

# Connecting Geology, History, and the Classics Through a Course in Geomythology

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## ABSTRACT

Geomythology is an interdisciplinary course in which students examine the possibility that some ancient myths may have originated as accounts of real geologic events. The course focuses on Mesopotamian, Greek, and Biblical stories and is divided by geologic theme into four segments. The first segment deals with myths that relate to climate and/or environmental change, including the Biblical story of the Garden of Eden and the Greek myth of a Golden Age. Floods are covered in the second segment, which examines the Mesopotamian Epic of Gilgamesh and the Greek tale of Deucalion. The third segment focuses on myths relating to earthquakes, which figure prominently in the Old Testament stories of the destruction of Sodom and Gomorrah and the capture of Jericho. The theme of the final segment is volcanism, including Hesiod's Battle of the Titans and Plato's Legend of Atlantis. A geomythology course requires students to integrate information from history, anthropology, the classics, and geology and thereby provides an excellent illustration of the interconnectedness of science, social science, and the humanities.

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classicist. The course has a maximum enrollment of 16 students, most of whom have had little or no prior coursework in geology, mythology, or ancient history. We provide background material on these topics at the beginning of the term, including an overview of plate tectonics, an introduction to the civilizations involved, and a discussion of the roles of myth in the ancient world. The remainder of the course is broken into four segments, each devoted to myths with a common geologic theme (for example, floods). A segment begins with one or more lectures that provide relevant geologic background, and then students are assigned one or more myths to read and interpret for discussion the following week. To guide them in this process and to ensure that they are prepared for the discussion session, each student is required to write a two-page "position paper" on the topic that will be discussed. We have found these short papers, which count for 40% of the overall course grade, to be an effective means of getting the students to read the myths closely and organize their thoughts before coming to class. The other major assignment for the course (40% of their grade) is a research paper; there are no exams, but class participation and homework assignments count for 20% of the grade.

## Science and History in Myth

Vitaliano (1973) recognizes two main categories of myths that contain geologic themes: those which are thought to be based on real events (euhemeristic myths) and those which are interpreted as attempts to account for features of the environment (etiological or explanatory myths). In addition, some myths may contain geologic elements that were added only for symbolic, stylistic, or dramatic purposes (Bentor, 1989). The question of whether a myth can be interpreted in terms of a real event is controversial, particularly in cases where the event may have occurred hundreds or even thousands of years before it was first written down (Dorson, 1968). However, Schliemann's unearthing of Troy in Turkey in the 1870s and the recent rediscovery of the lost city of Ubar in Oman (Crabb, 1993) provide evidence that some myths do indeed have a basis in fact.

One of our goals in the first class session is to persuade students that the distinction between myth (which they associate with "fantasy") and science (which they associate with "truth") was not so clear cut in ancient times as it seems today. For example, the Greek historian Ephorus' explanation for why flooding of the Nile occurred during the summer months (the heat of the sun caused more water to sweat from the Earth's pores) may sound today like a myth, but

## Introduction

Studies that seek ways to improve science education have repeatedly emphasized the need to make students aware of the connections between the sciences and other disciplines (Project Kaleidoscope, 1991). Over the past three years, we have developed a course in which students combine geology with history and the classics to examine the possibility that some ancient myths are based on actual geologic events. The course focuses on the Mediterranean region which, in addition to being among the most tectonically active areas on Earth and the site of countless natural disasters, is also an area rich with myths of the ancient civilizations of Mesopotamia, Egypt, Greece, and Rome. The purpose of this paper is to review a number of well known myths that have been linked to geologic phenomena and to describe how we use this material as the basis of a course we call Geomythology.

## Course Organization

Geomythology is offered at Valdosta State as an honors seminar, team taught by a geologist and a

from a 4th century BC perspective would have been a reasonable scientific explanation. To encourage them to think about the links between myth and science, we have students write their first position paper on the question of why humans feel a need to create or discover explanations for natural phenomena. A common theme to their essays is that phenomena that can be explained have a possibility of being predicted, or even controlled, and are thus less frightening than random events, which might strike anywhere at any time. From this perspective, modern science can be viewed as serving a similar function to that of myth in the ancient world.

### Myths Related to Environmental Change

As the first topic for this course, we examine the possibility that myths describing a past time when humans lived an easy existence in harmony with nature might record memories of climate change and/or anthropogenic environmental degradation. The oldest of these "Arcadian" myths is the Biblical story of the Garden of Eden, which has its roots in Sumerian mythology (Hamblin, 1987). Eden is described in the Bible as the home to "all sorts of beautiful trees...producing the choicest of fruit" (Genesis 2), and scholars have speculated for centuries as to whether the Eden was an actual geographic locality, and if so, where it was situated. Hamblin (1987) suggests on the basis of geographic and linguistic data that Eden lay at the northern end of what is today the Persian Gulf, an area that was dry land prior to a rise in sea level about 4000 BC. He also cites paleontological evidence that the Gulf region received abundant rainfall between about 6000 and 5000 BC, which would have made the area an attractive place for early peoples to inhabit. The expulsion of Adam and Eve from the Garden to live where the soil "will grow thorns and thistles" and where they "will sweat to master it, until [their] dying day" (Genesis 3) has been hypothesized to record the transition from a hunting-gathering way of life to one of agriculture (Hamblin, 1987; Tudge, 1996). We explore this idea by having students read papers that contrast the seemingly carefree lifestyle of modern hunter-gatherers, such as the !Kung, with the tedious and backbreaking life of early Egyptian farmers and laborers.

Greek mythology also contains allusions to an earlier era when humans lived in peaceful coexistence with the environment. Hesiod, a poet of the 8th century BC, describes a Golden Age when the first generation of mortals created by the gods "lived without troubles" and the "fruitful grainland yielded its harvest to them of its own accord" (Hesiod, 1973). Eight centuries later, Ovid writes of the Golden Age as being a time when "[t]he mountain trees in distant prospect please, [e]re yet the pine descended to the seas" and when "[t]he teeming earth, yet guiltless of the plough, [a]nd unprovok'd, did fruitful stores allow" (Ovid, 1964). The Golden Age is followed by the ages of silver, bronze, and finally iron, each more difficult than the one before, until in the age of iron "[n]ever will there be an end to hard work and pain, nor in the night to weariness" (Hesiod, 1973). Accounts of the Golden

Age may, of course, be entirely fictional, but it is intriguing that five centuries before Hesiod the Mediterranean region experienced a severe drought that lasted several centuries and has been blamed for the demise of the Mycenaean Age (Carpenter, 1966). Might Hesiod's poetry record this Late Bronze Age climatic deterioration and contemporary attempts to explain it?

In addition to climatic changes, there is also archaeological and geological evidence for anthropogenic environmental degradation in Greece and elsewhere in the ancient world. Pollen records from Greek lakes show evidence of deforestation in the Early Bronze Age (3500-2100 BC), and from 3000 BC onward, grazing and farming on steep slopes resulted in repeated episodes of catastrophic erosion that gave rise to the barren landscapes seen in many areas of Greece today (Runnels, 1995). Mining and smelting, which may have begun as early as 6500 BC (Gale and Stos-Gale, 1981) were additional sources of environmental degradation. Silver smelting by the Greeks and Romans resulted in hemispheric-scale air pollution that is discernible in Pb levels of ice as far away as Greenland (Hong and others, 1994), while closer to home these processes undoubtedly contributed to deforestation and surface-water pollution. Greek myths may also have been influenced by environmental problems that developed in ancient Mesopotamia, where deforestation exacerbated flooding and the silting of irrigation canals (Perlin, 1989). Large-scale irrigation, practiced as early as the 4th millennium BC, also resulted in salinization of agricultural lands and eventual collapse of the Sumerian city states (Jacobsen and Adams, 1958). Written records dating back to almost 3000 BC describe declining crop yields, decreasing production of wheat relative to barley (the former is less tolerant of salt), and eventually patches of soil that had turned white (Jacobsen and Adams, 1958). Recent studies (Issar, 1995) suggest that climate change may also have contributed to the salinization problems, when a shift to warmer, dryer conditions reduced the flow of the Euphrates and made it impossible for Sumerians to flush the salts from their fields. With elements of both natural and anthropogenic environmental change, the myths of Eden and the Golden Age provide an ideal context in which to link history to climate change, air and water pollution, soil formation and erosion, geochronology, and anthropology.

### Flood Myths

Our second topic in the course is flood legends, which appear in the folklore of peoples from virtually every part of the globe and are the most widespread of all natural-disaster myths (Vitaliano, 1973). We begin the segment with a discussion of the hydrologic cycle and have students calculate the volume of water that would be required to cover the entire Earth to the level of Mt. Ararat (Soroka and Nelson, 1983). This leads, of course, to the realization that a true global flood is not possible, and we then examine natural processes that can produce flooding, including precipitation, storm surges, tsunami, dam failures, and global rise in sea level, and to the geologic

of very large-scale floods, we describe the Spokane Floods (Bretz, 1969) and the late Miocene refilling of the Mediterranean (Hsü, 1972). Although neither of these examples occurred during human history, Ryan and Pitman (1998) have recently reported evidence for a similar episode of catastrophic flooding around 5500 BC when the failure of a natural barrier in the Bosphorus allowed Mediterranean waters to cascade into the Black Sea. They calculate that this event, over a time span of perhaps less than one year, raised the level of the Black Sea by more than 100 meters and inundated an area of >100,000 km<sup>2</sup>, displacing early farmers and perhaps providing the basis for the Mesopotamian flood story.

Given this geological background, we then focus on two flood myths: the Biblical story of Noah (including its earlier Mesopotamian versions in the Epic of Gilgamesh and the myth of Atrahasis) and the Greek story of Deucalion. Both of these myths share the common theme of natural disasters as punishment for human misdeeds, but they also contain segments and phrases that can be interpreted in terms of geologic phenomena. For the position paper in this segment of the course, each student is asked to choose one of the flood myths and discuss it in detail, citing evidence from the text, whether it might recount an actual flood event, and if so, what that event might have been.

The best known flood myth is the Biblical story of Noah (Genesis 6-8), but this account is almost certainly based on the older Babylonian tale of Ut-napishtim in the Epic of Gilgamesh, which in turn has been linked to a fragmentary Sumerian story that dates to 3400 BC (Vitaliano, 1973). As recounted in Gilgamesh (Frazer, 1919), Ut-napishtim lived in Shurippak, a city beside the Euphrates. He is warned in a dream of an impending flood, devised by the gods to destroy mankind. Instructed to build a huge six-storied boat, he gathers into it his family, craftsmen, and all types of animals. The rains then begin and the world is covered by water, but after seven days the storm ends and the boat comes to rest on a mountaintop. Ut-napishtim releases a series of birds, the last of which fails to return, indicating the flood waters have receded and it is safe to disembark. Citing references to heavy rains and gradually rising water levels, most students tend to interpret this flood as being caused by storms, possibly accompanied by a storm surge.

Greek tradition contains numerous references to great floods, the best known of which is the story of Deucalion and his wife Pyrrha. Warned of Zeus' plan to destroy mankind with a flood, Deucalion builds an ark in which he and Pyrrha float for nine days as rains overwhelm the world. When the waters begin to recede, the ark grounds on the summit of Mt. Parnassus. Deucalion and Pyrrha disembark, give thanks to Zeus, and then at his request repopulate the world by throwing rocks which become people. There are many versions of this myth, which vary with regard to where Deucalion and his wife land and whether the flood waters originate as rainfall or as a combination of rainfall, ocean waves, and "the fountains of

the deep" (Frazer, 1919). Student interpretations of this myth vary, with some students noting references to earthquakes and a "watry wall," concluding that the story is based on a tsunami, and others favoring an origin involving heavy rainfall, citing references to clouds and showers. It is worth noting that, although the date of 1529 BC assigned to this flood on the Parian Marble has led to speculation of a link to the eruption of Thera (Luce, 1969), the references to earthquakes and waves are not found in the earlier versions of the story (Frazer, 1919).

Although to date we have read only the myths described above, there are many others to choose from in Greek and other cultures (Frazer, 1919; Luce, 1969; Vitaliano, 1973). Perhaps the most geologically intriguing is the Greek story of Dardanus, who is said to have founded Troy after surviving a flood that occurred when a barrier in the Bosphorus/Dardanelles gave way, allowing waters from the Black Sea to rush into the Mediterranean and temporarily inundate the island of Samothrace (Frazier, 1919). Except for the fact that water is flowing in the opposite direction, this story bears a striking resemblance to the previously mentioned event that flooded the Black Sea around 5500 BC. Other potential discussion topics related to flooding include the purported discovery of Noah's ark on Mt. Ararat (Collins and Fasold, 1996) or a comparison of flood myths from different cultures.

### Myths Related to Earthquakes

In view of the high level of seismicity in the Mediterranean region, it is not surprising to find numerous references to earthquakes and tsunami in the Bible (for example, Job 9, Amos 1, Matthew 27, Zechariah 14) as well as in Greek mythology, where one of Poseidon's titles is "Earthshaker." This segment of the course begins with background lectures that cover the causes and effects of earthquakes, the determination of an epicenter, and the concepts of intensity and magnitude. We then focus on two well known Biblical stories that are thought to be related to earthquake activity: the capture of Jericho by Joshua and the Israelites (Joshua 3-4) and the destruction of the cities of Sodom and Gomorrah (Genesis 19).

The site of Jericho lies within the seismically active Dead Sea rift valley, a pull-apart graben produced where the sinistral Dead Sea fault system steps westward. Slip along this fault system has averaged 1 cm/yr during the Quaternary and has produced an average of one M6.5-7.0 earthquake per century over the past 3000 years (Bentor, 1989, Nur and MacAskill, 1991). Several of these earthquakes have triggered landslides that temporarily dammed the Jordan River at Adam (modern Damiya, Jordan), and a similar blockage is almost certainly recorded in Joshua 3, where passage of the Israelites across the river was possible after "the waters that came down from above stood and rose up upon a heap vary far at the city Adam ...and those that came down toward the sea of the plain...failed and were cut off." This excerpt, together with archaeological evidence for earthquake damage to walls of one of the buried cities at Jericho, provides compelling evidence that the Biblical story is

based on a seismic event that occurred around 1500  $\pm$  50 BC (Bentor, 1989; Pellegrino, 1994). Other details of this event, such as its magnitude, can only be roughly estimated, but students can gain an understanding of the basic concepts involved by using empirical relationships among magnitude, moment, ground acceleration, and intensity (Ambraseys, 1978) to estimate the magnitude, the slip required, and the recurrence interval for an earthquake of a given intensity. For example, if we estimate an intensity of 10 based on the description of widespread damage and assume a focal distance of 10 km, the calculated magnitude would be  $\sim$ 6. This would correspond to the energy released by  $\sim$ 70 cm of slip along a 10 km segment of the fault, an event that could be expected to occur roughly once per century.

The biblical story of the destruction of the "cities of the Plain," Sodom and Gomorrah, may have its origins in an even earlier earthquake along the Dead Sea fault. The exact location of these cities remains unknown, but they are thought to have existed around 2400-1900 BC along the southeast side of the Dead Sea, in an area that has since been flooded by a rise in water level (Neev and Emery, 1995). This area lies adjacent to the eastern border fault of the Dead Sea graben and would likely have experienced numerous seismic events. However, the description of the "overthrow" of the cities, with references to a rain of brimstone and fire and to smoke rising from the Earth (Genesis 19, 24-28) has given rise to diverse interpretations of what might actually have occurred. Our students initially hypothesized that the event was an explosive volcanic eruption, but there is no evidence for such activity in the Dead Sea region. However, there are basaltic vents along the eastern border fault, and Block (1975) has suggested that rising magmas could have ignited hydrocarbons, which are common in the area. Other proposed explanations for the Sodom and Gomorrah event include ignition of a natural gas or oil seep (Block, 1982), seismically induced soil liquefaction and ground loss (Harris and Beardow, 1995), and flooding caused by subsidence or climate-driven changes in the level of the Dead Sea (Bentor, 1989). Distinguishing among these alternatives may be impossible unless the sites of the cities are discovered, but the story affords opportunities to explore numerous geologic themes including tectonics, seismicity, volcanism, and hydrocarbon formation.

### Myths Related to Volcanism

There are over 60 volcanoes in the Mediterranean region that have been active within the past 10,000 years. These range from cinder cones to stratovolcanoes (for example, Mt. Etna and Mt. Vesuvius) to calderas (for example, Thera) and represent several tectonic settings. As background information for this final segment of the course, we provide a map of historically active volcanoes in the Mediterranean basin and discuss the relationships among tectonic setting, magma composition, volcano type, and eruption products, so students can make reasonable inferences about what types of phenomena to expect from specific volcanoes.

Prior to tackling veiled accounts of volcanism contained in myths, we also have students read contemporary reports of activity at Krakatoa and Mt. Pelee, and Pliny the Younger's account of the 79 AD eruption of Mt. Vesuvius. These provide vivid eyewitness descriptions of ashflows, airfalls, and tsunami, and Pliny's letters can be compared with the detailed reconstruction of the eruption by Sigurdsson and others (1985) that integrates geological and archaeological evidence.

The greatest eruption in the Mediterranean region within the past 10,000 years was the 1628 BC eruption of Santorini, which has been blamed by some for the collapse of Minoan civilization on Crete (Marinatos, 1939). Although recent work tends to indicate that devastation on Crete was not sufficient to wipe out the Minoans and that their decline was gradual (Pellegrino, 1991), there is no doubt that the eruption was a cataclysmic event. It occurred in four major phases over a span of days or weeks, producing ashflows, surges, and a plinian column over 30 km high (McCoy and Heiken, 1990; Sigurdsson and others, 1990). Eruption deposits on Santorini locally exceed 50 meters in thickness, and fine ash has been found as far away as the Nile delta (McCoy and Heiken, 1990). Evidence for tsunami and for vast rafts of floating pumice has also been reported from the eastern Mediterranean and Aegean Seas (McCoy and Heiken, 1990). To date we have provided students with these details of the eruption, but a more investigative approach would be to have them reconstruct for themselves such parameters as eruption volume and column height using isopach maps of the deposits (Carey and Sparks, 1986).

Vitaliano (1973) has suggested that some of the biblical plagues, particularly the plague of darkness (Exodus 10:22), as well as references in Egyptian papyri to a veiled sun and times of hardship may describe distal effects of the Santorini eruption. Although intriguing, such fragmentary passages provide little for discussion, and we mention them only briefly in class. Instead we focus on the account in Theogony (Hesiod, 1973) of the battle between Zeus and the Titans, which has been interpreted as a chronological account of the eruption (Green, 1992). This reading forms the basis for the next position paper, which focuses on whether this battle was based on a volcanic eruption and, if so, what types of events are described. Students tend to be very imaginative on this assignment, recognizing metaphors for such phenomena as volcanic bombs, ashflows, lightning, and tsunami.

The most famous legend that may have links to the eruption of Santorini, and our final topic in this course, is Plato's account of the disappearance of Atlantis. We save this tale for the end because it relates to all of the earlier geologic themes and because the vast literature on Atlantis provides a wealth of theories for the students to ponder in their final discussion. Unlike most myths which have their basis in oral tradition, the story of Atlantis is known only from the 4th century BC dialogues of Plato, which purport to recount information obtained by Solon during a visit to Egypt several centuries earlier. As described

in the *Timaeus* (Plato, 1929), Atlantis was a powerful island nation, larger than Libya and Asia combined, which had existed 9,000 years earlier in the Atlantic Ocean until it sank beneath the sea after a day of violent earthquakes and floods. The idea that the Atlantis legend might be a garbled account of the eruption of Thera and its impact on Minoan civilization has been examined in detail (Luce, 1969; Vitaliano, 1973; Pellegrino, 1991), and is probably the most reasonable explanation for this myth from a geological perspective. However, literally hundreds of books and papers have been published on Atlantis, and a plethora of alternative locations ranging from the Bahamas, Central America, and the Azores, to Scandinavia, Ceylon, and the Arctic (see summaries in DeCamp, 1970 and Ellis, 1998) have been proposed in these accounts. Alternatively, a strong case can be made that Plato invented the whole story, perhaps to warn his fellow Athenians of the risks he saw in their corruption (Ellis, 1998). This in fact is the conclusion most of our students reach after we compare Plato's descriptions of Atlantis with the geological and geographic constraints on "sinking continents" with what is known of Minoan civilization and of the Santorini eruption.

### Discussion

Besides learning about the geology, history, and literature of the Mediterranean region, students in Geomythology gain an appreciation of the interconnectedness of knowledge in these seemingly unrelated disciplines. The course also provides opportunities for critical and imaginative thinking, both of which are underrepresented in many introductory science courses. Evaluations by the students have been very positive, with comments that the course exposes "another realm of science and imagination" and that it "encourages new ideas about two completely opposite realms." Almost half the students last year wrote that the discussion-oriented format was one of the strengths of the course, and we credit the position papers with improving the quality of these sessions. Nonetheless, there were still some students who failed to participate, and for this reason we plan to incorporate a "jigsaw" element (Tewksbury, 1995) into future discussion sessions. The course attracts a high proportion (>75%) of non-science majors, some of whom have gone on to take additional geology courses. This suggests that Geomythology could be an effective recruiting course for geoscience programs; however we cannot document this at Valdosta State because we do not offer a geology major.

Although our course is concentrated on the Mediterranean region, a similar course could easily be developed with a different geographic or cultural focus. For those interested in additional information about our course or about geomythology in general, I have established a Web site (<http://www.valdosta.edu/~jtepper/geomyth>) to serve as a clearing house for information about connections between geology, mythology, and ancient history and how these topics can be integrated in the classroom.

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### About the Author

Jeff Tepper received his AB from Dartmouth College and his PhD from the University of Washington. Since 1994 he has been an Assistant Professor at Valdosta State University, where he teaches geochemistry, geomythology, and various introductory-level geology courses. His interests include arc magmatism, environmental chemistry, and the development of geology courses that cross traditional discipline boundaries.

### Food for Thought

The size and age of the Cosmos are beyond ordinary human understanding. Lost somewhere between immensity and eternity is our tiny planetary home. In a cosmic perspective, most human concerns seem insignificant, even petty. And yet our species is young, and curious, and brave and shows much promise. In the last few millennia we have made the most astonishing and unexpected discoveries about the Cosmos and our place within it, explorations that are exhilarating to consider. They remind us that humans have evolved to wonder, that understanding is a joy, that knowledge is prerequisite to survival. I believe our future depends on how well we know this cosmos in which we float like a mote of dust in the morning sky.

Carl Sagan, 1980, *Cosmos*: New York, Wings Books, 365 p. (from p. 4)