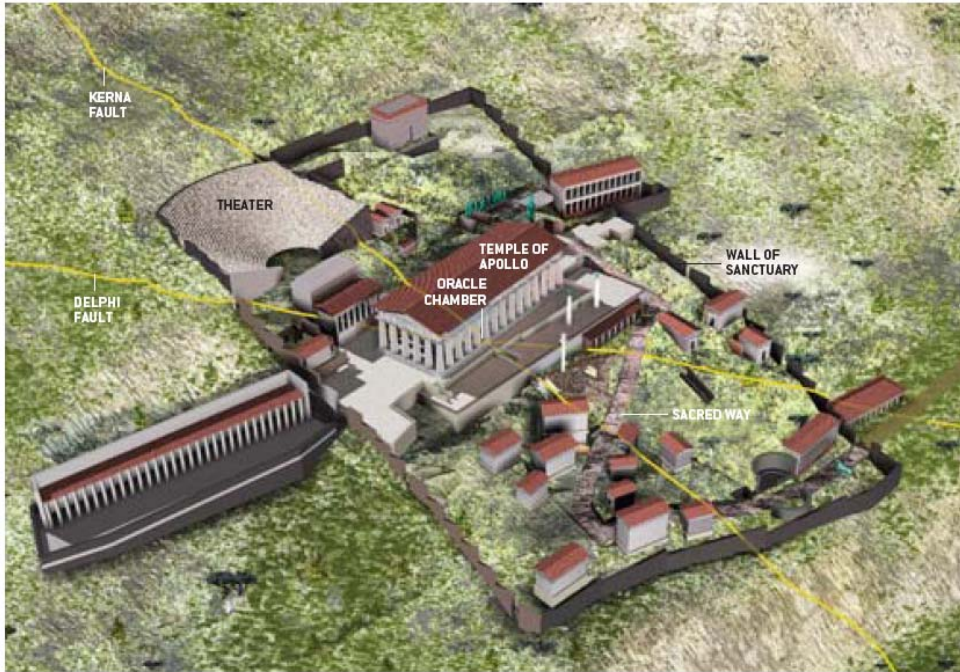


Figure 10 Two geologic faults intersect under the Temple of Apollo at Delphi*

* This intersection made the rock more permeable and provided pathways (*visible in cutaway*) along which both groundwater and gases were able to rise. Tectonic activity heated the limestone adjacent to the faults to temperatures high enough to vaporize some of its petrochemical constituents. These gaseous vapors then moved through the fissures created by the faults into the small, enclosed chamber lying below the floor level of the temple, where the oracle sat to prophesy.

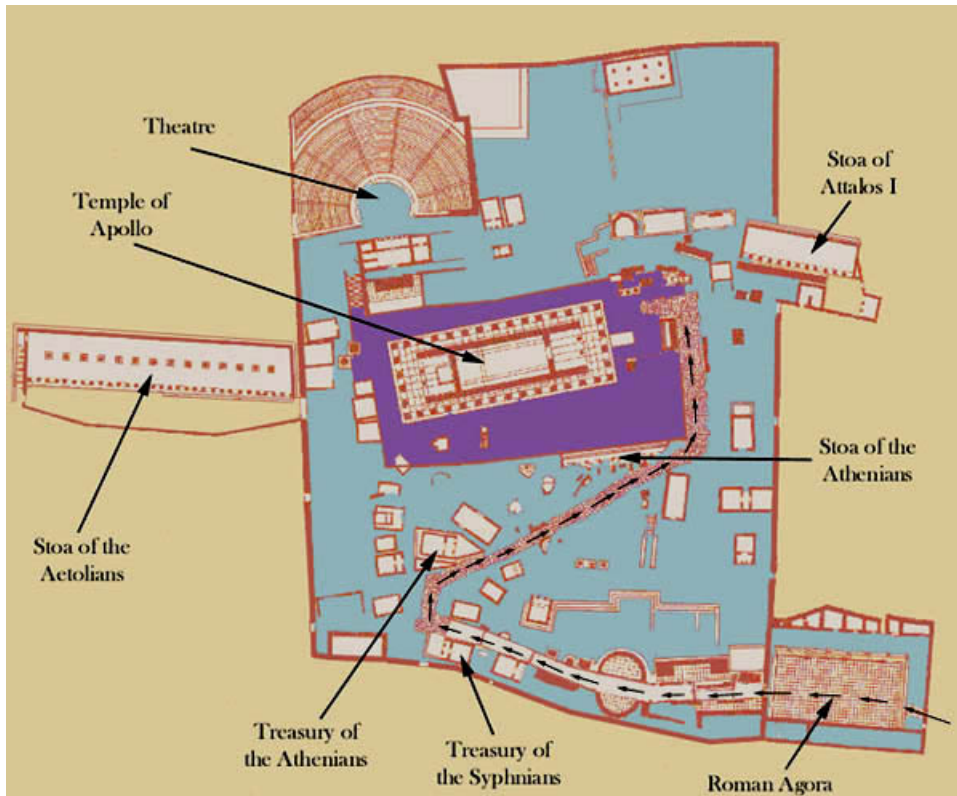


Figure 11 Plan of Delphi

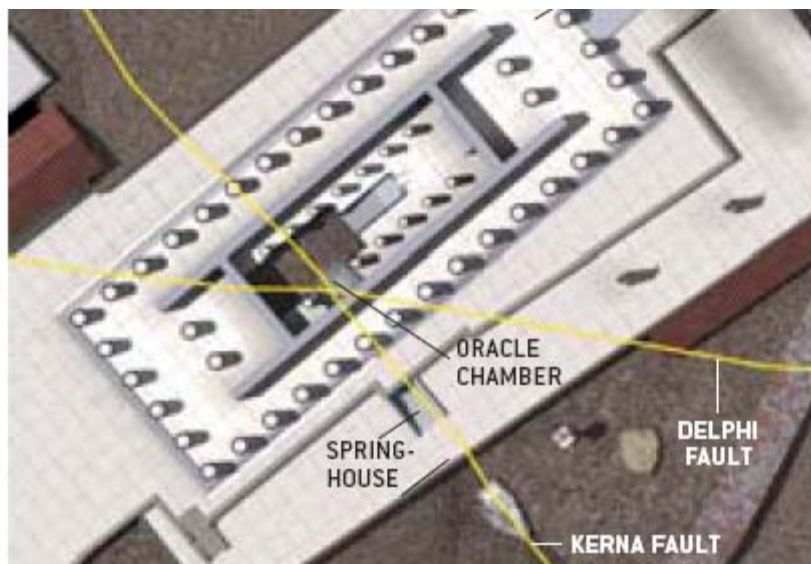


Figure 12 Bird's eye view of temple interior

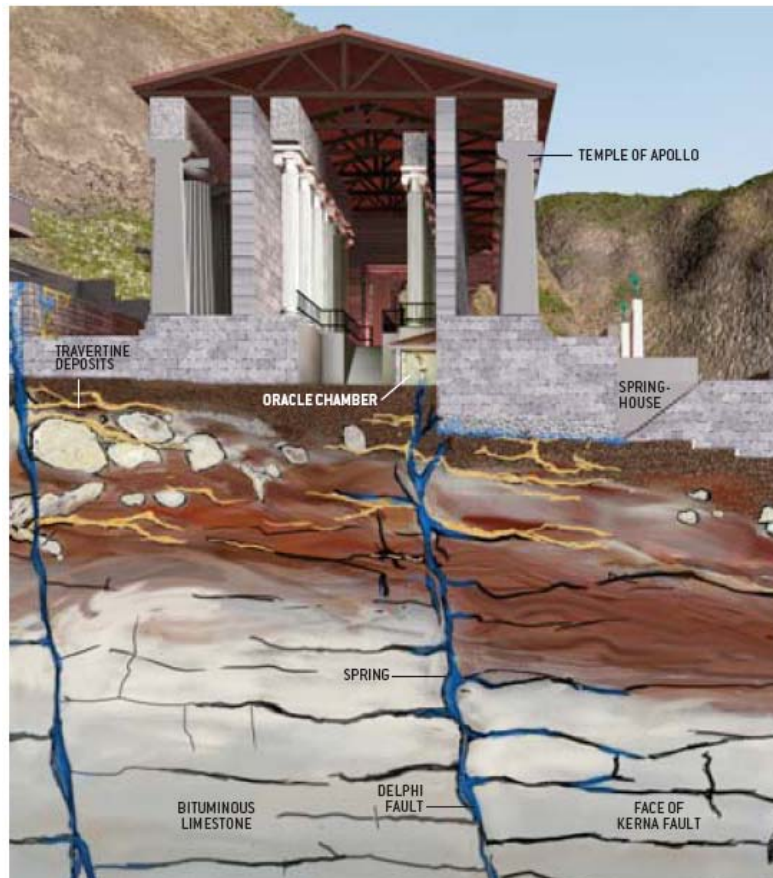


Figure 13 Cutaway view along Kerna fault



Figure 14 Location of the tripod*

* The location of the oracle was near the block set inside the sunken area within the temple's foundations. In the photograph above, one of the authors (de Boer) sits on the block, in much the same spot where the Pythia would have sat on her tripod centuries ago.

The Perfect Gas

Although the newly discovered faults at Delphi indicated that gases and spring water could have reached the surface through cracks that the faults created in the ground below the temple, they did not explain the generation of the gases themselves. De Boer, however, had observed travertine deposits, flows of calcite laid down by spring water, coating the slopes above the temple and even an ancient retaining wall. These flows suggested to him that the water had risen through deep layers of limestone to the surface, where it had deposited calcite mineralizations (a phenomenon also seen at Hierapolis in Turkey). A search through Greek geologic studies of Mount Parnassus revealed that among the Cretaceous rock formations in the vicinity of the temple were layers of bituminous limestone that had a petrochemical content as high as 20 percent.

De Boer now began to see a system taking shape. Faults, which were well exposed on the uplifted slopes of Mount Parnassus, had cut through bituminous limestone. Movement along the faults created friction that heated the limestone to a point at which the petrochemicals vaporized. They then rose along the fault with the spring water, especially at points where the presence of cross-faulting made the rock more permeable. Over time, gas emissions would decrease as calcitic crusts clogged the spaces inside the fault, only to be restored with the next tectonic slip.

De Boer's reasoning seemed in accord with the findings of the early 20th-century French archaeologists, who had finally reached bedrock under the *adyton* a few years after the publication of Oppé's article. Beneath a stratum of brown clay, they encountered rock that was "fissured by the action of the waters." We believe that faulting and fracturing rather than water may have created these fissures, al-

though groundwater may have widened them over time; in early attempts to reach bedrock, the French archaeologists noted that the holes kept filling up with water. We also believe that the visible chasm in the *adyton* may have been a gaping fissure that extended into the layer of clay above the faulted bedrock.

As careful geologic research and reasoning solved riddle after riddle, we were still left with the question of what gases might have emerged. De Boer learned that geologists working in the Gulf of Mexico had analyzed gases that bubbled up along submerged faults. They had found that active faults in this area of bituminous limestone were producing light hydrocarbon gases such as methane and ethane. Could the same have been true at Delphi?

To find out, we asked for permission to take samples of spring water from Delphi, along with samples of the travertine rock laid down by ancient springs. We hoped to discover in this porous rock traces of the gases that were brought to the surface in earlier times. At this point, Chanton, who is a chemist, joined the team. In the travertine samples collected by de Boer and Hale, he found methane and ethane, the latter a decomposition product of ethylene. Chanton then visited Greece to collect water samples from springs in and around the oracle site. Analysis of the water from the Kerna spring in the sanctuary itself revealed the presence of methane, ethane and ethylene. Because ethylene has a sweet odor, the presence of this gas seemed to lend support to Plutarch's description of a gas that smelled like expensive perfume.

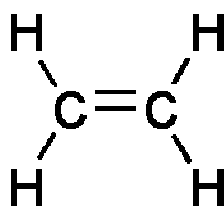


Figure 15 Ethylene

To help interpret the possible effects of such gases on human subjects in a confined space, one like the *adyton*, Spiller, a toxicologist, became a member of the project. His work with "huffers"—teenage

drug users who get high on the fumes from substances such as glue and paint thinner, most of which contain light hydrocarbon gases— had shown a number of parallels with the behavior reported for the trance state of the Pythia.



Figure 16 Isabella Herb (1869-1943): Early pioneer of anesthesiology.

Spiller uncovered even more parallels in the reports of experiments on the anesthetic properties of ethylene carried out more than half a century ago by pioneering American anesthesiologist Isabella Herb. She had found that a 20 percent mixture of ethylene produced unconsciousness but that lower concentrations induced a trance state. In most cases, the trance was benign: the patient remained conscious, was able to sit up and to respond to questions, experienced out-of-body feelings and euphoria, and had amnesia after being taken off the gas. But occasionally Herb would see violent reactions, the patient uttering wild, incoherent cries and thrashing about. Had a patient vomited during such a frenzy and ingested some of the vomit into the lungs, pneumonia and death would inevitably have followed. Thus, according to Spiller's analysis, inhaling ethylene could account for all the various descriptions of the *pneuma* at Delphi—its sweet odor and its variable effects on human subjects, including even the potential for death.

An Unexpected Inspiration

Two thousand years ago Plutarch was interested in reconciling religion and science. As priest of Apollo, he had to respond to religious conservatives who objected to the notion that a god might use a fluctuating natural gas to perform a miracle. Why not enter the woman's body directly? Plutarch believed that the gods had to rely on the materials of this corrupt and transitory world to accomplish their works. God though he was, Apollo had to speak his prophecies through the voices of mortals, and he had to inspire them with stimuli that were part of the natural world. Plutarch's careful observations and reporting of data about the gaseous emissions at Delphi show that the ancients did not try to exclude scientific inquiry from religious understanding.

The primary lesson we took away from our Delphic oracle project is not the well-worn message that modern science can elucidate ancient curiosities. Perhaps more important is how much we have to gain if we approach problems with the same broad-minded and interdisciplinary attitude that the Greeks themselves displayed.

John Hale, Jelle de Boer, Jeff Chanton and Rick Spiller have formed an interdisciplinary team to investigate the Delphic oracle. Hale, an archaeologist at the University of Louisville, has written two previous articles for *Scientific American*. De Boer is a professor of geology at Wesleyan University. Chanton, a chemist, teaches in the department of oceanography at Florida State University, and toxicologist Spiller is director of the Kentucky Regional Poison Center.

MORE TO EXPLORE:

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