

## HISTORY

# The Delphic Oracle: A Multidisciplinary Defense of the Gaseous Vent Theory

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## ABSTRACT

*Ancient historical references consistently describe an intoxicating gas, produced by a cavern in the ground, as the source of the power at the oracle of Delphi. These ancient writings are supported by a series of associated geological findings. Chemical analysis of the spring waters and travertine deposits at the site show these gases to be the light hydrocarbon gases methane, ethane, and ethylene. The effects of inhaling ethylene, a major anesthetic gas in the mid-20th century, are similar to those described in the ancient writings. We believe the probable cause of the trance-like state of the Priestess (the Pythia) at the oracle of Delphi during her mantic sessions was produced by inhaling ethylene gas or a mixture of ethylene and ethane from a naturally occurring vent of geological origin.*

**Key Words:** *Delphi; Ethylene; Altered mental status; Oracle*

## INTRODUCTION

Oracles were used in the ancient world to gain insight to the future. Oracles were believed to have unique access to the gods of a particular religion and through this access were often able to see into the future. The most revered oracle in ancient Greece was located at the town of Delphi in the temple of Apollo, the god of prophecy. The prestige

of this oracle made Delphi the most important, influential, and wealthy sacred place in the entire Greek world. For at least a thousand years, the pronouncements of the Delphic oracle offered divine guidance on issues ranging from the founding of colonies to declarations of war, as well as advice on personal issues. Rulers of Greece, Persia, and the Roman Empire made the arduous journey to this mountainous site. The ancient Greeks believed that the

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prophetic power of the Delphic oracle derived from the unique location of the temple at Delphi. According to classical authors such as Plutarch and Cicero, the priestess who spoke the prophecies (the Pythia) sat on a tripod that spanned a fissure or cleft in the rock deep within the temple of Apollo. A *pneuma* (breath, wind, vapor) rose from this chasm into the recessed inner sanctum, or “*adyton*,” where it intoxicated the Pythia and inspired her prophecies. During the last century, however, these ancient testimonies have been challenged and dismissed as unreliable, even as fraud. We use a combination of the ancient texts, geological evidence, and modern understanding of the properties of anesthetic gases to defend the argument that the prophecies of the Pythias in fact occurred after an intoxication from gases of geological origin.

### MODERN CONTROVERSIES

When French archaeologists began to dig at Delphi in the 1890s, they expected to find an elaborate marble temple, fine statuary, and an inner sanctum built on bedrock with a large cleft or fissure in the floor. To their disappointment, the excavations revealed only the foundations of the Temple of Apollo, along with parts of fallen columns. The center of the temple had no floor, but instead of revealing an expanse of fissured bedrock or the mouth of a cave it seemed to be built over a thick bed of natural clay.

A visiting English scholar was the first to express skepticism about the ancient traditions (1). Half a century later, an influential book was published by one of the leaders of the French team (2). Amandry maintained that there was no archaeological evidence in the temple itself to support the belief in a fissure or a gaseous emission (2). Moreover, he claimed that such an emission would be geologically impossible in the limestones of Mount Parnassus and stated that such vapors are only produced in volcanic areas.

The great authority of Amandry persuaded almost all historians, classicists, and archaeologists, except the Greeks themselves, that the ancient tradition recorded by Plutarch, Diodorus, and other writers was either a myth, a confusion, or a deliberate fraud. Most modern books on Delphi state categorically that there was not and could not ever have been an intoxicating gaseous emission inside the Temple of Apollo (3,4).

### HISTORICAL RECORD

The historical defense of the gaseous vent theory is based on evidence that includes ancient Greek and Latin

texts as well as the archaeological remains of the temple and sanctuary. The literary texts include the testimony of ancient historians such as Pliny and Diodorus, philosophers such as Plato, poets such as Aeschylus and Cicero, geographers such as Strabo, the travel writer Pausanias, and even a priest of Apollo who served at Delphi—the famous essayist and biographer Plutarch. These writers consistently link the power of the oracle to natural features inside the temple, such as a fissure, a gaseous emission, and a spring. The geographer Strabo (64 B.C.–25 A.D.) wrote:

They say that the seat of the oracle is a cave that is hollowed out deep down in the earth, with a rather narrow mouth, from which arises *pneuma* that inspires a divine frenzy; and that over the mouth is placed a high tripod, mounting which the Pythian priestess receives the *pneuma* and then utters oracles in both verse and prose.

The historian Diodorus of Sicily (first century B.C.) noted an additional element in his description of the Delphic oracle:

They say that the water of the Cassotis spring plunges underground and emerges in the *adyton* of the temple, where it makes the women prophetic.

While the Temple of Apollo was run by men, the person who spoke the oracles was always a woman. She was given the title “Pythia.” The Pythia served as a medium for Apollo, who was believed to take over her body and voice during her prophetic trances. The priest Plutarch described the supposed relationship between the god, the Pythia, and the natural forces by picturing the god Apollo as a musician, the Pythia as his musical instrument, and the *pneuma*, or vapor, as the plectrum or tool with which he drew sounds from the instrument. The Pythia was always a woman of the settlement of Delphi, but she could be old or young, rich or poor, well educated or illiterate. While she was serving as oracle, or mouthpiece of the god, the Pythia lived in the sanctuary, abstained from sexual intercourse, and fasted on or before the days scheduled for oracular sessions. During normal trances she heard the questions of visitors and gave coherent, if cryptic, replies in verse or ordinary speech. Occasionally she was seized with a violent delirium rather than a benign trance.

### THE SETTING OF THE ORACLE

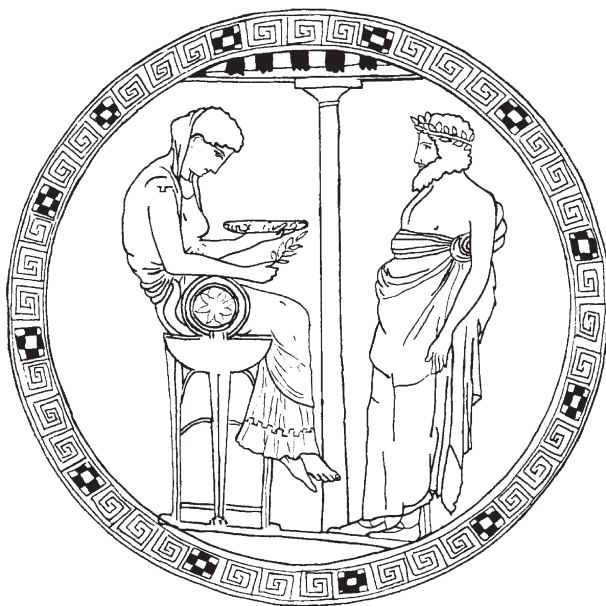
The oracles at Delphi were delivered when the Pythia was placed on a tripod (somewhat like a modern

barstool) in an enclosed chamber within the temple called the *adyton*, a Greek term meaning literally “do not enter.” The Pythia alone remained in the *adyton*. Those consulting the oracle remained in a separate antechamber nearby. The one surviving depiction of the *adyton* seems to show that it had a low ceiling held up by a column or columns (Fig. 1). This part of the temple was recessed below the main floor level of the temple entrance. Visitors descended a long narrow ramp or staircase to reach the lower level of the waiting room and the Pythia’s *adyton*.

Only nine times each year did the woman mount the tripod, enter the trance state, and speak for the god. These sessions were held on “Apollo’s Day,” the seventh day after each new moon in spring, summer, and fall. The oracle did not operate during the three months of winter. During days of oracle activity, the Pythia would initially be brought by priests of the temple from a secluded and protected residence and led through a series of purification and religious rituals in preparation for her performance. Eventually she was led down into the inner sanctum of the temple (the *adyton*).

### GEOLOGICAL EVIDENCE

The geological defense of the gaseous vent theory is supported by a series of associated facts: (1) the location

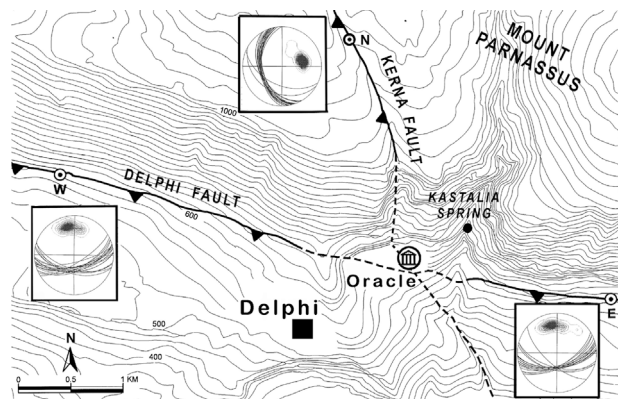


**Figure 1.** Only surviving depiction of the Pythia from the time when the oracle was active.

of the temple directly above the intersection of two major faults, (2) the location of springs emerging from the ground inside and around the temple, (3) the limestone formations of the area containing petrochemicals, (4) the unique design of the temple, (5) the fact that the oracle did not function in the cold winter months, and (6) the documentation of the presence of hydrocarbon gases from the spring waters and travertine deposits.

The temple at Delphi is on a site intersected by major tectonic faults that are part of the Korinth rift zone, a region of crustal spreading (Fig. 2) (5). It sits on the mainland of Greece on the southern slopes of the Parnassos mountain range. Evidence for the recent geologic activity of one of these faults includes earthquakes and landslides. Evidence for intermittent seismic activity is important as it helps to explain: (1) the venting of the gases over an extended period of time, (2) the periodic changes in the intensity of the gaseous emissions, and (3) the eventual cause of their cessation. Neft believes that an earthquake destroyed the main part of the Delphi settlement around 730 B.C. Delphi’s highest period of prestige and wealth followed this event and lasted to the end of the fifth century B.C. Another earthquake severely damaged the temple in 375 B.C. and again in 23 A.D. Quakes in the area have been reported in 1580, 1769, and 1870. Early references to landslides may have been indicative of seismic activity in the region. Rockfalls thwarted attempts to ransack the temple complex by the Persians in 480 B.C., the Phocians in 354–352 B.C., and the Gauls in 279–278 B.C. Pechoux wrote:

Time and again earthquakes had rumbled here, frightening away the plundering Persians and a



**Figure 2.** Intersection of the Kerna Fault and the Delphi Fault. The temple site is located directly above this intersection.

century later the plundering Phocians and a century later the plundering Gauls; it was the God protecting his shrine.

The oracle site is underlain by a limestone formation of late Cretaceous age, which contains layers rich in bitumen (oil). These limestone deposits formed some 100 million years ago in a shallow tropical sea. The tectonic collision between the Eurasian and African plates lifted these rocks above sea level to form the mountain range of the Parnassos. Friction along fault planes during slips heated and vaporized the lighter constituents in the bituminous layers forming hydrocarbon gases. The most likely path for the gases to follow upwards would be to rise through the fault lines dissolved in percolating ground water and to emerge eventually as springs. There were a number of such springs recorded at the Delphi site, including the Cassiotis that emerged in the *adyton*.

It is interesting to note that the mantic sessions of the Delphi oracle were never held during the winter months when the god Apollo was believed to have gone north to the land of the Hyperboreans. This suggests that the gas emissions at Delphi may have diminished during the colder periods when much of the water had accumulated on Mount Parnassos as snow and ice, and ground water temperatures were relatively low. As the ground water temperature rose in the spring, more of the gas it had incorporated was released.

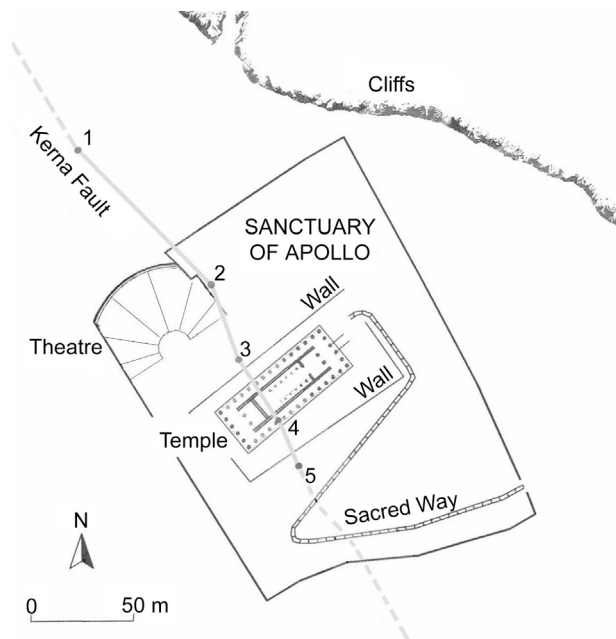
Another key feature to support the argument for a geological vent is the unique design of the temple. Despite being one of the richest sites in ancient Greece, the temple had an earthen floor in its center with stone walls surrounding it. This unique construction, as opposed to the standard stone floor of the other major temples, suggests the design followed a physical need. The site certainly did not lack funds or engineers, as evidenced by the other major buildings at Delphi such as the gymnasium, theater, and Temple of Athena.

A final note of importance is the relationship of seismic activity and continued gas emissions. Because of changes in the solubility of calcium in enriched ground water the spaces in the fault zones would be slowly and inexorably filled with calcite. Such a process would inevitably clog or close the exit pathways for the trapped gases. To reopen such pathways brecciation is needed. Such a process commonly results from motion along a fault. Periodic seismic activity, as has been recorded in the area, is necessary to produce a ten-century-long venting of gas deposits. Additionally, seismic activity is also probably responsible for the final silencing of the gas

vents and of the oracle. Significant earthquakes shift the flow of ground water with its dissolved gases, frequently forcing it to emerge elsewhere along the fault.

A collapsed section of the ruined temple floor has been tentatively identified as the possible site of the *adyton* (26). It should be noted that three springs have been identified at the site whose location of emergence and flow all follow a pattern of northwest to southeast in a path that follows the geologic direction of the fault line and that crosses directly under the temple itself (Fig. 3).

Chemical analysis by gas chromatography was recently performed on water samples from the springs in and around the temple site and from travertine deposits in the *adyton* using a headspace equilibrium technique (5). The results of these samples have identified the trapped gases as primarily methane, ethane, and ethylene. Results showed the presence of methane and ethane in the travertine deposits with no ethylene detected. Evaluation of the spring water, however, showed a greater concentration of ethylene than ethane, with 0.3 and 0.2 nM/L, respectively. Ethylene is a significantly less stable molecule than ethane and methane, and may not have remained intact in the travertine deposits in the proportions that originally existed (11).



**Figure 3.** Location of fault line under temple and of the springs' emergence from ground.

**Table 1**

*Comparison of Historical Descriptions of Usual Response/Presentation of the Pythia with That of Mild Anesthesia via Inhalational Anesthetic Gases*

Description of Pythia at Delphi from a "Normal" Mantic Session <sup>a</sup>	Description of Mild Anesthesia with Ethylene or Nitrous Oxide
Rapid onset of trance state	Full effects in 30 seconds to 2 minutes (Borne)
Calm response, willingly entered the <i>adyton</i> . Remained there for hours	Pleasant state of being, no sense of anxiety or asphyxiation. Happy to stay under influence of gas for long periods of time (Lockhardt)
Remain conscious	Remain conscious (Lockhardt)
Able to maintain seated position	Able to maintain seated position (James)
Can see others and hear questions	Responds to questions and write answers (James)
Tone and pattern of speech altered	Pattern of speech altered
Describe out of body experience—Feeling of being possessed by the god Apollo	Altered state—experienced religious revelations (James)
Free Association—images not obviously connected to questions	Free Association—random thought pattern not obviously connected to initial question (James)
Recovers rapidly	Complete recovery in 5–15 minutes from full operable anesthesia (Herb)
Amnesia of events while under influence	Amnesia of event while under influence (Lockhardt, James)

<sup>a</sup>Based on evidence from Plutarch, Plato, Lucan, and other ancient authors, as well as depiction of Pythia on a vase from the fifth century.

The concentration of gases that were produced by the ground vent at the time the oracle was functioning is unknown. In all likelihood, the strength of the vent varied over the centuries due to geological conditions, and in fact Plutarch remarks on the waxing and waning of the oracle over time. The oracle was reported to have ceased to function sometime prior to the fourth century A.D. It is unclear that if 1800 years after the reported cessation of the vent, the gases present today reflect the same proportion as existed in ancient times.

### INTOXICATING PROPERTIES OF ETHYLENE

The third portion of the defense of the gaseous vent theory is that the volatile fumes produced an altered mental state that is similar to that produced by inhalation of anesthetic gases. The effects described in the Pythia are the same as the first stage of anesthesia, alternately referred to as the excitation or amnesia phase (Table 1).

Of the three proposed gases, all have the potential to produce an altered mental state, with ethylene > ethane > methane (6). In present day volatile inhalant abuse, hydrocarbon gases remain one of the primary sought-after substances for their intoxicating properties (7–10). In one report on volatile inhalant abuse, three of the top four volatile substances chosen for abuse were aliphatic hydrocarbons (7). Of the three gases available at

Delphi, ethylene is the most likely candidate to have produced the intoxicating vapor. Ethane, however, would be nearly equipotent and a mixture of the two would also produce significant altered mental status (6).

Ethylene is a simple aliphatic hydrocarbon gas (C<sub>2</sub>H<sub>4</sub>), with a sweet odor detectable at 700 ppm (11). It was one of the major inhalational anesthetic gases used in general anesthesia from the 1930s through the 1970s (12–16). Induction of full anesthesia with ethylene occurs rapidly (12,13,16–18). In less than 2 minutes after inhalation, levels of ethylene in the brain are capable of producing full anesthesia (16,17,19,21). Bourne found ethylene to be approximately 2.8 times as potent as nitrous oxide or ether (16). Some of the advantages of ethylene were its rapid onset and clearance, and the lack of respiratory and cardiovascular depressing effects. This is primarily due to low solubility and distribution outside of the vascular compartment. The major disadvantages were the rare fires or explosions in the operating room (22,23). It was replaced with safer, less explosive gases by the 1970s.

There are relatively few eyewitness descriptions of the Pythia in her intoxicated state. This is most likely because relatively few insiders knew the inner workings of the temple. The descriptions that do exist offer two distinct pictures of the Pythia in her intoxicated state. The first is the normal and "working state" of a calm relaxed woman able to respond to questions with visions that in many cases were random and not apparently associated



to the subject at hand (Table 1). The second description is that of an apparently rare event of a delirious, ataxic, and combative woman, described as in a frenzy. Both descriptions are consistent with intoxication by ethylene and the early stages of anesthesia. This was a naturally occurring vent. Strict control of the flow of gas would not exist and therefore control of the depth of anesthesia would be crude, if at all. The likelihood of an adverse event is high with hundreds of subjects over the ten centuries using a poorly controlled source of gas. Lockhardt et al., in their description of the first human experiments with ethylene as an anesthetic gas, reported 10 of their 12 subjects had a very pleasant experience. However, two of the 12 had periods of excitement, confusion, and combative behavior.

An interesting modern illustration of the power of mild anesthesia to produce a religious visionary state comes from the philosopher William James who, during the late 19th and early 20th century, experienced religious mysticism and “extraordinary revelations” while experimenting with nitrous oxide. Descriptions of his “sessions” are similar to descriptions of the “normal” Pythia (24,25).

The most dramatic and detailed descriptions of the Pythia are during sessions gone awry. This situation, however, is not unlike the modern medical literature where case reports of difficult cases or adverse events get published in great detail, while the many “normal” cases go unrecorded and unpublished.

The most reliable documentation of the Pythia during her mantic sessions comes from the essayist Plutarch. His description of a mantic session gone awry correlates well with the effects that have been reported from the excitation phase of anesthesia: confusion, agitation, ataxia, and delirium. Plutarch described how a rich deputation from abroad had come to the temple for a consultation. The preparatory rituals indicated it was not the proper time but eventually the Pythia was forced to take her position on the tripod by the temple priests who were interested in satisfying the rich clients.

She went down into the oracle unwillingly and half-heartedly; and with her first responses it was at once plain from the harshness of her voice that she was not responding properly; she was like a laboring ship and was filled with a mighty and baleful spirit. Finally she became hysterical and with a frightful shriek rushed toward the exit and threw herself down, with the result that not only the members of the deputation fled but also the oracle-interpreter Nicander and those holy men that were present.

Marcus Anneeus Lucanus (Lucan) relates another story of a mantic session gone awry. It is the story of when the Roman Governor and General Appius Claudius consulted the oracle. Appius Claudius desperately needed a consultation concerning which side to join in the Roman civil war between Caesar and Pompey. He had traveled a great distance; however, it was not the seventh day and the oracle was not open for business. The Roman general forced the oracle to open for him and forced the Pythia down into the chamber against her will. Lucan reports:

She initially dreaded the oracle recess of the inner shrine, she halted by the entrance and counterfeiting inspiration uttered feigned words from a bosom uninspired; with no inarticulate cry of indistinct utterances proved that her mind was not inspired with the divine frenzy. Her words that rushed not forth with the tremulous cry, her voice had not the power to fill the space of the vast cavern.

It is interesting to note that the ancient Greeks noted a change in her speech, both in tone and in pattern. The idea that lack of indistinct utterances proved her mind was not inspired, suggests recognition of a different clinical presentation during the time of “possession.” Appius Claudius was not happy with the initial efforts of the Pythia and is reported to have shouted down to her:

Profane wretch. I have come to inquire about the fate of this distracted world. Unless you stop speaking in your own voice and go down to the cave for true inspiration the gods whose oracles you are taking in vain will punish you—And so will I!

Lucan, then describes how, terrified by the Roman General, the Pythia entered the *adyton*.

And her bosom for the first time drew in the divine power which the inspiration of the rock, still active after so many centuries, forced upon her. At last Apollo mastered the breast of the priestess. Frantic she careens about the cave, with her neck under possession, she whirls with tossing head through the void of the temple she scatters tripods that impede her random course.

What they appear to be describing are consistent with the excitation phase of general anesthesia. Lockhardt et al., when working with ethylene, describe a period of ataxia after ethylene intoxication and later describe two of their 12 subjects going through a period of excitement

“so that restraint by holding down of the extremities was necessary” (12).

Another piece of supporting evidence is the report by Plutarch of a sweet odor like that of perfume that would drift to the outer sections of the temple from the *adyton*. Ethylene has a slight smell that is described as sweet with odor recognition at 700 ppm (11). That this odor was detectable in the outer sections of the temple, after diffusion over a large area, strongly suggests that greater concentrations existed in the enclosed *adyton* where the Pythia sat. The unique setup of the temple at Delphi, with a history of a recessed enclosed cell, would tend to concentrate the fumes around the Pythia allowing for a more significant exposure (Fig. 4). Also there is archeological evidence of efforts by the Greeks to concentrate the fumes by capping the vent and funneling it through a directed opening (26). It is suggested that the tripod of Pythia was then placed directly over this funneled gas jet.

Historically with ethylene, a mixture of 70–80% ethylene and 20–30% oxygen was used to produce full operable anesthesia. Mixtures of 20% ethylene and 80% oxygen were also used successfully (13). A concentration of less than 20% would be capable of producing an altered mental state while allowing her to remain conscious. This is something that could easily be produced using a directed vent in a small, enclosed chamber.

Another intriguing piece of evidence is offered by the sole representation of the Pythia existing from the period when the oracle functioned. It is interesting to note the unusual slumped posture of the Pythia, in a period when Greek human forms were proudly rendered with rigid erect posture (Fig. 1). The artists of the period did not attempt to portray her as raving and flailing, nor as erect and alert, but rather slumped over, as one would expect from a mildly anesthetized woman.

Another example from the ancient texts that suggest mild anesthesia is the report that the Pythia did not remember her utterances or other events after she had recovered. This is typical of the first stage of anesthesia, sometimes referred to as the stage of amnesia and analgesia (27). Luckhardt et al. also describe amnesia of the period under the influence of ethylene (12).

Several other interesting similarities exist but their value is unclear. The ritual to prepare the Pythia for her ordeal, for instance, involved fasting the day of the ordeal. Similar advice is given to patients undergoing anesthesia to fast the night before surgery. The well-known side effect of nausea and vomiting may have been learned by the ancient Greeks and incorporated into their ritual.



**Figure 4.** Sketch of the Pythia in the *adyton*, showing fractures from which gaseous emission rose into the small, enclosed structure. Based on archeological text and findings in the temple remains.

In conclusion we believe that: (1) the ancient texts all consistently refer to a gas or breath from a cavern as the source of the marvel at Delphi, (2) the geological studies show the existence of conditions for producing hydrocarbon gases in a manner consistent with the ancient texts, and (3) intoxication by one of the hydrocarbon gases, ethylene, produces effects consistent with the descriptions of behavior of the Pythia in the ancient texts. We believe the probable cause of the trancelike state used by the Pythia at the oracle of Delphi during her mantic sessions was produced under the influence of inhaling ethylene gas or a mixture of ethylene and ethane from a naturally occurring vent of geological origin.

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