



## Mapping Tartaros: Observation, Inference, and Belief in Ancient Greek and Roman Accounts of Karst Terrain

. . . when I try to imagine a faultless love  
or the life to come, what I hear is the murmur  
of underground streams, what I see is a limestone landscape.

W. H. Auden, *In Praise of Limestone*



Edward Dodwell, *A Katabathra of Lake Copais* ©Trustees of the British Museum.

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This interdisciplinary article argues that ancient Greek and Roman representations of Okeanos, Tartaros, and the underworld demonstrate an observational awareness of the hollow underground spaces that characterize the geomorphology of karst terrains in the Mediterranean world. We review the scientific facts that underlie Greek and Roman accounts of karstic terrain in observation-based discourse and in myths, and we demonstrate that the Greek words *barathron* (pit), *limnē* (lake), *koilos* (hollow), and *dinē* (whirling current) are used with precision in observational accounts of karst terrain. Ancient accounts of the dynamic *limnē* and barathrum systems characteristic of much karst terrain offer a complex matrix of observation-based and belief-based discourse: at the edge of the barathrum, the imaginative or spiritual realm of the underworld has a material plausibility and the closely observed material world has a plausible potential to connect to a world we cannot see.

## I. THE GEOMYTHOLOGY OF KARSTIC PLACES<sup>1</sup>

The term geomythology, coined in 1968 by Dorothy Vitaliano, refers to the study of the geologic causes of natural phenomena which were long explained in terms of myth and folklore. Her book was the first to demonstrate in one volume the ways in which geology, history, and legends can be interrelated.<sup>2</sup> Mayor's excellent overview of the issues notes that "Some geomyths are simply fanciful stories based on imagination or popular misconceptions. . . . Many geomyths, however, contain surprisingly accurate insights into geological processes, as well as important eyewitness data from the distant past. Modern scientific investigations have revealed that much ancient folklore about the earth was based on rational speculation and understandings grounded in careful observations of genuine but extraordinary physical evidence over time."<sup>3</sup> While early geomythical approaches tended to focus on geological cataclysms and spectacular or unusual landforms, geomythological attention has recently been directed toward a water-caused phenomenon known as karst that manifests gradually, appears in varied forms, and can occur at scales ranging from very small to very large. Clendenon has argued that Greek myths display an observational awareness of properties of karst terrain.<sup>4</sup> The present paper expands this geomythological perspective in two ways: by taking a philological approach to the Greek and Latin words that express awareness of karst features and by bringing what we might call a karstic sensibility to interpretations of ancient literary texts. On a small scale this

1. For ancient place names we generally use those of the *Barrington Atlas of the Greek and Roman World* (Talbert 2000). Translations of Strabo are cited from Jones 1917–1932, Pausanias from Jones 1918–1933, and Plato from Fowler 1914. Unless noted otherwise, other translations of Greek and Latin works are those of C. Connors.

2. Vitaliano 1968, 1973, esp. xii.

3. Mayor 2005: 96. See also the essays collected in Picardi and Masse 2007.

4. The term hydromythology was coined by William Back in 1978 to frame his discussions of oral traditions and cultural beliefs about water; see Back 1981, esp. 257. Clendenon 2009a expands Back's definition and proposes a geomythological approach to ancient texts that describe natural surface-water and groundwater environments, including karst. Clendenon 2009b, 2009c, and 2010 offer convenient points of entry to various myths and topographical discourse associated with karst terrain.

approach can illuminate why a particular story or hero cult is attached to a particular place, or can make a joke more pointed, while on a large scale it can advance understanding of such issues as how and why Ocean is connected to the underworld in Greek storytelling or how and why ancient philosophers thought about disappearing rivers. What emerges overall are sharper, much more detailed perceptions of how useful an observational awareness of karst terrain was for producing material and physical plausibility in narratives of the afterlife and the underworld, and how appealing such plausibility was in myth, poetry, philosophy, and ritual.

The term karst refers to terrain wherein soluble rocks, commonly but not exclusively those categorized as carbonates (e.g. limestones, dolomites, and marbles), have undergone dissolution by rainwater percolating underground through cracks and crevices in the rocks.<sup>5</sup> Over time, parts of the rock formations dissolve and are carried away, leaving behind all types of voids and ultimately creating a distinctive landscape dominated by subsurface drainage via subterranean passages instead of surface drainage via streams. Indeed, in karst terrain, streams tend to be discontinuous or absent altogether.<sup>6</sup>

The internationally recognized European nomenclature used to designate karst forms includes the terms ponor, doline, and polje. This nomenclature evolved through scientific studies in a karst region of the northeastern Adriatic known as the “Classical Karst,” which is part of the larger Dinaric karst region.<sup>7</sup> This distinctive terrain was described by Strabo in his account of the Timavus river and its springs, part of Slovenia’s Škocjan cave system near Trieste, Italy:

And in the very recess of the Adriatic there is also a temple of Diomedes that is worth recording, “the Timavum”; for it has a harbour, and a magnificent precinct, and seven fountains of potable waters which immediately empty into the sea in one broad deep river. According to Polybius, all the fountains except one are of salt water, and, what is more, the natives call the place the source and mother of the sea. But Poseidonius says that a river, the Timavus, runs out of the mountains, falls down into a chasm (*berethron*), and then, after running underground about a hundred and thirty stadia [about 20 kilometers], makes its exit near the sea.<sup>8</sup>

Str. 5.1.8

5. On karst geomorphology and hydrogeology see Herak and Stringfield 1972, Jennings 1985, White 1988, Gunn 2004, Ford and Williams 2007, and White and Culver 2012.

6. Where a subterranean solution conduit is large enough to convey a turbulent flow of water, the term “underground stream” is scientifically accurate, in contrast to typical non-karstic groundwater movement that seeps very slowly and diffusely through small pores, and for which “underground stream” is a common misnomer.

7. See further Cvijić 1893, Gams 1973, Kranj 1998, 2000, and Ford 2007.

8. Verg. *Aen.* 1.242–46, Pliny *Nat.* 2.229; Livy (41.1) mentions the Lacus Timavi. For the topography and ancient descriptions, see Smith 1854, s.v. “Timavus.” Claus 2002/2003 offers a meta-literary interpretation of the Timavus’ reputation for being connected to Ocean in a discussion of Verg. *Ecl.* 8.6.

The passage of Poseidonius that Strabo cites here describes the spot where the Reka river plunges underground through the Škocjan caves, flows below the Dinaric karst for 38 kilometers, and re-emerges as the Timavo.<sup>9</sup>

Ancient accounts of the Timavus identify some of the most curious water-related phenomena of well-developed karst regions. The fresh waters of surface rivers and surface lakes can be “swallowed”—sometimes very quickly—by holes in the ground known as sinkholes, swallowholes, or ponors. Depending on local hydrogeological conditions, the subterranean water can resurface as one or more springs several kilometers away, in locations such as a cave, a hillside, a ravine wall, a marshy area, a seacoast, a dry streambed (perhaps as a resurgence of the same stream that was swallowed upstream), the bed of a flowing stream (as an underwater spring), a lakebed (as an underwater spring), or even a coastal seabed (as a submarine spring where the fresh water emerges from the spring vent into the overlying salt water). In some cases, the fresh groundwater sourced from a terrestrial (onshore) karst system can discharge from the seabed with enough momentum to roil the sea surface. These fresh submarine springs can occur near the seashore or at various distances offshore, perhaps 25 kilometers or more.

Saltwater springs commonly occur in coastal karst systems when saline water from the sea intrudes through subterranean routes to contaminate fresh groundwater found either beneath the seabed or beneath the terrestrial land surface, or both. In coastal karst, sinkholes (ponors) in the sea floor can “swallow” sea water, which can resurge inland several kilometers from the coast, as it does at Karavomilos on Kefalonia.

Cone-shaped depressions of the land surface called dolines are caused by solution and/or collapses of the underlying rocks, and provide a drainage route for rain and snowmelt. Dolines may contain visible sinkholes, and some people use the terms interchangeably. Poljes are valley-like flat plains that may be several kilometers in width and length. A polje that is either seasonally or perennially dry and contains fertile bottomland soils is often farmed. A polje that is either temporarily or permanently flooded yields a marsh or lake.

Beneath the land surface, whether in low elevations or in high alpine elevations, karst regions frequently are rich in caves, pits, chasms, irregular passages, and other natural structures that in some cases are hidden by the overlying rocks, soil, or water but in other cases may be visible where the subterranean structures connect to the land surface. When the roof of a large cave or pit collapses and exposes the formerly hidden feature, the resulting collapse structure can be spectacular, and it may contain a significant amount of water. And if a karst landscape coincides with areas of geothermalism or volcanism, or both, then the complex dynamics of earth, water, air, and fire can be dramatic to the point of being unbelievable, and yet still be within realm of geological proof and possibility.

9. For images of the area, see Škocjan Caves—UNESCO World Heritage Centre <http://whc.unesco.org/en/list/390> accessed 5 March 2016.

Significant areas of karst are found in Greece as well as in other limestone-rich areas of the Mediterranean: the Adriatic coasts, southern peninsular Italy, Sicily, Cyrenaica (northeastern Libya), Egypt, the Levant, coastal Turkey, the island of Cyprus, and the Black Sea coast.<sup>10</sup> We estimate that in mainland Greece alone, ancient settlers collectively would have observed hundreds of karst forms such as sinkholes, springs, pits, and caves, as well as other landscape features not described in this paper.

Crouch has emphasized the central role of karst in the settlement of Greek cities and the development of ancient water management practices (Crouch 1991, 1993, 1996, 2004). Of the roughly fifty sites of ancient Greek settlement that she visited, almost all were located on karstlands: ancient Greeks had learned to recognize the karst terrains that were likely to provide an abundant supply of water from springs (Crouch 1991: 27). As she further notes, disciplinary boundaries have constrained research on human settlements on karstlands: “Karst has been studied by hydrogeologists, and ancient Greek settlements have been studied by classicists, with an impenetrable membrane separating the two fields of knowledge. Yet my study has conclusively demonstrated that one cannot understand either the choice of an ancient Greek site or the subsequent history of the settlement without factoring in the geological base and water resources” (Crouch 1991: 29).<sup>11</sup>

Karst water movement witnessed by Greeks and Romans was the basis for inferences and theories about the hydrologic cycle and groundwater occurrence.<sup>12</sup> Karst terrains also were central to mythological, religious, and philosophical perceptions of mortality and the creation and nature of the cosmos. While Western historians of hydrology, hydrogeology, and karstology have acknowledged the descriptions of karst phenomena in ancient Greek and Roman geographical and philosophical texts,<sup>13</sup> the expression of karst-influenced ideas in mythological and religious texts has not yet been fully appreciated.

Accounts of nature are always accounts of culture.<sup>14</sup> Bakke 2007, an excellent case study of the cultural geography of Tegea, provides many useful perspectives and insights regarding the relation of karst forms to mythological discourse in this

10. On the significance of karst in the Greek world see also Higgins and Higgins 1996, Fagan 2011: 159–65, and Morfis and Zojer 1986.

11. Cf. Crouch 1993: 63–99. On karst in the vicinity of Rome, see Heiken, Funicello, and De Rita 2005: 138. Tozer 1873, Lecture III, gives an eyewitness account of the most notable places in mainland Greece now recognized as karstic.

12. Adams 1938: 430–31, Forbes 1963: 16–18, Ford and Williams 2007: 6, LaMoreaux 1991: 215–16, 218, Brutsaert 2005: 562–63. The karst-inspired subterranean theory of groundwater became the *de facto* scientific model and remained dominant through the end of the seventeenth century. Although many of these concepts eventually were replaced by the correct explanations, some of the fundamental principles of karst water occurrence, as formulated in Greek and Roman texts, remain accurate.

13. Baker and Horton 1936, Adams 1938: 426–32, Forbes 1963: 1–19 (with brief discussion of myth at 16–17), Biswas 1970: 37–119, Herak and Stringfield 1972: 19–20, LaMoreaux 1991: 218, Shaw 1992: 8, 65–67, 80–82, 123, 176, LaMoreaux 2004: 1026–27, and Brutsaert 2005: 559–69.

14. Cronon 1992.

regional context (see esp. 23–31 and 230–59). More broadly, studies of ancient literary representations of space by Purves (2010) and Thalmann (2011) have clearly demonstrated the extent to which a map of the world is a map of the mind. Ancient Greeks and Romans used strong observational knowledge of caves, chasms, and pits to envision a dynamic subterranean world of caverns, interconnecting conduits, and subterranean lakes and rivers. Mythological narratives share with ancient proto-scientific accounts a careful consideration of hydrogeologic processes and natural structures.

Our discussion connects with and expands upon recent work by Nagy (2011). Drawing on analysis by Fearn (2003), Nagy investigates the streams in Thessaly, Boeotia, and in the Peloponnese that bear the name Asopos. Describing their multifiform paths as “the virtual Asopos” Nagy demonstrates the range of ways that communities could express relationships to other communities by asserting that their streams were connected. Canny bestowal of names in a karstic landscape can suggest that one river does not merely have the same name as another, but is, in fact, in some non-visible but material sense, the same river. The Achelous River was the largest in southern Greece, and its power is reflected in the Homeric lines that pair it with the river Okeanos (Hom. *Il.* 21.195). Cults of Achelous and the nymphs are identified with karstic landscapes at Athens by the Ilissos (Pl. *Phdr.* 230b, on which see Connors and Clendenon 2012: 345–46), at the sanctuary of Amphiaraus in Oropus (Paus. 1.34.3), and in a description of a cave next to the pool at Thespieae where Narcissus met his end (Philostr. *Im.* 1.23). That is to say, cults of Achelous are located in places where karstic features could produce the narrative that there was a physical connection to the mighty river. Such expressions of connectivity through representation of karst terrain are widespread in Greek and Roman discourse; they stretch far beyond one river’s network to the furthest reaches of Greek experience and imagination, even to the realms of Okeanos and Tartaros.

## II. EVIDENCE FOR OBSERVATIONAL AWARENESS OF KARST TERRAIN IN THE GREEK AND ROMAN WORLD

While limestone is plentiful in mainland Greece, several karstic areas receive the most attention in the ancient Greek and Roman written evidence.<sup>15</sup> These are: the Stympthalian lake of Arcadia, an intermittently flooded polje that traditionally was understood to connect via a subterranean watercourse to the spring-source of the

15. Many of the following places are illustrated in Dodwell 1821; evocative photographs are juxtaposed with ancient accounts in Brewster 1997; overview of karst in Greece and the Greek world: Clendenon 2009a: esp. 251–363, and see now Walsh 2013: 78–81 and 109–10. As Farinetti 2008: 122 points out, in many cases major drainage projects undertaken in the nineteenth and twentieth centuries have caused karst landscapes to look quite different now than they did in ancient times.

Erasinos River south of Argos (a supposition that was very close to the truth);<sup>16</sup> the former lake Pheneos of Arcadia, an intermittently flooded polje correctly understood to have a subterranean connection to the Ladon river and thereby to the Alpheios river;<sup>17</sup> Lacedaemon, including the Taygetos Mountains; an area in Boeotia comprising the Kiphissos basin (Cephisos), Lake Copais (drained in 1892), Orchomenos and Lebadeia (Levadia);<sup>18</sup> and in Thessaly, the area drained by the Peneios river.<sup>19</sup> Also subject to ancient inquiry were: the karstic areas through which flow the Timavus, the Nile, the Orontes, and the Euphrates and Tigris; areas around the Black Sea; western and southern coastal Turkey;<sup>20</sup> and northern and western coastal Cyrenaica.<sup>21</sup>

There is no evidence that Greeks understood the true geochemical causes of the karstification process. In some contexts, Greeks and Romans consider earthquakes, volcanoes, and karst phenomena all to be manifestations of the hollowness of the earth, in combination with air (wind), water, and/or fire. Despite their lack of understanding of the *underlying* geochemical and associated weathering processes, we believe that it makes sense to speak of Strabo or Pausanias and other authors as having an *observational* awareness of karst forms and places.

Aristotle discussed the circulation of water through earth's hollows in his *Meteorologica*. The polymathic poet Callimachus (c. 305–240 BCE) wrote a work on the rivers of the world (Call. fr. 457–59 Pfeiffer) and collected many stories about unusual lakes and underground streams in his writings on paradoxes;<sup>22</sup> Antigonus of Carystos used these as a source in his collection of marvels during the third century BCE (Call. fr. 407–11 Pfeiffer). Eratosthenes (c. 276–195 BCE) had an interest in the karstic places of Arcadia (cf. Str. 8.8.4) and near the Nile. Poseidonius (c. 135–51 BCE), quoted by name in Strabo's account of the Timavus, and interested in a wide range of geological and hydrological phenomena, is known to have written about the behavior of water in other karstic locations (Str. 1.3.16). Ovid includes the disappearance of rivers in his account of creation, and provides a comprehensive account of such rivers in the speech of Pythagoras (*Met.* 1.40, 15.268–78).

Strabo (c. 64/63 BCE–25 CE), and Pausanias (second half of the second century CE) thus draw on an established body of knowledge about karstic places across the

16. On dye traces that map the flow of water in the central and eastern Peloponnese karst, see Morfis and Zojer 1986.

17. See Baker-Penoyre 1902, with his map at 229 and discussion of “mythologic indications” and classical texts at 234–36; Higgins and Higgins 1996: 49 and 70–71.

18. Copais basin: Farinetti 2008; Kifissos basin: Koukis and Koutsoyiannis 1997: 233–34.

19. Peneios: Migiros, Bathrellos, Skilodimou, and Karamousalas, 2011.

20. The caves Cennet (Heaven) and Cehennem (Hell) are near the Turkish fishing village Narli-kuyu (cf. Atalay 2003). Cehennem was said to be inhabited by the monster Typhon (son of Earth and Tartaros, opponent of Zeus and father of Cerberus: Hes. *Th.* 311, 820–68; Apollod. 1.6.3); cf. Str. 12.8.19 and 16.2.7.

21. Cyrenaica: Laumanns 2008, Halliday 2003: 28–29.

22. Disappearing rivers in Callimachus: in Arcadia *Jov.* 1.18–32; of the Inopus on Delos as being connected to the Nile: *Del.* 206–208 cf. Call. *Dian.* 171, and Paus. 2.5.3 with Str. 17.1.21 and Stephens 2003: 74–121. The story of Proteus' passage from Pallene to an island off of Egypt through an undersea cave (*specus*) known to DServius likely derives from Callimachus: Call. fr. 54 Harder, with DServius on Verg. *G.* 4.390.

Mediterranean world. They and other Greek and Roman writers are fascinated by the phenomenon of rivers that disappear underground and reemerge, especially if this can be proven by throwing objects in at one end and retrieving them at the other, much as modern scientists carry out dye tracing experiments to map karstic streams.<sup>23</sup> Pliny cites disappearing rivers including the Alpheios (and its connection to Arethusa), Lykos, Erasinus, Tigris, and Timavus (*Nat.* 2.225 and 2.106). Strabo broadens his discussion of the caverns and underground streams of Sicily to address subterranean rivers in various other locations including the Orontes in Syria (cf. *Str.* 16.2.7), the Tigris, the Nile, and in Greece the Stymphalus, the Erasinus, the Asea, the Eurotas, and the Alpheios and the Timavus (*Str.* 6.2.9).

In their narratives, Strabo and Pausanias use a consistent vocabulary that includes the terms *limnē* (lake or marsh), *dinē* (whirlpool), *barathron* (pit), and *koilos* (hollow) to describe karst forms interacting in a dynamic system, especially as it involves water. In Latin, the terms typically used in descriptions of karst forms include *palus* (marsh), *gurgēs* (swirling water), *barathrum* (pit), and *vorago* (chasm).

In Classical and Hellenistic texts, the term *limnē* could mean either a morass, a marsh, or a lake. Further, *limnē* is regularly though not exclusively used of a flooded karstic polje. A polje lake may form and its level may fluctuate either gradually or rapidly, depending on rainfall, snowmelt, and other hydrologic inflows and outflows. The sense of a *limnē* as a dynamic system emerges in the Greek verb *limnazein*, “lake-ify,” used in descriptions of flooded landscapes in karstic terrain (*Str.* 8.8.4, near Pheneus; cf. *D. S.* 4.18.6, near the Peneios). Pausanias reports stories that after a festival of Stymphalean Artemis was carried out without proper care, the mouth of the *barathron* was blocked by a log and a large lake (*limnē*) formed. When a hunter chased a deer into the water “the *barathron* swallowed up both the deer and her pursuer” along with all the water; by the next day the whole lake had completely drained away. Rituals of Stymphalean Artemis were subsequently conducted more thoroughly (*Paus.* 8.22.8–9).

Occurrences of the word *limnē* in Homer indicate some awareness of *limnē* either as a dynamic system or a portal between the sunlit earth and its hidden depths. When Homer uses *limnē* of specific places, these are places in which lakes are known to flood and drain (*Boibe Il.* 2.711: cf. *Str.* 9.5.2; *Cephisos Il.* 5.709: cf. *Str.* 9.2.18) or places known for hollows and passages (*Gygae Il.* 2.865 and 20.390: cf. *Str.* 13.4.5–6). Other instances of *limnē* describe spaces through which the gods move between earth and its depths. The river god Scamander threatens to defeat Achilles and to hide his armor “way down in the *limnē*” (*Il.* 21.317). Poseidon leaves Samothrace and descends to his undersea palace at Aegae “in the depths of the deep *limnē*” (*Il.* 13.21). He drives his chariot from there to a “wide cavern (*speos*) in the depths of the *limnē* halfway between Tenedos and craggy Imbros,” where he ties up the horses and leaves the chariot so he can proceed

23. See also Diodorus Siculus 15.49.5 and Josephus *Jewish War* 3.513 (Thackeray 1997); cf. Shahar 2005.

onward to the battlefield at Troy (*Il.* 13.32). When Iris travels to Thetis' undersea dwelling she descends between the islands of Tenedos and Imbros, and "the *limnē* made a groaning sound around her" (*Il.* 24.79). In the *Odyssey* the word *limnē* is used three times: Tantalus stands in a *limnē* in the underworld (*Od.* 11.583); Ino Leucothea rises up out of a *limnē* to alight on Odysseus' raft and give him the veil that will preserve his life (*Od.* 5.337); and Helios rises out of the *limnē* as day breaks (*Od.* 3.1).

In Apollonius of Rhodes too, the word *limnē* expresses an awareness of a dynamic system with connections to hidden depths. When Apollonius uses *limnē* of identifiable places, these are in karstic terrain.<sup>24</sup> The Argonauts travel on large lakes in the land of the Celts (4.627–36) and in Libya they spend a long time in the Triton *limnē* trying to find the passage (*stoma*) through which they can leave it (e.g. 4.1539, 1568).<sup>25</sup> In a powerful analysis of Apollonius' constructions of space, Thalmann argues that the Celtic *limnē* "is a place of spatial confusion and category blurring, whereas the seashore represents spatial clarity" (Thalmann 2011: 155). In Thalmann's view, Apollonius constructs in rivers and lakes "a kind of 'anti-space' where space is not culturally produced but left vague and in some ways menacing" (2011: 163). To depict *limnai* as sites of spatial confusion and perplexing or menacing possibilities, Apollonius has at his disposal the whole complex of observation-based ideas about the unpredictable outlets and passages a *limnē* might have.

Whirlpools in a waterbody such as a river, lake, or sea often are caused by factors not related to karst. But these waterbodies nonetheless may be situated in karstic regions, thus making possible the contribution of karst inflows and outflows. The Greek word *dinē* (whirlpool) typically refers to spiraling currents in rivers, including ones that drain karstic areas: well-known examples include the Scamander, as Achilles battles it (e.g. *Il.* 21.11), and the river in Phaeacia where Nausicaa's companion loses her ball (*Od.* 6.116); Staius' Hippomedon is engulfed in the *barathrum* created by the whirling currents of the Ismenos (*Th.* 9.503). The Asopos was called "deep-swirling" (*bathydineentos*, see Paus. 2.6.4). The river Ocean is frequently said to have "deep-swirling" currents (e.g. *Od.* 10.511, Hes. *Th.* 133, *Op.* 171). *Dinē* is the ancient place-name for the site in the Argolic gulf (Genesion or Genethlium) at which karstic submarine springs discharged with enough momentum to roil the sea surface. Other freshwater spring roils in the sea formerly were observed in both bays flanking Ortygia in Syracuse. In his account of *Dinē*, Pausanias compares submarine freshwater springs at Thesprotia, in the Meander river, and near Dicaearchia on the bay of Naples.<sup>26</sup> In our view, while the term *dinē* is not exclusively used of karstic

24. Xynias near Ctimene in Thessaly A. R. 1.67, Stymphalus A. R. 2.1053, Lake Serbonis A. R. 2.1215.

25. Clendenon 2009a: 367–411 and 456, fig. 7 examines the Lake Tritonis myths in their environmental contexts and suggests that a once-flooded karstic or semi-karstic landscape may indeed have presented a maze to ancient coastal mariners in eastern Libya.

26. *Dinē*: Paus. 8.7.1–2 and 8.8.1 with Mariolakos and Mariolakos 2004: 1147 and 1151. Ortygia: Crouch 1991: 25 and 2004: 103–105 and fig 3.31.

phenomena, references to whirling currents are part of ancient Greek discourse about karstic streams, pools, and springs.

The adjective *koilos*, typically translated as “hollow,” describes things that are curved and receptive to being filled such as ships, cups, or the cupped hand of a beggar; it is also used to describe places as curved or receptive spaces: a coastline that curves concavely (Str. 6.2.1, 8.6.22, cf. 9.2.25); holes or pits visible on the surface of the earth (Str. 4.1.7, 16.2.26); spaces between hills or mountains or the sides of a ravine (Str. 5.1.3, 5.3.8); a plain that is low lying (Str. 7a 1.44) or surrounded by hills (Str. 12.2.2, 12.6.5, 16.2.10). Koile (Coele) Syria is so called from the “hollow” between the Lebanon and anti-Lebanon mountains (Str. 16.2.16, cf. 16.2.21 and 6.2.7). “Hollow” Elis near Olympia, an area with karst, is so called because it is “*koilē*” says Strabo (8.3.2); it may be that Strabo and others could understand *surrounded-by-mountains* and *having-underground-hollows* as related features, likely to be found together, in a landscape described with forms of *koilos*. Because earthquakes, volcanoes, and karst phenomena are all understood as manifestations of the earth’s hollowness, Strabo uses forms of *koilos* to describe what he envisions as interconnected caverns prone to disturbances beneath the surface of the earth and the bed of the sea extending from Sicily to Cumae (Str. 5.4.9 cf. 6.2.9, 9.3.5).

The ancient Greek noun *barathron* designates a hole in the surface of the earth.<sup>27</sup> It has variant forms *berethron* and *zerethron*; the Latin term *barathrum* has been taken into English. The Modern Greek term is *katavothra*, where the prefix *kata* emphasizes the idea of descent. In karst terrains, a hole (sinkhole or ponor), including one created by the collapse of the land surface, may open into further hollows, chambers, or streams beneath. The lexicographer Stephanus of Byzantium (6th century CE) defines *barathron* as “a hollow place” (*topos koilos*). Thus the Timavus is said to plunge into a *barathrum* (*eis berethron*, Str. 5.1.8). Strabo’s description of Pelusium at the eastern mouth of the Nile describes how the land is characterized by pits (*barathra*) formed by the Nile in its flow “since the place is by nature hollow (*koilon*) and marshy” (16.2.33). Modern lexicography related to the terms βέρεθρον and βάραθρον in Greek and *barathrum* in Latin divides references to the observable world from references to the underworld, which cannot be verified by observation.<sup>28</sup> Yet the particular ways that Greeks<sup>29</sup>

27. It has been suggested that it derives from the Indo-European root  $g^w erh_3$  connected with swallowing: LSJ s.v. βάραθρον, cf. Mallory and Adams 2006: 255. Beekes 2014: 48 argues that it is a non-Indo-European Pre-Greek word.

28. LSJ s.v. βάραθρον and βέρεθρον; OLD s.v. *barathrum*. TLL s.v. *barathrum* uses the headings “*proprie*” (“in a literal sense”) (15 examples), “*i. q. [idem quod] infernus*” (“the same thing as the underworld”) (38 examples), and “*imagine*” (“in figurative language”) (35 examples).

29. In the TLG database, the search term βάραθρον yields more than 800 results. Ordering these by date yields 185 results (with fragmentary pieces of evidence often reported more than once) ranging in time from Herodotus (c. 484–425 BCE) to the Emperor Julian (331/2–363 CE). A chronologically ordered search of the database for the term βέρεθρον yields 80 results ranging from Homer to the commentary on Plato’s *Republic* by Proclus (412–485 CE); many of these quote or discuss the Homeric

and Romans<sup>30</sup> used these terms indicates that they could align what we might call the believed-in world of the underworld with the observed world of the landscape, and thus provide a structure for the plausibility of the idea of the underworld as a physical place with many points of access.

Homer uses the term βέρεθρον to describe the realm of the underworld in which Zeus confined the Titans after defeating them (Hom. *Il.* 8.14). When βάραθρον describes a known physical place, its earliest recorded uses refer to the barathron at Athens, a pit into which people were thrown as punishment.<sup>31</sup> A remark in Plato's *Republic* indicates that a place of public execution was located "outside (the city) by the side of the northern [Long] wall" (ὕπὸ τὸ βόρειον τεῖχος ἐκτός, 439e). Writing in 1873 Dyer can remark of this area, "Now there still may be seen on this spot a deep chasm or ravine, answering admirably to the βάραθρον into which the bodies of the executed were thrown" (Dyer 1873: 98). It is worth noting, too, that the spot discussed in the *Republic* is by the Hill of the Nymphs, and thus is fairly close to the area identified as the deme Koile (hollow) between the Pnyx and the Hill of the Muses (Hill of Philopappos; cf. Hdt. 6.103; Marcellinus, *Life of Thucydides* 17).<sup>32</sup> The term *barathron* is used in threats about punishment;<sup>33</sup> the word for the individual who carried out executions is "the one at the *orygma*" (Din. 1.62, Lycurg. 121, Poll. 8.71). Wycherley suggests that the cuttings in the area indicate that limestone from the area of the barathron near the Hill of the Nymphs was used in construction at Athens (Wycherley 1978: 269). Whether or not that punishment involved throwing individuals into the *barathron* while still alive or disposing of their bodies to prevent them from being memorialized,<sup>34</sup> the use of the term barathron to describe such punishments associates the process of punishment with a natural feature commonly found in karstic terrain.

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passage or the fact that βέρεθρον is a dialect variant for βάραθρον, or are from epic poets using Homeric vocabulary.

30. The search term *barathr* returns 32 results from the Packard Humanities Institute Latin Texts (<http://latin.packhum.org>). Roman poets sometimes use the word *barathrum* to refer to Tartarus and sometimes use its Latin equivalents, *gurgēs* and *vorago*, cf. *Lewis and Short s.v. gurgēs*. The qualities of the *gurgēs* seem especially close to the dynamic earth-penetrating qualities of a barathrum at, e.g., Verg. *Aen.* 6.296, 11.298, 913, 12.114; Ov. *Met.* 5.413, 421, 469, 504, 597, 6.354, 381, 11.249, 15.275 with Sen. *NQ* 3.26.4, *HF* 554, *M* 723, *Ph.* 1206, *Th.* 175, Juv. 2.150, Plin. *Epist.* 8.8.2, *Sil. Pun.* 1.210, 13.567, 15.250.

31. Literal references to such punishments include Hdt. 7.133, Xen. *Hell.* 1.7.20.5, Pl. *Grg.* 516d6, Plut. *Arist.* 3.3.1, cf. *Suda* B 99, 100, 101 Adler 1928–1938, <http://www.stoa.org/sol/>. Greek authors extend the term *barathron* to punishments at Rome: Dion. Hal. 4.48.2, Plut. *Mar.* 12.4.6. The word *barathron* is used for a greedy courtesan (Theophilus Com. Kassel Austin 11.3 = Ath. 13.587f), of male prostitution in a poem attributed to Archilochus (fr. 328.13 West) and for debt (Plut. *Mor.* 524a3).

32. The *barathron* is associated with "the deme of Keiradai" in a lexicographical note at Bekker 1814: 219; Keiradai is between the deme Melite by the Hill of the Nymphs and the deme Koile between the Pnyx and the Hill of the Muses (Traill 1975: 51 and Map 2).

33. Ar. *Knights* 1362 (cf. Plaut. *Rud.* 570), *Clouds* 1449, *Frogs* 575, *Wealth* 431, 1109; Men. *Dyscolos* 394, 575, Lucian *Icaromen.* 33.

34. For detailed discussion see Allen 2000: 219–24 and 393–94.

The term *barathron* designates subterranean passages that allow rainwater and runoff to flow out of places which have no surface outflow.<sup>35</sup> When a river or *limnē* disappears into the ground it is said to plunge down through a *barathron*.<sup>36</sup> The word is also used for a specific type of grain storage pit in Thrace.<sup>37</sup> In the plural, *barathra* is used of wet places near rivers where the land becomes impassable.<sup>38</sup> According to Plutarch the site in the center of Rome known as the lacus Curtius got its name when Curtius' horse plunged into a *barathron* and could not be extricated (Plut. *Rom.* 18.4, cf. Liv. 7.6.2).

Overall it seems fair to say that where references to *barathra* have geographical specificity, those places generally include karstic terrain or associated features such as marshiness, gorges, or sinkholes.<sup>39</sup> Some karstic terrain coincided with areas of volcanism, geothermalism, or both. Probably for this reason, *barathron* is sometimes used to describe specific types of pits that were felt to have a particularly evident connection to the underworld because of sulphurous vapors. Antigonas of Carystos and Eudoxus referred to “a category of things called *barathra* and *charonia* (*charonia*, lit. ‘things having to do with the realm of Charon’),” in discussions of a pit (*bothynos*) near Phrygia called the Kimmeros and of the cleft (*orygma*) in Latmos (Antigonus Caryst. *Mirab.* 123.1, Eudox. *Astron.* F 337.2).

In wrapping up his account of Arcadia Strabo offers an overview of marvelous (*paradoxon*) disappearing rivers and temporary karst lakes (flooded poljes), including the Alpheios, Eurotas, Erasinus, Stymphalus, Ladon, Pheneus, and Styx, and quotes Eratosthenes' explanation of the karstic terrain at Pheneus (Str. 8.8.4). In introducing a discussion of Cephisos, Orchomenos, and Lake Copais in his account of Boeotia, Strabo gives another regional account of underground streams. Here as elsewhere, Strabo explains the geomorphology of particular “hollow” places within a larger theory

35. Arist. *Probl.* 26 Becker 947a line 20 (of Arcadia); Thphr. *HP* 3.1.2 (Pheneus), 5.4.6 (Pheneus), Paus. 8.14.1 (Pheneus), Plut. *Mor.* 557c (Pheneus).

36. E.g. Str. 5.1.8, 8.8.4, 11.14.8, cf. 6.2.4, and Paus. 8.20.1.

37. Dem. *de Chersoneso* 45 (= 8.45), with scholia ad loc. citing Theopompus *FGrH* 2b 115 F 349 6, and [Dem]. *Phil.* 4 17.1, and cf. Var. *R.* 1.57. On the karstic geology of Abdera in Thrace, one of the places conquered by Philip, see Isaac 1986: 73–75.

38. Lake Sirbonis D. S. 1.30.4 = Hecataeus *FGrH* 3a 264 F 25, 268; D. S. 1.30.9 = Hecataeus *FGrH* 3a 264 F 25, 286; near Pelusium: D. S. 16.46.5, 20.74.1 and Str. 16.2.33 and 17.1.21; near Mt. Casius: Plb. 5.80.2; near Leptis Magna: Str. 17.3.18. Appian says that the land at Thermopylae was a “marsh (ἔλος) that was impassable (ἄβατον) and had the look of *barathra* (βαραθρῶδες)” (App. *Syr.* 76 = 4.17), cf. Plb. 3.78.8 on the appearance of the Arno. Figuratively, Demosthenes says that there is no possible way for his opponent to argue, only cliffs (*apokremna*), ravines (*pharangas*), and *barathra* (Dem. *in Aristog.* 1.77.1). The most detailed narratives of the difficulties of passing through places where there are *barathra* occur in metaphorical descriptions of the struggles of the mind or soul, although these do not describe landscapes in specific locations: Plut. *Mor.* 171 F, Philo *legum allegoriae* 1.73.5, *de agricultura* 101.5, *de plantatione* 62.1.

39. Limestone and marshes at Abdera: Isaac 1986: 73–75 with Str. 7 fr. 43. Celaenae in Phrygia was the location of the source of the Maeander river: Xen. *Anab.* 1.2.7; cf. Paus. 2.5.3 for the story of an underground connection between the Maeander and the Asopos in the Peloponnese. Latmos, in the Beşparmak Mountains, is karstic ([http://en.wikipedia.org/wiki/Beşparmak\\_Mountains](http://en.wikipedia.org/wiki/Beşparmak_Mountains)). See too Lucretius' use of the term *barathrum* in his extended account of earthquakes (*DRN* 535–607, at 606).

of underground channels and passages whose blockages and unblockages cause intermittent flooding (Str. 9.2.15–16, cf. 1.3.16, 10.1.9 and Paus. 1.38.1, 2.24.6).<sup>40</sup>

Pausanias uses the terms *barathron* and *limnē* in connecting recognizable karst features to the labors of Heracles. On the Plain of Pheneus in Arcadia, according to Pausanias, people say that “Under each mountain is a chasm (*barathron*) that receives the water from the plain. These chasms according to the people of Pheneüs are artificial, being made by Heracles when he lived in Pheneüs” (Paus. 8.14). Stories about Heracles also are told in relation to the Stymphalian lake, where he killed or drove away its man-eating birds, and Lerna, where he defeated the many-headed hydra (Paus. 2.37). The Thebans told stories of Heracles directing the Cephisos river into the plain of Orchomenos in Boeotia and making a lake by blocking its passage under a mountain to the sea (Paus. 9.38.7). Heracles was said to have drained a lake at Abdera to make the land more habitable (Str. 7. fr. 43).<sup>41</sup> Such tales celebrate Heracles helping his friends and harming his enemies as he wields his infrastructure superpowers.<sup>42</sup> When Virgil compares Hercules’ penetration of Cacus’ cave to the moment when earth gapes open and “the huge barathrum can be seen from above” (*superque immane barathrum / cernatur*, *Aen.* 8.245–46), he uses an image that links Hercules’ attack on Cacus’ cave with Hercules’ other civilizing barathrum exploits.

In these stories, Heracles’ blocking and drainage of water pathways establish huge spaces for civilized life. Apollonius captures and refashions in miniature many elements of Homeric epic when Heracles drinks from a spring in Libya’s karstic terrain: “he drank a boundlessly great (*aspeton*) drink from the cleft rock like a grazing animal, until he filled his deep (*batheian*) belly (*nedyn*)” (A. R. 4.1444–49; the word for “boundlessly great,” *aspeton*, is used of the flow of Okeanos around the world on the shield of Achilles, *Il.* 18.402–403). Directing the “boundlessly great” stream into himself, Heracles is like Apollonius, who consumes all of Homer’s epic world to compose his own latter-day epic.

Both Strabo and Pausanias discuss the fact that at some points in its course the Alpheios River flows underground and emerges at Syracuse. The spring in Ortygia at Syracuse known as Arethusa was striking in itself, and also remarkable because only a short distance offshore there was a strong freshwater outflow visible in the

40. Greeks and Romans tended to attribute major changes in water flows to the agency of earthquakes, which were not uncommon in the Greek world (Kouskouna and Makropoulos 2004). Earthquakes occur independent of karst terrain, and may or may not have hydrologic impacts. Earthquake phenomena that cause flooding include ground subsidence, liquefaction, tsunamis, obstruction of rivers and other water pathways, and the opening of new water pathways. When earthquakes occur in areas of karst, geothermalism, and/or volcanism, the interrelationships of water-related impacts can be complex.

41. See Frazer 1898 ad loc.; cf. D. S. 4.18.7. In Strabo’s view the blocking and unblocking of the water passageways here are caused by earthquakes (9.2.16).

42. Further discussion and references in Salowey 1994, and Salowey n.d., each with detailed references to the investigation of ancient water management projects by Knauss 1988, 1989a, 1989b, 1990a, 1990b, and Knauss et al. 1986. See also Knauss 1991 and 2004. Heracles’ ability to defeat the Nemean lion by his awareness of the two entrances to the cave where the lion hid (Apollod. 2.5.1) also seems to suggest the hero’s ability to use awareness of karstic terrain to his advantage.

bay (Crouch 1991: 25 and 2004: 103–105 and fig. 3.31). Strabo and Pausanias differ sharply, though, in their accounts of the outflow of the Alpheios River into the Ionian Sea. Pausanias reports as fact that the Alpheios flows beneath land and flows underwater to Syracuse (Paus. 8.54.2). Strabo notes that people say this, but contends that the Alpheios does not fall “into a barathrum” (*eis ti barathron*) in the way that other disappearing rivers do. Strabo maintains that stories about the Inachos flowing into the Achelous, the Nile being connected to the Inopos on Delos, the Asopos in Sicyon flowing from Phrygia, and other such stories are mythical (Str. 6.2.4). Strabo’s discussion of the Alpheios demonstrates how important the idea of a visible barathrum is for constructing a plausible account of a karstic subterranean stream: if there is no barathrum for the Alpheios to plunge down into, then there is no river flowing through the seabed to Syracuse.

All of this goes to show that direct observational awareness of intermittent lakes and subterranean streams allows places designated by *limnē*, *dinē*, *barathron*, and *koilos* and the corresponding Latin terms to be understood as at least potentially connected to a dynamic system of disappearing and reappearing waters. That said, every river disappears in a way that reflects its storytellers’ larger preoccupations, as is clear in stories about Alpheios’ pursuit of Arethusa from Elis to Syracuse.<sup>43</sup> When Syracusans said their spring flowed from Greece and put Arethusa on their coins, they were asserting a material connection between themselves and the Greek homeland of those who had colonized their city. In the first lines of his first Nemean Ode, written in honor of the chariot race victory of Chromios of Aetna, probably in 476 BCE, Pindar addresses Syracuse as “holy place where Alpheios recovers his breath” (*ampneuma semnon Alpheou*). Pindar does not mention Arethusa’s name, but Strabo read these lines of Pindar as referring to the myth of Arethusa (Str. 6.2.4). Pindar’s focus on Alpheios’ breath assimilates the river’s journey from Elis to Syracuse to the exertions of athletes, whom he describes as breathless in competition at Olympia (Pind. *Ol.* 8.7), by Alpheios’ visible banks. Callimachus also had an interest in the Arethusa stories, and takes the materiality of the connection a step further: a fragment of the *Aetia* tells how the waste from sacrifices at Olympia was believed to create a foul smell at Syracuse (Call. *Aet.* fr. 407.45–50; cf. Str. 6.2.4, citing Pindar and Timaeus). A Roman account of Arethusa brings different emphases. When Aeneas tells Dido about his activities in Sicily he says of Ortygia in Syracuse: “the story is that Alpheus the river of Elis traversed hidden roads (*occultas egisse vias*) under the sea to here—Alpheus who is now mixed with Sicilian waters at your mouth, Arethusa” (Verg. *Aen.* 3.694–96). With the phrase “the story is” (*fama est*), Virgil acknowledges the long history of Arethusa tales from Pindar to Callimachus; his own innovation emerges as Alpheus’ feat is no longer athletic, but a matter of distinctly Roman-looking engineering and infrastructure.

43. Str. 6.2.4, Paus. 8.54.2; Clendenon 2009a: 356–63, 2009c: 295–98.

## III. INFERENCE APPROACHES TO THE HYDROGEOLOGIC CYCLE

Up to this point we have been discussing the key words used to identify visible landscape features that typically are karstic in nature. Awareness of karst terrain is also evident in early theories of the water cycle or the hydrogeologic cycle, parts of which are not clearly visible. Seneca's spacious account of Greek philosophical inquiry into the hydrogeologic cycle forms what has traditionally been known as the third book of his *Natural Questions* but is now recognized as the first book of that work.<sup>44</sup> Seneca opens his inquiry into natural philosophy by asserting that the powers of careful thought required to consider why nature works as it does in non-obvious situations will be useful for all kinds of decision-making in more obvious situations: *in occultis exercitata subtilitas non erit in aperta deterior* (Sen. *NQ* 3 Pref. 18). It is precisely the question of disappearing rivers with which he begins. He launches the discussion of "what causes terrestrial waters" (*qua ratione fiant*, *NQ* 3.1.1) by quoting Ovid's lines on the pool into which Narcissus gazes (*Met.* 3.407). Since Seneca is making the point that one can manage oneself better by knowing nature, it makes sense to begin with the myth of the boy who failed to manage his interest in himself. Ovid is not specific about the location of the myth beyond saying that Narcissus is the son of the river Cephisos (*Met.* 3.343). Pausanias (9.31.7) reports that people say Narcissus looked into the spring at Donakon (reed bed), south of the Copaic lake between Thespieae and Thisbe. Strabo's mention of Thespieae falls amid his extended treatment of the dynamic movement of water from the Cephisos river into the area of Lake Copais (Strabo 9.2.25). Narcissus' pool is not simply erotic or metaphysical: it is physically locatable within known karstic terrain. Ovid's description of Narcissus' death almost suggests that the surface pool is a portal to the Stygian waters in the underworld: *tum quoque se, postquam est inferna sede receptus in Stygia spectabat aqua*, "Then too he was staring at himself in the Stygian water, after he had been welcomed into his infernal home" (*Met.* 3.504–505).

Seneca next quotes Virgil's lines on the Timavus (*Aen.* 1.245–46) and a few words from his friend Lucilius' poem on Sicily that describe Arethusa's undersea passage to Syracuse. Rejecting the view that rain provides all the water in rivers, Seneca describes huge underground chambers (3.16, 19) where air condenses to produce water (*NQ* 3.10); such chambers make it possible for rivers to flow underground (*NQ* 3.26.3–4, citing Ovid's description of the Lycus and the Erasinus at *Met.* 15.273–76). Along the way Seneca quotes Thales of Miletus (c. 624–546 BCE) for the view that "Water is the most powerful element" (*valentissimum elementum est*, *NQ* 3.13); he is skeptical, though, of Thales' idea that earthquakes result because the earth is floating on water (*NQ* 3.14.1–2, cf. Arist. *Cael.* B 13, 294a and *Metaph.* 1.983b).<sup>45</sup> In a separate discussion of whether the motions of water beneath the

44. Hine 2010: 1, Williams 2012: 12–14.

45. Thales' views, perhaps influenced by Near Eastern conceptions of the world afloat (Kirk, Raven, and Schofield 1983: 92–94), were perhaps also fostered by the karstic and geologically active terrain of his hometown Miletus (Str. 12.8.15–17, cf. Crouch 2004: 198).

surface of the earth cause earthquakes (Sen. *NQ* 6.7.1), to argue that there are hollow spaces beneath the earth where such motions could happen, Seneca cites the Tigris and the Alpheios as rivers that disappear in one place and emerge elsewhere undiminished (Sen. *NQ* 6.8.2). Seneca's account of earthquakes caused by air passing through earth's hollow places also cites two defining events in the Greek landscape: in Thesaly, an earthquake severed Mt. Ossa from Mt. Olympos and the Peneios river flowed through the resulting space and cleared out the swamps that had been there; in Arcadia, an earthquake permitted the flow of the Ladon river (Sen. *NQ* 6.25).

These argumentative moves from observation to inference, from the visible world to the mind's eye, are a central expression of what Williams describes as Seneca's progression "from sight to insight."<sup>46</sup> Along similar lines, the Latin poem *Aetna* (thought to have been written before 63 CE, since it does not mention the severe Campanian earthquake of that year) explains earthquakes as the product of winds rushing through huge underground chambers, and uses observable karst features to move the argument from the visible world to the mind's eye:

*quis non credit inanes  
esse sinus penitus, tantos emergere fontes  
cum videt ac totiens imo se mergere hiatu?  
...  
argumenta dabunt ignoti vera profundi,  
tu modo subtiles animo duce percipe curas  
occultique fidem manifestis abstrahe rebus.*

*Aetna* 117–19, 143–45

Who does not believe that empty hollows exist within earth when he so often sees such springs burst forth and hide themselves in a deep chasm? . . . These [caves] will provide true evidence of the hidden depths. With your mind as guide, grasp the finely worked thoughts and draw belief in what is hidden from what is visible.<sup>47</sup>

Plato's *Critias* offers a vision of primitive Athens as containing flat-topped plateaus capped by rich soils that absorbed rainfall and drew it into hollows of these elevated areas, whence it was supplied to springs and rivers (*Criti.* 111c-d), and his *Phaedo* offers a vision of a huge central reservoir or hollow within the earth descending all the way to Tartaros (*Phd.* 111e-112d). In his *Meteorologica*, Aristotle considers the origins of wind and rivers.<sup>48</sup> Some, he says, believe that all rain that falls from the sky is ultimately gathered into one place and rivers flow

46. Williams 2012: 232.

47. Cf. Statius *Theb.* 7.809–12. Georg Leonberger turned to these passages from Seneca, as well as to Ovid's account of the flood in *Metamorphoses* 1.260–312, when he wrote his 1537 Latin poem about the Slovenian karstic lake Cernisko jezero; on the poem see, with further references, Shaw 2008: 58–60; and on the lake, Shaw 1992: 96–97 and 269–70. See Clendenon 2009a: 329–46 for an integrative treatment of environmental factors in the Amphiarus myths.

48. See Forbes 1963: 14–15.

out from under the earth “from the huge hollow” (*ek koilias megales*) (Arist. *Mete.* 1.13, 349b 5, cf. Anaxagoras fr. 502 Kirk, Raven, and Schofield 1983). Aristotle rejects the single-reservoir theory on the grounds that such a reservoir would have to be nearly as large as the earth itself, and argues instead that rivers are sourced by water condensing and gradually collecting within mountains (350 b24–31). Subsequently Aristotle characterizes the *Phaedo*’s account of all waters descending into and emerging from Tartaros as “impossible” for the way this model seems to require water to flow uphill (Arist. *Mete.* 2.2, 355b 33–356a34). In refuting the one-reservoir theory, Aristotle goes on to insist that even though some rivers can be observed to plunge beneath the ground, this does not prove that all waters descend to Tartaros: “even if they do disappear underground they come up again” (*Mete.* 2.2, 356a24–25). Aristotle does describe the behavior of rivers in Arcadia’s karstic terrain as proving the existence of some hollows in the earth, even if they are not all united in one single huge reservoir:

The rivers that are swallowed up (*katapinomenoi*) make clear that there are such chasms (*pharaggēs*) and fissures (*diastaseis*) in the earth. This happens in many places on earth; in the Peloponnese such things are most frequent in Arcadia. The cause is that since the area is mountainous there are no outflows to the sea through hollow valleys (*ek ton koilon*); when the places become filled and have no outlet, they find for themselves a passage (*diodon*) to the depths since the water flowing down from above forces its way through. In Greece such phenomena are quite small. But there is the *limnē* below the Caucasus, which those who live there call a sea [i.e. the Caspian Sea]: since many large rivers flow into it and it has no observable outflow, it goes out under the earth below the land of the Koraxi to the place called the Depths of Pontus (*Batheia Ponti*). This part of the sea is immeasurably deep; at any rate no one doing a sounding has ever been able to find its bottom. In this place, about 300 stadia [about 45 kilometers] off shore, fresh water comes up over a large area, not a unified area but one having three sections. And in Liguria a river not smaller than the Rhone is swallowed up and bursts forth in another place; the Rhone is navigable by ships.

Arist. *Mete.* 1.13 350b37–351a19

Because they are on a much larger scale than the rivers that flow in Arcadia, the fresh water off shore at the “Depths of Pontus” and the large disappearing river “in Liguria” are used by Aristotle to argue that visible features of karst terrain can provide an inferential basis for understanding some features of the structure of the earth and the water cycle at a larger, more global scale. In fact there is a huge discharge of fresh water offshore of Abkhazia in the Black Sea.<sup>49</sup> In referring to a river “in Liguria” Aristotle means the Po, whose upper reaches flowed at the edge of that

49. Clendenon 2009c: 294, Klimchouk 2012a: 448–49.

region (cf. Plb. 2.16); by avoiding the names Eridanus or Po, he keeps his distance from the myths of Phaethon's fall into that river. Pliny describes the Po as "flowing from a source that is worth seeing, concealing itself in an underground passage and reemerging in the territory of Forum Vibii" (*visendo fonte profluens condensque se cuniculo et in Forovibiensium agro iterum exoriens*, Plin. *Nat.* 3.117). According to Smith 1854 s.v. *Forum Vibii*, there is "no truth" to this assertion. Yet the fact that the town of Crissolo near the source of the Po does boast a spectacular cave with stalactites and waterfall, the Grotta di Rio Martino, makes it possible that Aristotle or his sources were not inventing the idea of a disappearing Po out of thin air. Pliny adds that the Roman town named Industria (on the Po about 32 kilometers downstream of Turin, where the river first becomes deep) had the name Bodicomagum, Ligurian for "Bottomless" (*Nat.* 3.122) (see Smith 1854 s.v. *Industria*). Stories of cave with a waterfall and a reputation for bottomlessness would make the Po a useful basis for inferences about the world's hollows.

Attempts to draw inferences about places in the Mediterranean where waters showed a greater than usual tidal variation aim to produce a physically plausible connection to Okeanos—and its tides—via hollow passages within the earth. Thus Strabo's account of the Po and the northern reaches of the Adriatic notes that "these are almost the only parts of the sea that is ours that behave like the Okeanos (ὁμοιοπαθεῖ τῷ ὠκεανῷ) and produce ebb tides and flood tides to a similar degree" (Str. 5.1.5).<sup>50</sup> While modern readers might think of the Po and the Timavus as two separate places, perhaps they could be thought of as conceptually adjacent parts of the northern Adriatic or as related manifestations of its unusual qualities: thus Virgil's reference to the marvelous streams of the Timavus (*Aen.* 1.242–47) is part of Venus' narrative of Antenor's settlement of Patavium (Padua) on the Po. Pliny, in his account of marvelous waters, says that an island (modern Monfalcone) in front of Timavus has warm springs "which rise and fall with the tides" (*qui pariter cum aestu maris crescunt minuunturque*, *Nat.* 2.229). Strabo cites Polybius for the report that "the local inhabitants at Timavus call the place the source and mother of the sea" (πηγὴν καὶ μητέρα τῆς θαλάττης) (5.1.8). Pliny's report that one of the rivers near the Po is called Tartarus (mod. Tartaro), likewise suggests a connection with hidden depths (*Nat.* 3.121), as does the rather florid narrative in a work attributed to Aristotle (*On Marvelous Things Heard*, 81, 836a32-b4): the *limnē* near the river that Phaethon plunged into after his ill-fated chariot ride (by which his sisters wept their amber tears) is hot, has a terrible smell, and (like Lake Avernus on the Bay of Naples) kills birds with its vapors (cf. *A. R.* 4.595–603).<sup>51</sup> Elsewhere, Strabo understands the Homeric story of Charybdis as a rendering of the visible surges in the narrow strait of Messina (Str. 1.2.36, cf. 1.1.7, 1.2.16) and quotes Eratosthenes' view that the surges at Messina "are like (ὁμοιοπαθεῖν) the ebb

50. On the notion of *homoiopatheia*, similarity of experience, in accounting for the behavior of tides see also Str. 1.1.9.

51. See further the entries Eridanus, Padus, and Tartarus in Smith 1854 and, on Greek and Roman settlements and trade in the region, Braccisi 2004.

and flow in the Okeanos” (1.3.11). In this wider context, Virgil’s use of the word *barathrum* to describe Charybdis (*Aen.* 3.421) suggests the possibility of a connection to the Okeanos-connected depths of the underworld. Such ideas probably are part of what motivates the assertion in the Suda that Charybdis is “subject to the currents of the ocean” (ὑποδέχεται τὰ τοῦ ὠκεανοῦ ῥεύματα), and the Suda’s inclusion of the idea that Charybdis is located (adjacent to the Atlantic Ocean) at Gadeira (Suda X 144 Adler).

#### IV. KARST TERRAIN IN NARRATIVES OF THE UNDERWORLD

Aristotle, Strabo, Seneca, and others use an observational awareness of the features of karst terrain to develop their inferences about the larger, less visible, structures of the world. Although these accounts emphasize material causes over divine causes, they share with accounts of the afterlife the practice of using observational awareness of karst features to extend a material and physical plausibility to accounts of what cannot be seen. In Greek and Roman discourse about the underworld observation-based ideas about karstic terrain are evident in various ways in texts, rituals, and in topographical discourse about real places. Narratives of the underworld in ancient texts emphasize its subterranean passages and streams and can include: a large dwelling place of Hades (e.g. “resounding abode” δόμοι ἠχήμεντες, Hes. *Th.* 767); the deepest section of the underworld, Tartaros, to which Zeus could confine his defeated enemies (Hom. *Il.* 8.13–16, Hes. *Th.* 719–21); and a pleasant place, said to be at the world’s end near the western streams of Ocean, where heroes have their afterlife, which could be called Elysium (Hom. *Od.* 4.563, Ἠλύσιον πεδῖον), or the fields of asphodel (*Od.* 24.14), or the islands of the blessed (Hes. *WD* 170–73, Pind. *Ol.* 2.70).<sup>52</sup> Evidence for Eleusinian, Dionysiac, Orphic, and Pythagorean ritual practices indicate that they included some instruction in how to manage the transition to the underworld via hollow passages in the earth.<sup>53</sup>

Topographical accounts of the specific places associated with those stories and rituals can often be connected to specific karstic terrain in the Greek and Roman world. Our discussion is organized around three main areas: the idea of connections

52. On Homeric conceptions of the underworld see Heubeck and Hoekstra 1989 on *Od.* 11.1–14, and Russo, Fernandez-Galiano, and Heubeck 1992 on *Od.* 24.1–14. Some Greek ideas about the organization of the cosmos are thought to derive from Near East conceptions and storytelling: see West 1966: 356–79 on Hes. *Th.* 720–819 and West 1997: 137–67, 297–99; Kölligan 2013 discusses evidence for the Proto-Indo-European etymology of the word Tartaros. On the development of the roles of Hermes as guide and Charon as ferryman see Sourvinou-Inwood 1995: 303–61.

53. See Plat. *Phd.* 69d, 108a, *R.* 365a, 366a, Kingsley 1995: 250–77, Edmonds 2004. On Aristophanes’ engagement with patterns of death and rebirth in Dionysian and Eleusinian rituals in the *Frogs*, see Lada-Richards 1999: 45–122. Small gold tablets discovered in Hipponion, Entella, Petelia, and Pharsalus carry instructions to guide the soul as it descends to the underworld: they mention a white cypress tree, and two bodies of water—one for the initiate to avoid and the lake of Mnemosyne from which the initiate should drink; see Bernabé and Jiménez San Cristóbal 2008: 9–58, with Edmonds 2011 and 2013.

between the river of Ocean and the streams of the underworld; accounts of Tartaros as the deepest part of the underworld; and stories of descent to and return from the underworld set in various locations characterized by karstic terrain.<sup>54</sup> Some modern scholars have argued that the realization that the earth is a sphere rather than a disk simply made it impossible to keep believing in a realm of Hades and Tartaros beneath the surface of earth.<sup>55</sup> But representations of karstic terrain in narratives of the underworld are important because they produce a material plausibility for the idea of Hades and Tartaros within a spherical world.

#### THE RIVER OF OKEANOS

In Homer's *Iliad* Hephaestus makes the shield that Thetis seeks for her son Achilles (*Il.* 18.483–84). He is willing to do it because Thetis and Eurynome cared for him by the shores of Ocean after Hera flung him down from the heavens (*Hom. Il.* 18.397–99). The shield contains various scenes of life in the Greek world, and Hephaestus puts “the great strength of river Okeanos” around its edge (*Il.* 18.607–608). The shield of Achilles is commonly understood as a conceptual map of the Greek world, reflecting the idea of an ocean-surrounded inhabited world (Harley and Woodward 1987:131–32), and indeed in Greek and in Latin, the name Okeanos/Oceanus is not associated with the relatively still waters of the Mediterranean but rather with the furthest edges of the world, where the sun rises and sets, and with the tidal waters that wash the outer shores of Europe, Asia, and Africa.<sup>56</sup> The Earth-encircling, deep-flowing Okeanos was said to be the single source of all earthly waters. In the *Iliad* when Achilles fights Pelegon, who boasts of being the son of a river, Achilles in turn boasts that he is a descendant of Zeus, and that no river can fight Zeus:

ἀλλ' οὐκ ἔστι Διὶ Κρονίωνι μάχεσθαι,  
 τῷ οὐδὲ κρείων Ἀχελώϊος ἰσοφαρίζει,  
 οὐδὲ βαθυρρεῖταιο μέγα σθένος Ὠκεανοῖο  
 ἐξ οὗ περ πάντες ποταμοὶ καὶ πᾶσα θάλασσα  
 καὶ πᾶσαι κρήναι καὶ φρεῖατα μακρὰ νάουσιν.  
*Il.* 21.194–97

It is not possible to fight Kronion Zeus,  
 not even mighty Acheloios is his match  
 nor the great strength of deep flowing Oceanos,  
 from which all rivers and every sea  
 and all springs and large wells flow.

54. Representations of the underworld in Roman poetry draw widely on these Greek ideas and practices: see especially Norden 1970 on *Aen.* 6.264ff., 295, 540–61 and Bremmer 2009.

55. Kirk, Raven, and Schofield 1983: 92–93 on Thales; Burkert 1972: 357–58 with further references.

56. LSJ s.v. Ὠκεανός, *TLL* s.v. *oceanus*.

This idea of Ocean being the source of all the earth's waters also appears in Hesiod's *Theogony*: "Tethys bore to Ocean swirling rivers," and a long catalog of the world's rivers follows. So many rivers are the children of Ocean that Hesiod cannot name all three thousand daughters of Ocean and "the same number of other rivers, flowing with a loud noise, sons of Ocean, to whom queen Tethys gave birth; it is hard for a mortal man to tell all their names, but people know the ones that they live close to" (Hes. *Th.* 337–70).

There are several ways that Okeanos can be understood to be connected to the underworld. In the *Odyssey* Circe directs Odysseus to sail where the north wind blows, cross the stream of Okeanos, beach his ship at the grove of Persephone, and go to the house (*domon*) of Hades. By digging a pit where Pyriphlegethon and Cocytos flow into Acheron and pouring the blood of sacrificed sheep into the pit (*bothron*, 10.517, 11.36), Odysseus can see the souls of the dead (*Od.* 10.504–30). When he sees his mother, she asks how he did it: "It is hard for living people to see these things. There are great rivers in between and terrible streams (*rheethra*); Okeanos is first, which a foot traveler has no way to cross" (*Od.* 11.156–59).<sup>57</sup> A similar idea emerges when Hermes is said to guide the souls of the dead suitors to the underworld, past "the streams of Okeanos and the white rock" and on to "the gates of the sun and the land populated by dreams" (*Od.* 24.11–12, cf. Nagy 1973). The idea of Okeanos having some connection to the realm of the dead also emerges in a recent discussion of the Derveni papyrus, a commentary on a lost Orphic poem that told of Zeus' rise to power. The author of the papyrus says that "Okeanos is air (*ἀήρ*) and the air is Zeus" (col. 23 line 3, Betegh 2004: 48–49). Betegh (2004: 198) compares the fourth-century CE lexicon of Hesychius defining "the way of Ocean" (*Ωκεανοῖο πόρον*) as "the air (*τὸν ἀέρα*), toward which the souls of the dead depart." In Hesiod's *Theogony*, each river on Earth draws water from one of the nine looped channels that originate with Okeanos, while "a stream of Ocean flows far beneath the earth from the holy river (*potamoio*) through the dark night; a tenth part of it is given as a share [to Styx]," (Hes. *Th.* 787–89). After a lengthy description of the course of the Styx and the oaths of the gods, Hesiod says "here are the sources (*pegai*) and edges of the dark earth and gloomy Tartaros and the barren sea and the starry heaven" (*Th.* 807–809).

Another way of thinking of Ocean being connected to the waters of the underworld occurs in narratives of the movements of the sun (cf. Kingsley 1995: 54). Each evening, Helios the Sun departs from the western shores of Ocean and reaches his home on the eastern shores in time for another day. Helios is imagined either to sail on the stream of Ocean, or to plunge beneath the surface of the inhabited world, and sometimes texts seem to be open to more than one of these interpretations. Mimnermus (fl. c. 600 BCE) describes Helios' voyage in a golden cup on the water surface (Mimnermus fr. 12, Gerber 1999). Heracles borrows the cup when he travels west by sea in search of the cattle of Geryon (Pisander fr. 5 Bernabé; Ath. 469d). Some

57. See Heubeck and Hoekstra 1989 on *Od.* 11.156–59 with further references for discussion of the possibility that these lines are an interpolation.

texts strongly suggest that the cup of Helios floats on the surface of a subterranean stream, not unlike ancient accounts of the Egyptian Sun-god Ra's nightly boat trip through the underworld. Could some versions of the Sun-god Helios' nightly traverse of Ocean's waters be an imaginative extrapolation from the kinds of subterranean passages that can take place through flooded karstic conduits? Stesichorus' account of Helios comes closest to suggesting a subterranean voyage: "Then Hyperion's strong child (Helios) went down (*eskataba*) into the cup of solid gold, so that he might cross over Ocean and reach the depths (*benthea*) of holy, dark night and his mother and wedded wife and dear children. . ." (Stesich. fr. S 17 = Ath. 11.469e, trans. Campbell 1991).<sup>58</sup> A narrative of the sun's travel in a vessel through the streams of ocean uses the passages and streams of karst terrain to map the organization of the cosmos onto the maritime trade and colonization networks of the archaic Greek world.<sup>59</sup>

Because *limnē* is so often used in contexts of karstic marshes containing barathra, the brief Homeric description of Helios rising and leaving behind a "very beautiful *limnē*" in the first line of Book 3 of the *Odyssey* has the potential to be understood as an expression of the idea of the sun traveling on waters beneath earth's surface and re-emerging in the way that subterranean streams emerge.

At the beginning of Book 20 of the *Odyssey*, Penelope, just before going to bed, has had a long conversation with Odysseus in his beggar guise. While she does not state that she recognizes him yet, their exchange is full of signals that she is at some level aware that he may be her husband.<sup>60</sup> Wakeful in the night, Penelope prays to Artemis that either Artemis shoot her with an arrow, or that a storm wind "bearing me down the gloomy paths (*eeroenta keleuthma*) set me by the outflow of back-flowing Ocean" so that she might see Odysseus there (*Od.* 20.64–65; 80–81). The word *eeroenta* "gloomy," is regularly used of the murky depths of Tartaros (*Il.* 8.13, Hes. *Th.* 119, 682, 721, 807, and the *Homeric Hymn to Hermes* 256) and of the realm of Hades (*Od.* 11.155, *Homeric Hymn to Demeter* 80, 446). Penelope's wish to plunge down into the depths is one of the ways that the *Odyssey* incorporates the symbolism of the sun's departure and return into the story of Odysseus' departure and return.<sup>61</sup> Penelope's prayer maps the gloomy—and thus leading-to-Tartaros—paths that lead to the outflow of Ocean. It is worth observing too that the maid who had tended to Penelope's requests and given the disguised Odysseus a blanket bears the name of Ocean's daughter Eurynome (*Od.* 19.96, 20.4). Perhaps Penelope had been thinking

58. Stesichorus was said to have mentioned Pallantion in Arcadia in his song of Geryon (Paus. 8.3.2, cf. *Sud.* Σ 1095 Adler 1928–1938, <http://www.stoa.org/sol/>, and Bowra 1934). On the *katavothra* near Pallantion see Frazer 1898: vol. 4, 420 on Paus. 8.44.5. Perhaps stories of Evander's journey to what would become Rome also drew on ideas about Pallantion's and Pheneus' subterranean passages: for Pallantion as the home of Evander see Livy 1.5.1, Dion. Hal. 1.31; Virgil says Evander was from Pheneus at *Aen.* 8.165; Pausanias mentions a statue of Evander at Pallantion at 8.44.5.

59. On the Greek motif of the sun's travels in a cup (*depas*) and its connections to Anatolian conceptions of the motion of the sun, see Watkins 2007.

60. Levaniouk 2011 provides a convincing argument for Penelope's awareness of Odysseus' identity. See also the airing of views on both sides in the essays collected in Myrsiadestr 2011.

61. Levaniouk 2011: 287–318, drawing on Frame 1978 and Nagy 1973.

about the distant shores of Ocean—and their connections to murky Tartaros—for a long time before Odysseus returned.

NARRATIVES OF TARTAROS AS KARSTIC “BERETHRON”

In the *Iliad* Zeus threatens the other gods that if any of them resist his authority by trying to help either the Greeks or the Trojans in the Trojan war, that god will be struck by lightning,

ἢ μιν ἐλὼν ῥίγω ἐς Τάρταρον ἠερόεντα,  
 τῆλε μάλ', ἧχι βάθιστον ὑπὸ χθόνος ἐστὶ βέρεθρον,  
 ἔνθα σιδήρειαί τε πύλαι καὶ χάλκεος οὐδός,  
 τόσσον ἔνερθ' Αἴδεω ὅσον οὐρανός ἐστ' ἀπὸ γαίης.  
*Il.* 8.13–16

or I will snatch him and cast him down to gloomy Tartaros,  
 far away, where lies the deepest barathron below the earth,  
 which has iron gates and a bronze threshold,  
 as far beneath the realm of Hades as heaven is from earth.

Zeus' ability to confine enemies to Tartaros is the foundation of his power over the universe. In describing Zeus' rise to power Hesiod describes the chasm (Greek *chasma*, “mouth”) of Tartaros with its bronze gates: “if once a man were inside the gates, he would not get to the bottom until a full year had reached its end, but awful windstorm after windstorm would toss him now this way now that way” (*Th.* 740–43). In the *Prometheus Bound* Prometheus says that he helped Zeus defeat the Titans: “by my counsels, the deep dark hollow (*keuthmon*) of Tartaros conceals ancient born Cronus” (221). Prometheus later raves, “let him [Zeus] snatch my body up and cast it down to dark Tartaros by means of the unyielding whirlpools (*dinai*) of Necessity; no matter what he does he shall not kill me” (1050–53).

The *Homeric Hymn to Hermes* replays Zeus' threat in the *Iliad* with a geographical specificity. Arcadia's Mt. Kyllene is most famous as the site of the cave in which Hermes was born to Atlas' daughter Maia and is the source of his epithet Kyllenian. Kyllene's southeast facing slopes are adjacent to the Stymphalian plain with its karstic *limnē*; to the southwest lies the plain of Pheneus. Apollo comes to the cave in order to reclaim the cattle which Hermes stole from him: if Hermes does not produce them, “I will snatch you and cast you down to gloomy Tartaros” (*HMerc.* 256), says Apollo, quoting the exact words of Zeus' threat at *Iliad* 8.13. Presumably in a cave on Kyllene there is a barathrum leading right down to Tartaros.

Accounts of Tartaros appear in several discussions of the afterlife in the works of Plato (e.g. *Gorgias* 523b). The most spatially detailed of these descriptions is in the *Phaedo*, which recounts the final hours in the life of Socrates leading up to the moment that he drinks the fatal hemlock to which he has been sentenced.<sup>62</sup> To

62. On the physicality and materiality of Plato's underworld see Pender 2012.

comfort his grieving friends, Socrates tells a “story” (*mython* 110b) about what happens to each person’s soul after death. A specifically karstic metaphor captures the peculiar sense of attempting to know the unknowable that is part of talking about life after death. Socrates explains that as humans we have only a partial understanding of the universe: just as we could imagine someone who lives under the sea believing that was the whole world, and never knowing of our world on land, so we, too, have only limited perceptions. All those who live between Phasis in the East and the Pillars of Hercules in the West are “like frogs or ants around a marshy spot (*telma*)” (109b). We “live in a hollow [*koiloi*] of the earth and think we dwell on an upper surface” (109d). The hollow limits human knowledge and experience: when you are inside at the bottom, its edges rise to the sky; no further world is visible. In fact, Socrates says, the entire earth is made up of “hollows” (*koila*, 110c), but we see only the one that we inhabit. Each hollow is different, and when seen from above the earth resembles a ball made of pieces of leather (110b-c). It is clear that these hollows are described in terms that reflect an observational awareness of karst terrain: all of the earth’s hollows

are connected with one another by many subterranean channels, some larger and some smaller, which are bored in all of them, and there are passages through which much water flows from one to another as into mixing bowls (*krateras*), and there are everlasting rivers of huge size under the earth, flowing with hot and cold water; and there is much fire, and great rivers of fire, and many streams of mud, some thinner and some thicker, like the rivers of mud that flow before the lava in Sicily, and the lava itself. These fill the various regions as they happen to flow to one another at any time. Now a kind of oscillation (*aioran*) within the earth moves all these up and down. And the nature of the oscillation is as follows. One of the chasms (*chasmaton*) of the earth is greater than the rest, and is bored right through the whole earth; this is the one which Homer means . . . .

Pl. *Phd.* 111d–112a

Socrates then quotes Homer *Iliad* 8.14, “the deepest gulf (*berethron*) that yawns beneath the ground” (112a). There is a specifically karstic spatial and topographical logic in this transition from the idea of living in a hollow to descending into the barathrum of Tartaros. This same sensation of karstic space is vividly captured in Edward Dodwell’s image of the karstic formation in “The Katabathron of Lake Kopais” (Dodwell 1821): the viewer is poised within the barathrum and looks out toward the sky while the karstic hollow fills the whole field of vision. Whatever lies beyond the edge of the karstic hollow is impossible to see and know from below.

In the *Phaedo*’s subterranean geography all of the interconnected movement of water from the subterranean zone to the surface throughout the earth is caused by a “kind of oscillation” (ὄσπερ αἰώραν) deep within Tartaros (111e). The major streams that flow back into Tartaros are identified by name: Okeanos (“the greatest and outermost of which is called Oceanus, which flows round in a circle,” 112e), Acheron,

Pyriphlegethon, Styx, and Cocytos (112e-113c); “most souls of the dead go” to the Acherusian lake formed by the outflow of the Acheron. The *Phaedo*’s picture of “everlasting rivers of huge size under the earth” (ἀενάων ποταμῶν ἀμήχανα μεγέθη ὑπὸ τὴν γῆν, 111d) and “terrible and irresistible blasts” (δεινούς τινας ἀνέμους καὶ ἀμηχάνους, 112b) corresponds to the ways that water and air move through large-scale karst features. Such features could be seen at Sicily in the Latomiae (large limestone quarries at Syracuse) and the Pantalica gorge of the Anapus (Anapo), which eventually flows into the marshy plain just southwest of Syracuse. As Kingsley argues in detail, the *Phaedo*’s account of the hollows of the earth probably reflects both time Plato spent in Syracuse and the influence of Pythagorean and Empedoclean ideas about the flow of fire and water in the hollows of a spherical earth.<sup>63</sup> Awareness of the ways that water could move under the surface of the earth and then reemerge as springs is also clear in the *Phaedo*’s account of hydrogeologic circulation in and out of Tartaros. In this model the energy built up in the “oscillation” forces subterranean streams to surge upward to connect with the land surface, thereby making rivers, springs, marshes, and seas.<sup>64</sup> Pender (2012: 221–22) persuasively argues that Socrates creates an analogy between the waters surging “up and down” (ἄνω καὶ κάτω) through Tartaros (*Phaed.* 111e, 112b) and the surging, tide-like flow of waters through the narrow channel of the Euripus, which Socrates mentions when describing people who pursue contradictory arguments in the belief that there is nothing stable and “as in the Euripus all things are simply turned up and down (ἄνω κάτω)” (*Phaed.* 90c). Pender emphasizes the idea of uncertainty and flux here; envisioning Tartaros as analogous to the Euripus is also one more way in which the idea of Tartaros is anchored to the observation of karstic terrain.<sup>65</sup>

63. Kingsley 1995: 71–132.

64. In fact, groundwater can indeed flow upwards against gravity in certain non-karstic hydrogeological contexts wherein the water is confined and compressed between relatively impermeable layers and hence is under hydrostatic pressure greater than atmospheric pressure. This pressurized groundwater can escape upwards through relatively permeable zones, including cracks and faults, that penetrate the upper confining layer. The ascending groundwater in some places can reach the land surface as an artesian spring. Other forces that can raise water against gravity are capillary action, suction by wind, and wave forces. In volcanic regions with a subterranean heat source, geysers can spout hot water. In some karst systems during heavy rains, floodwaters may gush through inclined pathways. Although the *Phaedo*’s model of air-blown water from the depths of the earth is flawed in its scope, because vast quantities of water in deep caverns are not lifted up to the land surface by strong air currents from the earth’s interior, its fundamental concept of raising water against gravity is not impossible as Aristotle believed it was.

65. The Euripus was noted for the ways that its narrow channel (which in fact amplifies the very small tidal currents in the Mediterranean, on which see Egnitis 1929) produces the appearance of large tidal surges several times per day; discussion of this feature of the Euripus at Chalcis was part of thinking about how water flowed through hollows in the earth, as when Aristotle mentions that in certain regions of Euboea that were “porous and cavernous” (*somphē kai hypantros*), the sea was believed to “flow in channels” (*diaulonizein*) beneath the Earth’s surface (*Mete.* 2.8, 366a25). Strabo, in a discussion that cites Eratosthenes, says that the current in the strait changed seven times a day (1.3.12); cf. Paus. 1.38.1, 2.24.6, Pliny *Nat.* 2.100, Livy 45.27.8, calling the current at the Euripus a spectacle (*spectaculum*), and Lucan *BC* 5.234. The story that Aristotle investigated the tides at the

The *Phaedo* emphasizes each individual's experience of the mysterious realm of the afterlife. The vision of an "oscillation" in Tartaros as a singular moving force that produces all the observable circulation of water on the earth relates individual observable phenomena to one hidden universal and uniform cause in a way that seems analogous to the Platonic theory of forms, the singular entities perceivable only in the mind's eye that lie behind the multitudinous phenomena of the observable world.<sup>66</sup>

#### NARRATIVES OF DESCENT TO AND RETURN FROM THE REALM OF HADES

Trips to and from the underworld happen in karstic terrain. In narratives of descent and return, arising in local communities and reported by Strabo, Pausanias, and others, actual karstic features are a point of access to and/or departure from the realms beneath the earth, either for a mythical figure such as Heracles, Dionysus, or Persephone, or for a real (or fictional) person consulting an oracle of the dead or otherwise seeking enlightenment.

The River Styx, in Arcadia, flowed in a karstic landscape and its course led underground. Pausanias even thought Homer had based his account of the Styx on the river in Arcadia (Paus. 8.18.2).<sup>67</sup> The real waterfall's reputation for unusually corrosive and deadly water, its exceptional height, and the fact that its water passes through a rock before connecting to the Crathis river are all features that make a physical connection to the mythical world persuasive. Pausanias also thinks Homer saw the places in Thesprotia in northwestern Greece known as the Acherusian Lake (*limnē*), and the Acheron and Cocytos rivers: "I believe it was because Homer had seen these places that he made bold to describe in his poems the regions of Hades, and gave to the rivers there the names of those in Thesprotia" (Paus. 1.17.5). There was an oracle at Thesprotia through which the dead could be consulted (Hdt. 5.92g).<sup>68</sup> Setting up an oracle of the dead at the karstic Acherusian lake expresses a belief that the waters of the Thesprotian River Acheron and the Acherusian lake have a physical connection to the realm of Hades. A similar set of ideas about access to the underworld operates at Cumae and Lake Avernus on the bay of Naples.

Believing that a body of water, a *limnē*, was bottomless made it possible to believe that it was connected to and supplied by waters circulating through Tartaros or the underworld more generally. The water depth in some karstic sinkholes and caves can

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Euripus and died in them (Procop. *Pers.* 8.6.20) partakes of and feeds ideas about philosophers' searches for insight in earth's hollows.

66. On the idea of the forms, explored in the Allegory of the Cave, see Pl. *R.* 514a-520a; cf. Arist. *Metaph.* 1.987b-988a.

67. On the toxicity of the Styx and its karstic features, see Mayor and Hayes 2011. For Porphyry's interest in the physical reality of the River Styx, see Castelletti 2006: 59-62 and fr. 5 (Stobaeus 1.49.51) and Johnson 2013: 31-37.

68. On the topography see Tozer 1873: 121.

exceed 200 meters, and the total depth can exceed 400 meters.<sup>69</sup> Pausanias describes the Alcyonian lake, near Lerna, where, according to the Argives, Dionysus went to the underworld to retrieve his mother Semele: it was reported to be bottomless—not even Nero could have its depth measured (Paus. 2.37). Heracles rescued Alcestis, wife of Admetus the king of Pherai, from the realm of Hades; Pherai is in Thessaly on the shores of the former *limnē* Boibe (cf. Strabo 9.5.2). That *limnē* is envisioned as the portal between life and death when Euripides' Alcestis says: "I see [Charon's] boat on the *limnē*" (Eur. *Alc.* 252–53). When Heracles brings Alcestis back from the underworld, Euripides does not say that they returned through a barathrum, but he does not have to: Heracles' travels back from the underworld always happen through a barathrum.

In Euripides' *Protesilaus* (surviving only in fragments) Laodamia so grieves for Protesilaus, dead at Troy, that he returns to her for one day. Deprived of him a second time, she commits suicide. This will have happened in Protesilaus' home of Phylake, also in the karstic terrain of southern Thessaly. An enigmatic fragment of the *Protesilaus* which mentions "a hollow place (*keuthmona*) and spring water" may come from Laodamia's thoughts about suicide (Eur. *Protesilaus* fr. 656, Collard and Cropp 2008: 117). Catullus compares the depth of Laodamia's love for her husband Protesilaus to the depth of the barathrum dug by Heracles at Pheneus (68.105–18).<sup>70</sup> Catullus' barathrum simile has been described as "bizarre pedantry" (Feeney 1992: 40), and this is true enough, but narratives of barathra as portals to the underworld may also allow the simile to be understood as reflecting stories that Protesilaus doubtless was thought to have travelled through a barathrum to see Laodamia.

In many places, people associated their local caves or pits with the story that Heracles brought the monstrous dog Cerberus up from the underworld as one of his labors.<sup>71</sup> At the city on the coast of Argos known as Hermion (or Hermione), Pausanias says that people pointed out their own Acherusian *limnē* and a chasm [*chasma*] through which Heracles retrieved Cerberus from the Underworld (Paus. 2.35.10). According to Strabo, "it is commonly reported that the descent (*katabasin*) to Hades in the country of the Hermionians is a shortcut (*syntomon*); and this is why they do not put passage-money in the mouths of their dead" (Str. 8.6.12; cf. Plut. *Mor.* 566a).

The cave associated with Heracles at Taenarum poses a special case: Strabo and Pausanias report that people say that Heracles brought Cerberus up from the

69. The world's deepest flooded karst sinkhole, the Pozzo del Merro, is located in the Cornicolani Mountains northeast of Rome and has an explored water depth of 392 meters (Caramanna 2002). See also on other locations Garašić 2001 and Klimchouk 2012a, 2012b.

70. Protesilaus and Laodamia: Ovid *Her.* 13, Hyg. *Fab.* 103 and 104, Apollod. *Epit.* 3.30, Lucian *DMort.* 23, Philostr. *Her.* 9.1–23.30 (Maclean and Aitken 2002). Cf. Paus. 2.4.7, Lyne 1998 and Tuplin 1981: 119–36.

71. There was a cave oracle of Heracles at Bura in Achaëa, near the Crathis, the river into which the Styx flows: Paus. 7.25.10–11; cf. Paus. 8.18.3–4, Ustinova 2010: 82. Laphystium in Boeotia near Lake Copais: Paus. 9.34.5; Heraclea Pontica: Xen. *Anab.* 6.2, Diod. Sic. 14.31, Pliny *Nat.* 27.2; Q. S. 6.490; the karst cave Cehennemagzi is located there.

underworld at Taenarum (Str. 8.5.1, Paus. 3.25.5). There was an oracular cave on this site (Ustinova 2010: 69–71). Pausanias finds the tale of Heracles at Taenarum unlikely on two counts: one narrowly geological and one we might call broadly theological. Geologically, Pausanias says that there is no obvious “passage” (*hodon*) in the Taenarum cave that goes deeper into the earth. Theologically, Pausanias himself is hesitant to believe that there is a subterranean realm of souls.<sup>72</sup> A recognition of karstic features in the mythical descent narratives shows how closely the realm of the dead is mapped onto the actual landscape. The geological side of Pausanias’ skepticism about underworld access at Taenarum reveals the significance of caves whose edges could not be perceived, for such a cave could be believed to connect with the whole subterranean network of Hades and Tartaros.

Locating myths and rituals of Demeter and Persephone in the marshy hollows of karstic terrain likewise lends a physical plausibility to their narratives of descent to and return from the underworld.<sup>73</sup> At Eleusis streams known as the *rhetoi* were said to have flowed from Euboea (Paus. 1.38.1); nearby was Erineüs, where it was said that Hades descended to the underworld (Paus. 1.38.5). The karstic Lago di Pergusa, near Enna in Sicily, was said to be the site of Persephone’s rape (Ov. *Met.* 5.386, Diod. 5.3.2–4), and elaborate rites were held at the pool Cyane (“dark blue,” Diod. 5.4.2) near Syracuse. The worship of Demeter is associated with karstic terrain at Lerna, Olympia, Mt. Kyllene, Thelpusa, Bathus, Basilis, Phigalia, Messenia, and Lake Copais.<sup>74</sup> Aristophanes’ *Frogs* depicts an area at Athens near the Ilissos as sacred to Dionysus *en Limnais* “in the marshes”, and the site of the Lesser Mysteries, that is, a version of the Eleusinian Mysteries celebrated at Athens. The play describes this location as an entrance to the underworld (*Frogs* 135–38, cf. Hooker 1960 and Slater 1986); the karstic terrain made that a physically plausible notion.

In his *Metamorphoses*, as Ovid tells the tale of the rape of Persephone (Proserpina) in Sicily, Arethusa reports to Ceres that “while I slipped along in the Stygian whirling stream (*gurgite*) under the earth,” she saw Proserpina in the Underworld (Ov. *Met.* 5.504–505). Having Arethusa provide Demeter with an eyewitness undersea report on Proserpina sounds like just the sort of thing Ovid would invent. But perhaps there were already stories that connected Arethusa and Demeter. Euboea

72. On Pausanias’ beliefs, see Veyne 1988: 95–102.

73. Compare this terrifying recent narrative: *The New Yorker’s* David Owen says of a conversation with Florida’s State Geologist Jonathan Arthur: “In the nineteen-nineties, he told me, a woman was working in her yard when a young child, who was playing near her, disappeared through the sod. ‘She heard a cry for help and saw fingertips at the grass level,’ he said. The woman grabbed a hand and pulled, and the child was unharmed, at least physically” (Owen 2013: 36). On the various versions of the Demeter myth see Richardson 1974: 74–87.

74. Lerna: Paus. 2.36.7, cf. 2.37.5–6; Olympia: Paus. 6.21.1; Mt. Kyllene: Paus. 8.15.1–4; Thelpusa: Paus. 8. 25.2–4; Bathus (“Depth”): Paus. 8.31.1, cf. 8.29.1; Basilis: Paus. 8.29.5; At Megalopolis: Paus. 8.31.7, cf. 8.44.4, 8.36.6; Phigaleia: Paus. 8.42; Messenia: Paus. 4.1, 4.26.8, with Graf 2003, 242–44; Lake Copais: Paus. 9.24.1, cf. Str. 9.2.15–18. On Sicily cf. Kingsley 1995: 98.

has its own “Arethusa” spring, near Chalcis (Eur. *IA* 164–70), and underground streams were believed to flow from Chalcis to re-emerge at Eleusis where two salt springs were the location of ritual cleansing in preparation for the celebration of the Eleusinian mysteries commemorating Demeter’s loss and recovery of Persephone (Paus. 1.38.1, cf. 2.24.7). Perhaps there too stories were told that Arethusa comforted Demeter with news of Persephone in the Underworld.

Communities use karstic terrain’s hollows and streams to make claims about connections to heroes who descended to the underworld in spots that provide access to prophecy or enlightenment. At Oropus, the prophetic hero Amphiaraus was said to have descended in his chariot to the underworld when the earth gaped open (Pi. *N.* 9.24–25, Paus. 1.34.2, Str. 9.1.22; on other locations for his chariot see Str. 9.2.11). Athenians promoted the story that Oedipus went down to the underworld at Colonus, just outside Athens (Soph. *OC* 56–61, 1589–1662). Pelops was worshipped with offerings poured into a pit at Olympia (Paus. 5.13.1–2). The karstic terrain at each of these places brought a material plausibility to these narratives of special access to a hero and the benefits he could provide to a community. The oracle of Trophonius, located in Lebedeia near Orchomenos in Boeotia, consisted of a descent underground through a chasm (*chasmatos* Str. 9.2.38, cf. Bonnechere 2003). The one who wished to consult the oracle undergoes some preliminary rituals and then is escorted by boys called Hermae (who perform a service comparable to the god Hermes’ escorting of souls to Hades) to drink from springs called Lethe “Forgetfulness” and Memory. The seeker of the oracle slips down through a narrow hole feet first “just as a man might be caught and dragged down by a swirl (*dinē*) of a mighty and rapid river” (Paus. 9.39). In Philostratus’ *Life of Apollonius of Tyana*, as Apollonius prepares to consult the oracle of Trophonius he tells his followers to meet him at Aulis, where in due course he returns to the surface (Phil. *VA* 8.19). In Lucian’s *Nekyia*, Menippus enters the underworld near where the Euphrates goes underground (9) and takes a shortcut back to emerge at the oracle of Trophonius in Boeotia (22).

In the *Georgics* Virgil depicts all the world’s rivers meeting in a vast space underground. Cyrene allows the distraught Aristaeus to descend beneath the waters of the Peneus to see her (*G.* 4.358–59). He marvels at “the damp realms (*regna*), the lakes closed in by caves (*speluncis*), and the resounding groves, and stunned by the huge movement of the waters he beholds all the rivers in different locations, flowing under the great earth” (*G.* 4.363–67). Virgil’s catalogue of rivers here may be an imitation of Callimachus’ lost work on rivers (so Thomas 1988 at 4.363–73). If Cyrene’s realm was Callimachus’ idea, it reflected both his comprehensive interest in rivers that plunge beneath the earth and his celebration of his native Cyrene’s own spectacular karst forms. The fantasy of recognizing all the world’s rivers underground (whether it is Virgil’s or Callimachus’) uses observational awareness of karst terrain to create an experience like looking at a map or walking into a library and having hidden truths about the world open to one’s informed gaze.

“HELLO PYTHAGORAS”: CAVES, SOULS, SPHERES, ZONES,  
AND MUSES



Edward Dodwell, *Salvator Rosa, Pythagoras Emerging from the Underworld* (1662), Oil on canvas, 51 5/8 x 74 7/16 in. (131.2 x 189 cm) AP 1970.22, Kimbell Art Museum, Fort Worth, Texas.

Ustinova’s study of the evidence for ritual, oracular, and philosophical practices associated with caves draws attention to the role of sensory deprivation in cave environments in producing narratives of insight (Ustinova 2010: 13–52). Arguing for the importance of narratives of descent into a cave or to Hades in accounts of Pherecydes, Pythagoras, Parmenides, and Empedocles (177–217), and in accounts of near death experiences in Plato and Plutarch and in mystery rituals (218–55), Ustinova emphasizes the mental experiences of isolation in caves. Yet Greek discourse about disappearing rivers seems to have room for local inhabitants to claim that any barathrum, any river’s underground passage, any lake that seemed bottomless, anywhere that frogs sing or a tall tree spreads out its shade, has the potential to be connected to the realms below.<sup>75</sup> Envisioning these narratives of enlightenment within physical features of karst terrain alerts modern readers to how important it was for narratives of out-of-body experiences to be anchored in a physically recognizable—even if extraordinary—world.

In this final section we consider a complex of motifs associated with the figure of Pythagoras that combine caves having characteristics of karstic terrain with

75. Cf. Ogden 2001: 252–53.

ideas about the spherical structure of the cosmos, the movement of souls into and out of physical bodies, and music and Muses. Subsequent ages project their own concerns and convictions back on to Pythagoras himself; the oldest layers of the tradition seem to involve going into caves (or cave-like spaces) and teaching of the immortality of the soul (Burkert 1972, Huffman 2014). Discourse that associates Pythagorean ideas about the cosmos with caves and Muses lasted from Plato and Aristotle through Plutarch (c. 46–120 CE), Porphyry (c. 234–305 CE), Iamblichus (c. 245–325 CE) and Proclus (412–485 CE). Boyancé (1937) has argued that philosophers cultivated worship of the Muses as a way of establishing continuity between traditional storytelling and philosophical pursuits. In the context of Pythagorean ideas, this cultivation of a connection to the Muses is part of the way that Pythagoreans and those influenced by their ideas use discourse about karstic terrain to envision physical and metaphysical maps of Tartaros and the cosmos. A robust observational awareness of karstic terrain offered a physical plausibility to narratives of the travels of souls to and from the underworld.

Physical and metaphysical maps of Tartaros are overlaid in Plutarch's story of a certain Timarchus who sought revelation in the chasm of Trophonius because he wanted to know the nature of the "daimonion" that guided Socrates' actions toward good choices (*Mor.* 590a). In Timarchus' vision, the structure of the cosmos is revealed—and it has recognizably karstic features. After his soul is released from his body he sees islands "in a *limnē* or *thalatta*" moving in a spiral path; he sees their colors through the translucent surface of this "*limnē* or sea" and hears the musical sounds that their movement generates. He next becomes aware of a huge chasm (*chasma mega*), full of darkness and wailing. He is shown the vertical course of the Styx, and souls moving into the chasm and then out of it to be reborn (*Plut. Mor.* 590b-592e). The content of the revelation—*limnē*, a spiraling current, a chasm—is thus closely aligned with the karstic elements of its physical setting in the chasm of Trophonius, and at the same time recalls the *Phaedo*'s picture of the circulation of souls through the chasms and streams of the underworld. Timarchus' vision of the luminous islands moving in a circular path through the blue water and producing beautiful sounds also has features in common with the account of the spiral motion and musical sound of the planets in the Myth of Er in Plato's *Republic*, which is likewise a revelation of the whirling structure of the cosmos and the passage of souls (*R.* 614c-621b). While the *Republic* uses the image of a spindle (*sphondylon*, *R.* 616c) to describe the spiraling motion, cosmic whirling is elsewhere expressed in the word *dinē* and the related term *dinos*;<sup>76</sup> such whirling has a physical analogue in the whirlpools that can occur in karst terrain.

The chasm of Trophonius is not especially big. There are places near Syracuse with large-scale karstic features that could have inspired the Platonic accounts that Plutarch is working with here. Southwest of Syracuse near the coast is the gorge known as Cava Grande del Cassibile, where a large quarter-spherical cave (known

76. Cf. Arist. *Clouds* 828, Eur. *Alc.* 244 with Ferguson 1971 and 1973.

as the “Grotta dei Briganti”) with rock-cut tombs is high above the spiral-rimmed blue pools of the “laghetti d’Avola”: the most striking features of Timarchus’ cosmic vision fit this expansive topography remarkably well.

In an allegorical interpretation of the *Odyssey*’s cave of the Nymphs (*Od.* 13.96-112), the site of Odysseus’ return to Ithaca, Porphyry discusses the way that “the ancients” use the cave as a “symbol of the cosmos” (*kosmou symbolon, de antro* 7). Porphyry also looks back to Pherecydes, whose work (now lost), variously titled *The Seven Nook Mingling of the Gods* and *Theogony* (Schibli fr. 2), told of the origins and structure of the cosmos; Porphyry cites Pherecydes’ account of souls’ passage through “nooks, pits, caves, doors, and gates” (*de antro* 31). Pherecydes was said to have been the first to teach that the soul is immortal (Cic. *Tusc.* 1.38). Souls migrate after death to new bodies (Schibli fr. 87), and this seems to have been envisioned, in the passages quoted by Porphyry, as traversing streams through hollows and passages into and out of Tartaros (Schibli 1990: 117–21 and 128–29). Purves (2010: 100–108) emphasizes the map-like qualities of Pherecydes’ account of the hollow passages of the cosmos, and the equally map-like qualities of the huge and lovely garment woven in many colors that Za (Zeus) bestows upon Chthonie that depicts earth (*ge*) and Ocean and the dwelling places (*domata*) of Ocean (Pher. fr. 68–69 Schibli).

According to Porphyry, “the Pythagoreans, and following them Plato, demonstrated that the cosmos is a cave (*antron*) and grotto (*spelaiion*), for the powers that are the conductors of souls say a verse of Empedocles: “now we have arrived within this roofed cave (ἡλύθομεν τόδ’ ὑπ’ ἄντρον ὑπόστεγον)” (*de antro* 8).

Among the tall tales told of Pythagoras (that his thigh was made of gold, that he was seen in two places on the same day, and so forth), one claimed that when he crossed a river, it said “hello Pythagoras.”<sup>77</sup> Alongside the many other stories that associate Pythagoras with descent into the earth, this seems to be a story about observational awareness of karstic terrain, implying that the river recognized Pythagoras because they had seen each other underground. On the island of Samos (which has many karstic caves and streams), Pythagoras “made for himself a cave (*antron*) outside of the city suitable for his philosophy” (ἔξω τε τῆς πόλεως οἰκεῖον τῆς αὐτοῦ φιλοσοφίας ἄντρον ποιησάμενος, *Iamb. VP* 27 = *Por. VP* 9, citing Aristoxenus). Iamblichus associates this cave closely with the full scope of Pythagorean mathematical and cosmological thought, saying in the immediately following sentence that in it “Pythagoras brought to completion his understanding of heavenly matters and undertook his demonstrations with all of arithmetic and geometry” (Πυθαγόρας δὲ συνετέλεσε τὴν περὶ τῶν οὐρανίων ἐπιστήμην καὶ ταῖς ἀποδείξεσιν αὐτὴν ὅλαις ταῖς ἀριθμητικαῖς καὶ ταῖς γεωμετρικαῖς διέλαβεν, *Iamb. VP* 5.27).<sup>78</sup> On a stay in Crete, Pythagoras was said

77. *chaire pythagora*, Porphyry. *VP* 27. The story goes back to Aristotle; accounts differ on which river it was: cf. D. L. 8.11, Aelian *Var. Hist.* 2.26. See, with further references, Burkert 1972: 142 and cf. Kingsley 1995: 289–316.

78. The fine points of geometry can seem far from a search for enlightenment underground, but it was on this island, during the reign of Polycrates, that the engineer Eupalinus used astoundingly

to have spent the customary twenty-seven-day sojourn in the Idaean cave (Porph. *VP* 17). When he arrived in Italy, according to Hermippos, Pythagoras made a “little dwelling” (*oikiskon*) beneath the earth to which he adjourned for some time. When he emerged, emaciated and like a skeleton (*kateskeleteumenon*), he spoke in the public assembly, recounting that he had gone to Hades and reading out an account of his experiences (D. L. 8.41, cf. Hdt. 4.95). Stories that a river said hello to a man who said that he went to Hades and who taught that souls migrate to new bodies (D. L. 8.36, Arist. *de An.* 407b20 with Burkert 1972: 120–65, esp. 121) express an impulse to map the cosmos and mortality within the contours of karst terrain.

Plato’s Er and Plutarch’s Timarchus hear the Pythagorean music of the spheres in their descents to the world below and revelations about the cosmos. Stories about Pythagoras’ connection to one or another *mouseion* or shrine of the Muses situate Pythagorean ideas about harmony, order, number, and song within the caves and grottos that that word typically evokes.<sup>79</sup> Aristotle’s argument against the Pythagorean notion of the harmony of the spheres notes that this idea “is expressed [by the Pythagoreans] in a harmonious and musical way” (ἐμμελῶς μὲν λέγεται καὶ μουσικῶς, Arist. *Cael.* 2.9 290b30). In the preface of his ninth book, on geometry, measurement, astronomy, and sundials, Vitruvius mentions that there were stories that Pythagoras sacrificed to the Muses when he figured out the 3–4–5 ratio of the right triangle (Vitr. *de Arch.* 9 pr. 6–7). The word that Vitruvius uses for the triangle is *norma*, the carpenter’s set-square; the corresponding Greek word is *gnomon* (Polyaen. 4.3.21). The *gnomon*, as the vertical pointer of a sundial (e.g. Hdt. 2.109), is a tool for understanding the cosmos because with it one can map the path of the sun over the year and plot latitudes on earth by measuring the length of the shortest shadow cast on the solstice. Knowing the 3–4–5 ratio is part of making the *gnomon* precisely vertical and therefore of constructing an accurate map of heaven and earth.

Like descents to the underworld, encounters with the Muses happen in the caves and streams of karstic terrain: most especially at the Hippocrene spring on Mount Helicon and Thespieae in the plain below (Paus. 9.29–31, Str. 9.2.25, 8.6.21), or in Parnassus’ Corycian cave (Str. 9.3.1, Paus. 10.32.2, 7). Songs of the order of the cosmos and of descent and return are associated with hollow places holy to the Muses. Hesiod situates the utterance of his *Theogony* in the places frequented by the Muses “below Helicon” in the karstic terrain where the rivers

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accurate practical earth measurement to construct an underground aqueduct—dug from each end and meeting in the middle—to bring water through an underground channel from its source to the city of Samos (Hdt. 3.60).

79. See Boyancé 1937: 233–47, Iamb. *VP* 45, 170, 261–64. One version of Pythagoras’ death places it in a shrine of the Muses at Metapontum (D. L. 8.40); Porphyry quotes Timaeus as saying that “the people of Croton made his house a shrine (*hieron*) of Demeter and called his *stenopon* a *mouseion*” (Porph. *VP* 4, cf. D. L. 8.15, of his house at Metapontum). The word *stenopon* means a narrow passage, and it can be used of streets (cf. Paus. 5.15.2, D. L. 2.48, 4.16). Plutarch *Mor.* 17c cites στενωπὸς Ἄιδου καὶ παλιρροία βυθοῦ (fr. 832 Radt) alongside Hom. *Od.* 24.11 among mythical descriptions of the passage to the afterlife, and perhaps the same kind of idea is operating in the Pythagoras anecdote.

Permessus and Olmeius flow into Lake Copais (Hes. *Th.* 3–4; 23, cf. Str. 9.2.19); Ovid situates the performance of the cosmic song of Jove’s defeat of the Giants and the song of Ceres’ loss of Proserpina amid the “living rock” by the spring of Hippocrene on Mount Helicon (*Met.* 5. 317). The celebration of mystery rites of various kinds included narratives of access to the underworld and revealed the structure of the cosmos and the nature of the soul; music and the Muses are strongly associated with those rites.<sup>80</sup> The term *mouseion* is associated with Plato’s Academy at Athens.<sup>81</sup> We may think of the Mouseion at Alexandria (Str. 17.1.8) as a proto-university building, not a cave. But as a center of learning it is a direct descendent (cf. Athen. *Deipn.* 1.3) and much expanded version of the Nymphaion at Mieza, which Philip set up as a place for Alexander to be taught by Aristotle. The Nymphaion at Mieza is a karst cave enhanced with a portico, and there are stalactites nearby (Pliny *Nat.* 31.20). According to Plutarch, Alexander was instructed by Aristotle not only in ethics and politics, but also in things that were “not to be spoken” (*arrheton*) and “very deep” (*bathuteron*), and Alexander later objected to Aristotle’s writing about those topics (presumably in his *Metaphysics*) (*Alex.* 7.2–3; Larson 2001: 169). Theophrastus knows of a Mouseion at Aristotle’s birthplace Stagira where a remarkable white poplar tree grew (*HP* 4.16.3, cf. Pliny *Nat.* 16.133), and Diogenes Laertius’ record of Theophrastus’ will includes instructions for completing restoration of the *mouseion* associated with Aristotle’s Lyceum at Athens. There is an additional direction to “set up, in an [adjacent] lower stoa, tablets on which were recorded journeys around the world” (ἀναθεῖναι δὲ καὶ τοὺς πίνακας, ἐν οἷς αἱ τῆς γῆς περιόδοί εἰσιν, εἰς τὴν κάτω στοάν D. L. 5.51). The Mouseion hill at Athens contains rock cut chambers and was said to be the home and burial place of the singer Musaeus (Paus. 1.25.8), who is credited by Diogenes Laertius with being “the first to produce a Theogony and a sphere” (D. L. 1 pr. 3) and is said to know his way around the underworld (Verg. *Aen.* 6.667). Pliny notes a particular kind of rough stone that is used to decorate the inside of structures called *musaea*—the stone gives the structure the appearance of a natural cave (*Nat.* 36.154). References to shrines of the Muses that are connected somehow to a time-measuring device (*horologium*) may also indicate a way of thinking about connections between shrines of the Muses and knowledge of the order of the cosmos<sup>82</sup> (Pliny *Nat.* 37.6, cf. Var. *R.* 3.5.9).

When Ovid’s Ceres stands on the edge of what is a barathrum and sees Proserpina’s *zonam* floating on Cyane’s blue pool (*Met.* 5.470), she understands it as *signa . . . manifesta*, revealed signs of her daughter’s capture (5.468). *Signa* is

80. Str. 10.3.9–10; Burkert 1972: 350–68, cf. West 1983: 29–33, Hardie 2004 esp. 26–27, Provenza 2013.

81. See D. L. 4.1, Paus. 1.30.2, and Plut. *Mor.* 745a-b, 746a with Dillon 2014.

82. Pliny *Nat.* 37.6. Ferrari 1999: esp. 366–86 argues that the Nile mosaic at Praeneste was part of a *mouseion* that included an artificial cave complete with imitations of stalactites, and that the Nile Mosaic and its companion piece depicting the sea are analogous to the representations of geography reported in Aristotle’s Lyceum at Athens (D.L. 5.51). A *musaeum* and a structure with qualities of a *horologium* are included in a complex designed for birds at Var. *R.* 3.5.9 and 17.

the typical Latin word for constellations (e.g. *Vitr.* 9.1.16). The word *zona* too has an astronomical and cosmic valence (*Ov. Met.* 2.131). Could Ovid's audience understand the *zona* as a garment that mapped the cosmos? Proserpina weaves such a garment in Claudian (*DRP* 1.246–68). Claudian's Proserpina shows the "sequence of elements" and the realm of Zeus (1.248) and maps the five climatic regions of the world onto the earth.<sup>83</sup> The word Claudian uses here is for the latitudinal divisions of the earth is *plagas* (1.259); the usual word in Greek for these divisions of the earth (and borrowed into Latin as *zona*) is *zonē*, literally a woven band.

Strabo (2.2.2) cites Poseidonius as crediting Parmenides with originating the division of the earth into five *zonai*. A work attributed to Plutarch (*de placitis philosophorum*) says that Thales and Pythagoras made a five-zone division of the heavens (2.12) and Pythagoras mapped this division on to the earth (3.14). The process that pseudo-Plutarch attributes to Pythagoras is the definition of terrestrial regions according to what stars can be seen from where. It follows from observations of what stars can be seen from where that the earth is a sphere (*Arist. Cael.* 297b31–298a9). Thus, perceiving the relation of the stars to the terrestrial *zonae* is to perceive that the world is a sphere. According to Pliny's account of this mapping of earth by stars, the celestial firmament (*fastigium*) is so manifestly (*manifesto*) curved that the constellation Canopus appears to viewers at Alexandria to rise the height of one quarter of a *signi*, that is one quarter of a constellation in the band of the zodiac (*Pliny Nat.* 2.177–78, with *OLD* s.v. *signum* 13). In similar terms, the *Aetna*'s account of the hollows within a spherical world (*Aet.* 94–174) exhorts readers to "draw belief in what is hidden from what is visible" (*occultique fidem manifestis abstrahe rebus*, *Aet.* 145). Strabo's account of the spherical universe and earth and the flow of water into and out of hollows of the earth in a passage that draws on Poseidonius (cf. *D. L.* 7.138), includes a reference to Pronoia (Providence) as "being a kind of embroiderer" (*poikiltria*) in bestowing living beings on the earth (*Str.* 17.1.36).

Alongside these visions of a spherical world mapped against zodiacal "zones," as Ovid's Ceres stares at Cyane's pool Proserpina's *zona* hints at a cosmic map comparable to the revelations of the cosmos attributed implicitly or explicitly to Pythagoras by Plato, Plutarch, and Porphyry. Ovid's own Pythagoras undertakes such cosmic contemplation when he appears near the end of the *Metamorphoses* (15.143–52).<sup>84</sup> Apollonius' fleeting picture of the cosmos-mapping sphere with its golden encircling bands and dark blue spiral (*helix . . . kyaneē*) that baby Zeus played with in the Idaean cave seems to share these ideas (*A. R.* 3.133–40). Did those who told of Pythagoras' sojourn in the Idaean cave imagine him showing off a spherical cosmos too? Perhaps people who told stories about Pythagoras

83. On this cosmic cloth, see Gruzelier 1993 on 1.246ff.

84. Similar cosmic contemplation, though we have no evidence that it was framed as revelation within a cave, occurs in a fragment of Eratosthenes' *Hermes* (Powell 1925 fr. 16). Cf. *Plut. Numa* 11 on Numa's construction of the temple of Vesta as a model of the cosmos in the context of stories that Numa was instructed by Pythagoras.

imagined that lamplight's glint in the swirling current of a *limnē* in a barathrum could map the stars while songs told of the soul's journeys within or beyond a spherical world.

When the river says hello to Pythagoras, when Proserpina's *zona* floats on Cyane's dark blue *limnē*, at the edge of a barathrum, Greek and Roman storytellers could imagine the underworld as a physically plausible place and the afterlife as a physically plausible experience in part by observing and making inferences about the surprising, paradoxical, implausible, or unknowable features of karst terrain. Even the most spectacular features of the Homeric underworld can make a kind of physical sense in a world where observation will indicate that any *limnē* might drain away into a barathrum that opens into an expansive network of interconnected passages and streams. Telling the story of the cosmos at the edge of a barathrum has the potential to reconcile observation-based discernment of the spherical earth and cosmos with generations of storytelling about Tartaros and the afterlife. Greeks set many of their stories, like many of their cities, in places where they could draw strength from the visible and invisible resources of karst terrain. Those who bring a karstic sensibility to ancient Greek and Roman texts, who hear in them Auden's "murmur of underground streams," will understand more of that strength in all its varieties.

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