Underground Rivers

from the River Styx
to the Rio San Buenaventura
with occasional diversions

Richard J Heggen

DRAFT **8/8/2013**

Updates at http://www.unm.edu/~rheggen/UndergroundRivers.html

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Cover adapted from Journey to the Center of the Earth, Reader's Digest edition (1992), illustrated by Lars Hokanson.

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PROLOG

Learning of my topic, underground rivers, my sister recalled that long ago I'd taught her to draw underground worlds in ant-farm perspective. I'd forgotten my artistry, but once reminded, my subterranean creationism came to memory -- tunnels and caves in which the likes of Happy, Grumpy, Dopey, Doc, Sneezy, Sleepy and Bashful might chorus, "Hi ho, hi ho. It's off to work we go," as they march to the diamond mine. The enterprise of course needed a few waterways? And there'd be forts and secret hideouts. Unencumbered minds are knowledgeable of such.

Grade-schoolers know of the hydrologic cycle as a wheel of evaporation, clouds, rainfall and rivers flowing back to the sea. Geoscience textbooks add infiltration, a groundwater reserve, seepage to springs and the role of vegetation, often citing Leonardo da Vinci as the discoverer of it all. Actually, he wasn't, but indeed he was on the right track if we limit our look to a favorable few of his backwards-scribed thoughts.

Unencumbered by criteria of scientific rigor, Leonardo simply recorded his ponderings, what he believed he saw. While he envisioned a hydrologic cycle as we now know it, he likewise conceived of a subterranean cycle spinning in reverse, one in which water flows from sea to mountain. A divergent mind is free to venture.

I, on the other hand, as an engineering academic, was a touter of physical principals. Fluid mechanics is obligingly law abiding.

Leonardo and I would thus seem to have had little in common, other than that he might have appreciated my childhood art, and I, his sketches of cascading waters.

Perhaps through erroneous cataloging did The Hydrologic Cycle and the Wisdom of God, A Theme in Geoteleology (1979) by Yi-Fu Tuan end up in the University of New Mexico Centennial Science and Engineering Library. Curiosity led me to pull the slight volume from the shelf where it languished -- long languished, according to the due-date stamps -- amidst weighty references, my interest at the time in kinematic waves.

"Geo," engineers know, pertains to the earth, but "teleology" wasn't in my vocabulary; it's the philosophical study of design and purpose. Tuan's book dealt with how 17th-century Christianity came to presume hydrologic vindication in the works of Newton. Not an engineering reference, to be sure, but I was enchanted by the antique woodcuts.

Tuan's work -- not a quick read for one unschooled in history -- revealed to me that the subject of hydrology -- a field in which I'd thought myself reasonably versed -- engendered intertwining streams, streams through a world in which like Leonardo's, ideas run freer.

I thus return to my juvenile sketches of underground wonders. It's not the Seven Dwarfs' gold I pursue, but the subterranean streams that they encounter.

Regarding the Seven Dwarfs, not until much later would I discover that Disney's Snow White (1937) actually contains an underground river. See Chapter 24, Girls, Too! I shouldn't have been surprised, as such rivers are indeed everywhere.

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INTRODUCTION

Hydrology is the study of the occurrence, distribution, movement and properties of the waters of the earth. As water impacts so many aspects of science, we have engineering hydrology, geohydrology, hydrogeology, geographical hydrology, environmental hydrology, fluvial geomorphology and the list goes on.

But hydrology is more than science; it's the study of our relationship to water. We draw water to drink, of course, but we as well draw upon water for intellectual sustenance. What would art be without paintings of seascapes? What would poetry be without stream banks upon which to sit and read? What would adventure be without uncharted oceans? Huckleberry Finn is about the Mississippi and in turn, the river is about the boy.

Consider the academic departments at a university and with each, there's a tie to the words "underground river." We engineers relish in the fluid mechanics aspect. Philosophers know of the mythical rivers in Greek classics. Political scientists speak of underground rivers of social change. Art historians recognize Charon, the wizened boatman, in millennia of paintings.

What would be our awareness of the unseen without allusions to subterranean streams?

And why be faint in our quest? We shall follow underground rivers wherever they lead through Western civilization.

Our journey won't be technical, though we will encounter occasional decimal numbers, a few lines of chemistry and a bit of physics. But we will also encounter (but only briefly, rest assured) the likes of James Joyce. When we tire of literature, we can collect stamps. We'll add "achluohydrophobia" to our vocabulary. We'll be the life of the party, sharing really-interesting facts of history and geography, though we might not get invited to the next party.

Our journey's not about ports, but about pathways. We will travel underground waterways that stray across the boundaries of co-existing, sometimes contrasting, perspectives. As do above-ground rivers, our subterranean journey may meander, diverge and reconnect. If a particular segment fails to catch our fancy, we're free to portage onward and drift back as we like.

No serious scholar would so risk his or her credibility, of course, but the rest of us have less to risk.

Models

Before we embark, however, we need an underlying concept, that of modeling.

To illustrate how a model works, we'll ask a basic question,

Why do underground rivers do what they do?

Consider modeling's two definitional phrases: "something we wish to understand" and "something we think we do understand." Modeling can lead us in odd ways when either is astray.

The "we wish to understand" introduces subjectivity. What sort of behavior of underground rivers piques our curiosity? The velocity? The direction? For illustrative purpose, we'll say that our interest is the mechanism that transports water from the sea to an upland spring. If we're misinformed regarding the river in the first place, the answers may be legion and their content most imaginative, but for that we must wait to Chapter 8, Subterranean Engines.

The "something we think we think we do understand" is as open ended as our capacity to host ideas. As applied to an underground river, mechanical engineers, for example, might turn to laws of thermodynamics. Geographers might prefer a topographic map. Scholars of the humanities might look to literary portrayal.

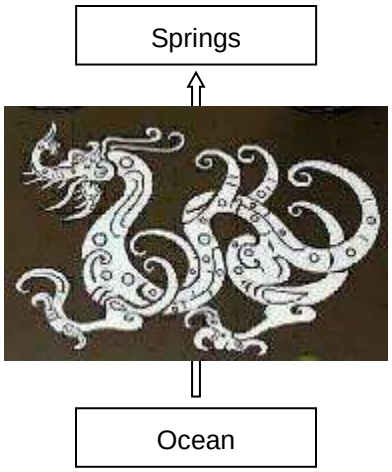
Science involves the perception of patterns that exist. Superstition involves the perception of patterns that do not. We tend to be good at perceiving patterns, but weak in discerning the veracity aspect. Science and superstition thus aren't as distinct as we prefer to believe.

In that light, let's imagine that Hollywood has recently entertained us with a blockbuster involving dragons. The animated creatures seemed, in fact, quite alive. Our hypothesis is that subterranean water is propelled from sea to springhead by a dutifully-belching reptile. We prefer our dragon theory over, say, one utilizing a hose, because in blasting the water upward, our great beast also consumes the salt.

To wit,

We wish to explain spring flow.
We do so by means of a dragon.

We'll express our model as a graphic.



The boxes represent water; the upward arrow, transport. What's between is the means. It might seem silly to bother with a drawing, but we may be thankful for such visuals in Chapters 8-10.

An errant hypothesis can be a useful step in the scientific process. A dragon would tire of a salt diet and our sonar device yields no belching. After a bit of reflection and observation, we'll perhaps dismiss the dragon model. We'd prefer a mechanism more satisfactory in terms of realism, precision, generality and/or intellectual manipulability.

How about, say, we replace the dragon with a giant magnet? After all, everyone knows that there's iron in the earth.

CHAPTERS

Although the contents intertwine, the designations at the right may assist in plotting the journey.

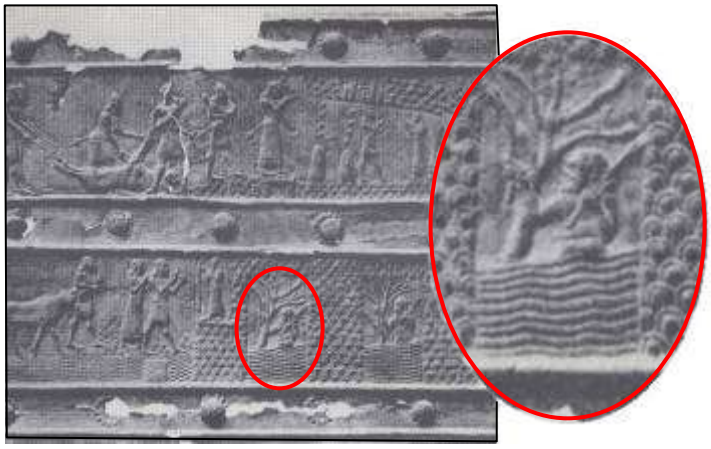
CHAPTER 1
GREEK MYTHOLOGY

We begin our underground river journey with Homer (c. 800 BC), whose works -- as we will come to see -- yet underpin Western culture.

Let us pause, however, to recognize that the Greeks were themselves drawing upon other civilizations.

To the right we have from the British Museum a bronze Babylonian panel showing a visit to caves near the source of the Tigris in about 852 BC.

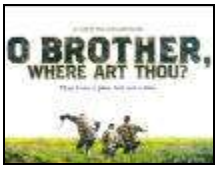
We see stalagmites and, in the lower portion, an underground river. We'll see much more of the boatman in chapters to come.



To ancient Greeks, the underworld was not an abstraction. Their underworld -- or least its upper layer -- was more than 10,000 limestone caverns. And where there's limestone, there's been (and still may be) water. What humans see, they strive to explain.

Homer's Iliad and Odyssey are archetypal folkloric epics of human quest. The Iliad describes the conclusion of the Trojan War and the Odyssey tells of Odysseus' (Ulysses in Latin) ten-year homeward journey. Sailing his bark into the dark unknown and undertaking a series of ordeals, the hero re-emerges as a fuller person. Odysseus and the Sirens are illustrated on the 2500-year old vase.

Those unfamiliar with the saga can rent the video. While director Joel Cohen admits only to having read the Classic Comics Odyssey, his and his brother Ethan's film O Brother, Where Art Thou? (2000) faithfully replicates the tale. Following are a few correspondences.

	 Odyssey (c. 855 BC)	
Author	Homer	Joel/Ethan Cohen
Protagonist	Odysseus	Everett Ulysses McGill
Setting	Mythical Mediterranean, Mythical times	Mississippi, 1920s
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Sing in me, and through me tell the story of that man skilled in all the ways of contending a wanderer, harried for years on end.*
Characters	Lotus Eaters Cyclops Sirens	Baptists Bible salesman Washerwomen
Rivers	Acheron Cocytus Styx Lethe Pyriphlegethon	A river is involved at either end -- the baptism and the flooding.

We'll make similar Odyssean comparisons in chapters to come. One can't keep a good story down.

As enduring as the saga's hero are the deities of the world through which he journeyed. To the right are several of the many Greek gods, along with their Romanized names. Though we today may be only vaguely familiar with the particular legends, the gods of Homer live on in our common references.

In addition to committing to written form the even-then ancient mythology, Homer draws upon cultural memories of Bronze Age seamen who sailed to where the “Ocean River” flows.

Greek	Roman
Aphrodite	Venus
Apollo	Apollo
Ares	Mars
Hermes	Mercury
Poseidon	Neptune
Zeus	Jupiter
Eros	Cupid
Heracles	Hercules
Atlas	Atlas
Cronus	Saturn
Hades	Pluto

Oceanus, the Ocean River

Oceanus was both a god and a water body. As the former, Oceanus was the eldest of the twelve Titans (the race from which sprung humans), Oceanus did not join the dispossessed Titans against the Olympians, but instead withdrew from the struggle doomed by Zeus’ thunderbolts.

With his sister Tethys, Oceanus fathered some three dozen gods, 3000 rivers and 3000 ocean nymphs.

Oceanus was represented as an old man of noble presence and benevolent expression, with the horns of an ox or bull, sometimes crab claws on his head, a long beard, a muscular upper body and the lower torso of a serpent encircling the earth. His attributes included a pitcher, cornucopia, rushes, marine creatures and a scepter.

As a water body, Oceanus was the Atlantic Ocean, but not the geographically-bounded sea we know today. Oceanus was a river running around and the earth, which in turn was believed to be a flat disk called Gaea, a derivative of a prehistoric Egyptian/Babylonian account in which the god Marduk piled dirt on a rush mat floating on primordial water. The sun and moon rise from and descend into this stream and only the Great Bear remains above the waters.

From the Iliad,

> *Deep flowing Oceanus, from which flow all rivers and every sea and all springs and deep wells. Never mingling with the sea which it encloses, it has neither source nor mouth.*
>
> *With Jove neither does King Achelous fight nor does the mighty strength of the deep-flowing Oceanus, from which flow all rivers and every sea and all springs and deep wells.*

On Oceanus' shores dwell the minute Pygmies. On the southern banks lies Elysian where the "blameless Aethiopians" dwell in perfect happiness.

Beyond the west lies the realm of eternal and infernal darkness where vegetation is black poplars, fruitless willows and funerary asphodel. “The Afterworld,” says Circe to Odysseus “lies at the extreme of the earth, beyond the vast Ocean.”

As traders continued to find inhabited and fruited land where Oceanus’ desolation would have been expected, however, an adjustment was called for. Connection to the infernal region must be via another Oceanic link, perhaps one closer to home, perhaps even in Arcadia where watery caves abound. (We will see why this is so in later chapters, but we don't want to muddle Hellenist thought with geologic digression.)

And thus came to be known the five subterranean rivers, mythical waters, we'd like to say, but like the gods, still very much alive.

The Cocytus, the river of lamentation

> The dead who cannot pay Charon (whom we will meet shortly) must wander its banks forever.

The Lethe, the river of forgetfulness

> The Lethe passes the extremity of the Elysian Fields. Those who drink of this stream forget the past. The Eridanus (Po) was said to spring from the Elysian Fields, where Aeneas saw it flowing. As later expressed by the Roman poet Marcus Annaeus Lucanus in his epic Pharsalia,
>
> *Here Lethe's streams, from secret springs below*
> *Rise to the light; here heavily, and slow,*
> *The silent, dull, forgetful waters flow*

The Acheron, the river of woe

> Myths tend to be inconsistent regarding geography. Homer described the Acheron as the channel into which the Pyriphlegethon and Cocytus empty. Virgil (the Roman Encyclopedist,

Chapter 3) described the Acheron as the source of the Styx and Cocytus. And yet others claimed the Acheron to be a branch of the Styx.

According to others, the Acheron, turbid with mud, flows from desert places to

The Stygian marsh, or
Acherusian Lake where the souls remain until they are reborn, or perhaps,
The Grove of Persephone, the wife of Hades, whose kingdom lies further downstream.

The Styx, the river of hate, the river of unbreakable oath

The poet Hesiod (c. 750 BC) considered Styx to be the daughter of Oceanus. Comprising one-tenth the volume of its parent, the Styx flows out of a rock and into a mass of broken rock where it encircles the underworld nine times. In other accounts, the Styx passes around Acherusian Lake and becomes the Cocytus.

We'll have more to say about the River Styx in Chapter 33, To Cross the Stys, and in Chapter 69, The Law of Subterranean Streams.

The Pyriphlegethon, the river of fire

Around the underworld runs a fence of bronze beyond which night spreads in triple line to the Pyriphlegethon, a torrent of lava and clashing boulders. The Pyriphlegethon approaches the edge of boiling Lake Acherusia, but does not mingle. Souls remain here until they are reborn.

A handy mnemonic: the first letters of the five rivers spell CLASP. As we'll be encountering them over and over, it may help speed the recognition.

The five rivers oscillate from one side of the underworld to the other. As they surge to and fro, surficial waters flow into and out of chasms, generating the sea's tides.

Tartarus, the lowest abyss beneath the earth, from where all waters originate and to where all waters return, is as far distant from earth as earth is from the sky. An anvil falling down from heaven would take ten days to reach the ground. An anvil falling from earth to Tartarus would take ten days more. Homer portrayed Tartarus as an ominous realm inhabited by shadows. In the dank, gloomy pit below the roots of the earth and sea, the dead fade into nothingness. . Nothing is real; existence itself is but a miserable illusion.

(Note the term "abyss," a noun more ominous than "hole" or "cave." We'll deal with the idea of a foreboding cavity within the earth's interior in many chapters to come.)

In myth closer to the present, Tartarus becomes Hades, a place of punishment for mortal sinners, antithetic to the blessed afterlife on the Elysium Fields.

Recalling the disagreement about the Acheron, we'll view the 19th-century map below as someone's best guess. Pertinent names are overtyped for easier identification.

We will remap today's superterranean Arcadian watershed in Chapter 29.

To enter Tartarus, souls must cross a river, but which one? Early Greeks thought it to be the Acheron. The Romans said it to be the River Styx or Lake Acherusia.

The Acheron	Both the Acheron and the Styx	The Styx
Pindar (ca. 522–443 BC)	Virgil (70-19 BC)	Propertius (ca. 45-15 BC)
Aeschylus (c. 525-455 BC)		Ovid (43 BC-17 AD)
Euripides (ca. 480–406 BC)		Statius (ca. 45-96 AD)
Plato (428-348 BC)		
Callimachus (ca. 310-240 BC)		
Pausanias (110-180)		
Dante (1265-1321)		

We will meet many of the above in later chapters.

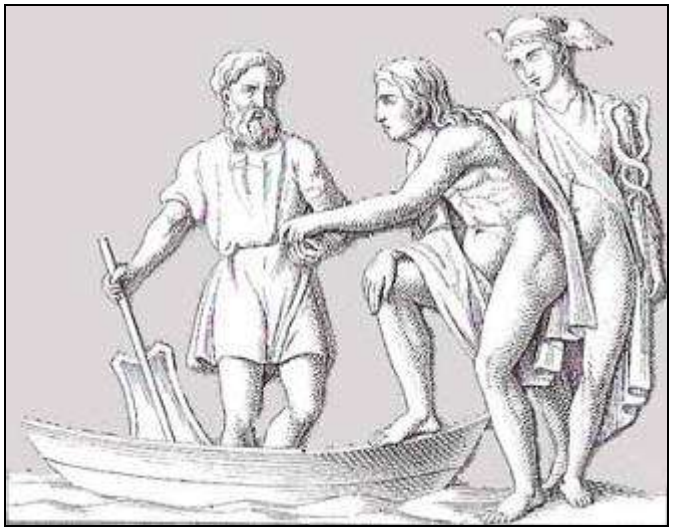
To muddle the lore a bit more, some accounts thought the psychopomp -- a general term for a guide of the dead -- to be the god Phlegyas, but in the overwhelming majority, it's Charon.

In deference to the lore that's todays standard, that of Virgil, we will call it the Styx.

To this purpose, the aged and avaricious boatman, Charon, ferries those upon whose lips has been placed the two-obol fare at cremation. As the coin was worth less than a modern American dollar, the poor were not excluded; at issue was preparation of the corps.

As fares for underground river passage have carried over into modern life, we'll use the box format to note prices as we come upon them throughout the remainder of our journey.

Boatman's Fee
2 obols



Charon receives a fare. Hermes stands to the right.

A sarcophagus depicting Charon

The fifth century BC Greek tragedy "Aeschylus, Seven against Thebes" speaks of the voyage.

> *But sail upon the wind of lamentation, my friends, and about your head row with your hands' rapid stroke in conveyance of the dead, that stroke which always causes the sacred slack-sailed, black-clothed ship* [of Charon] *to pass over Acheron to the unseen land where Apollo does not walk, the sunless land that receives all men.*

In the course of Aeneas's descent to the underworld after the Cumaean Sibyl has directed him to retrieve the golden bough, Virgil's Aeneid (a Roman retelling of the Greek tale) describes the ferryman.

> *From here* [the path to the underworld] *is the road that leads to the dismal waters of Acheron. Here a whirlpool boils with mud and immense swirlings of water, spouting up the slimy sand of Cocytus. A dreadful ferryman looks after the river crossing, Charon, appalling filthy he is, with a bush of unkempt white beard upon his chin, with eyes like jets of fire; and a dirty cloak draggles down, knotted about his shoulders. He poles the boat, he looks after the sails, he is all the crew of that rust-colored ferry which takes the dead across.*

Or in a more poetic translation.

> *There Charon stands, who rules the dreary coast*
> *A sordid god: down from his hairy chin*
> *A length of beard descends, uncombed, unclean;*
> *His eyes, like hollow furnaces on fire;*
> *A girdle, foul with grease, binds his obscene attire.*

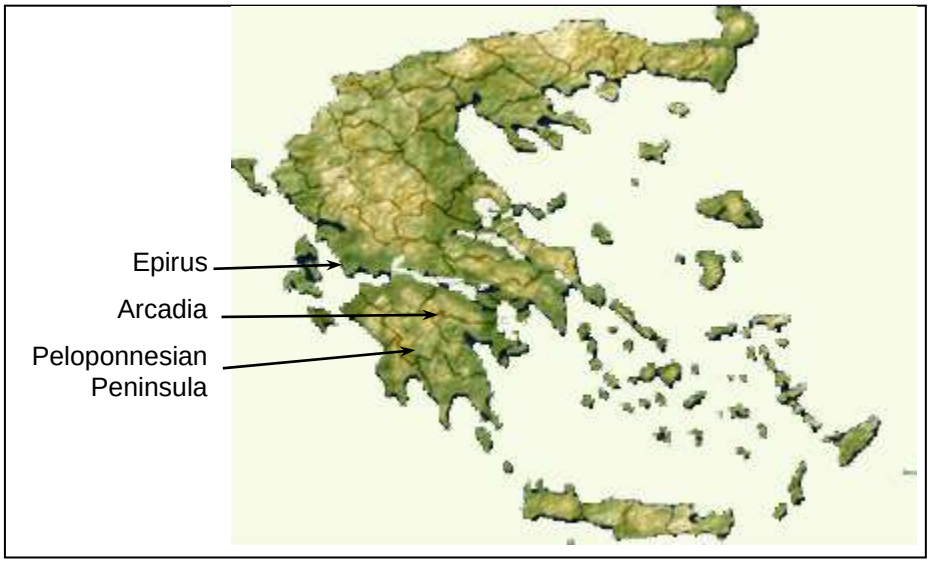
Although Homer makes no mention of the ancient boatman, Charon is long rooted in Greek lore, originally probably not the ferryman, but possibly as an ancient and respected death-god. A hint comes from Strabo's Geographia (Chapter 3) where the Roman writes of a cave in Asia Minor that was once Charon's sanctuary, a place where priests sought his aid by dream-incubation. If Charon indeed had formerly been a death-god, he would also have possessed an intrinsic power of restoring life. With such power yet within him, yet denied its use by the Olympians, no wonder he succumbed to despair. He is going nowhere but back and forth, constrained, as are we, by the rulers of the day.

In his tragedy Hercules Furens, Seneca (also Chapter 3) describes Charon when the boatman tells Hercules to halt.

A rock funereal o'erhangs the slothful shoals, where the waves are sluggish and the dull mere is numbed.
This stream an old man tends, clad in foul garb and to the sight abhorrent, and ferries over the quaking shades.
His beard hangs down unkempt.
A knot ties his robe's misshapen folds.
Haggard his sunken cheeks,
Himself his own boatman, with a long pole he directs his craft.
Again and again in the chapters before us, we will meet this same boatman, always plying the waters below.

Geographical Correspondences

The map locates Epirus, Arcadia and the Peloponnesian Peninsula where limestone formations of Peloponnesus exhibit numerous watery grottos, giving rise to classical documentation of rivers swallowed into un-plumbable caverns and breaking forth elsewhere.



In the table below are several purported correspondences between waters of the Greek underworld and today's geography.

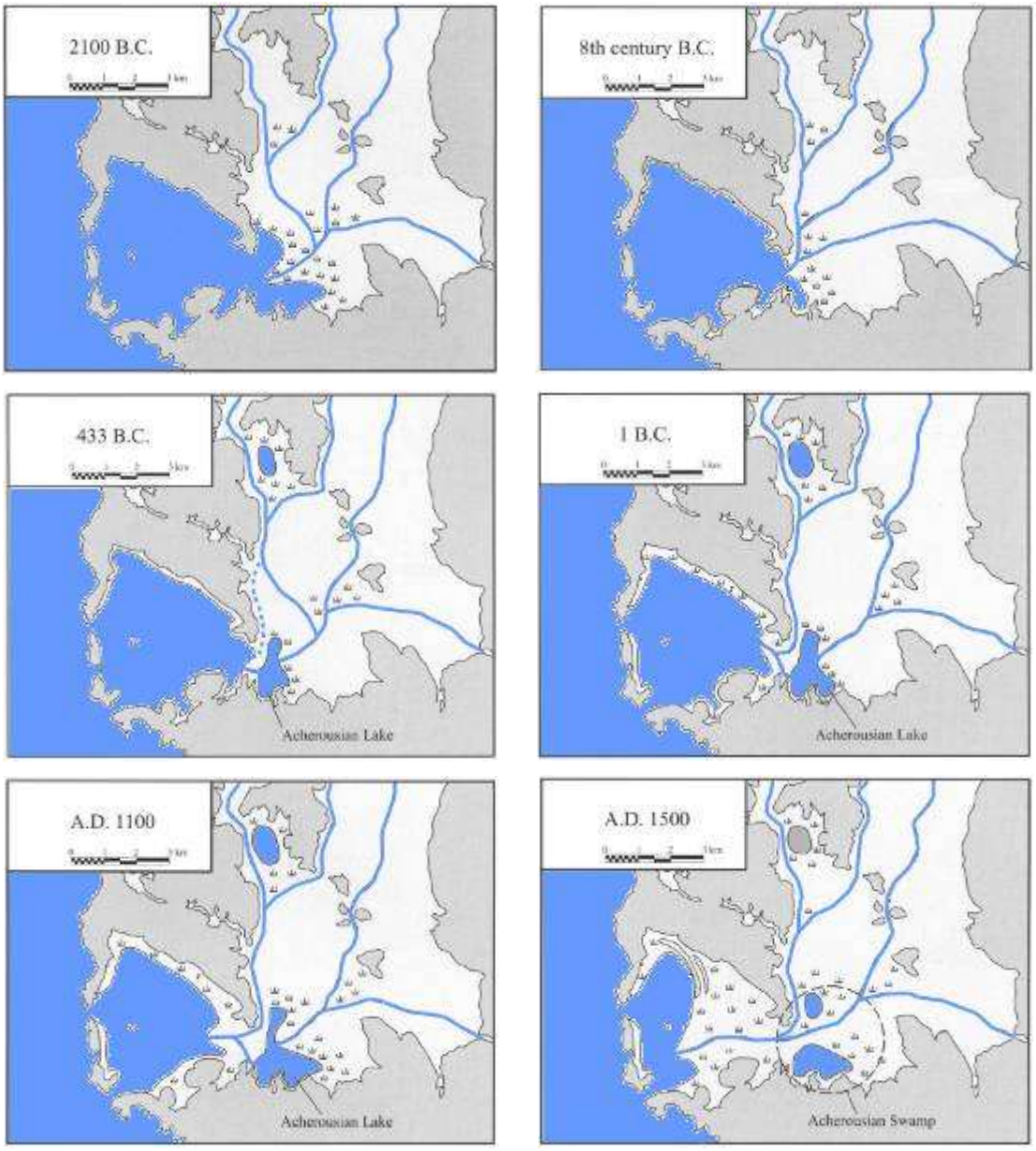
	Underworld	Modern Geography
Lethe	Oblivion	Springs near Krya (northwest of Athens), location of the Oracle of Trofonios 
Acheron	Tar with iron plates floating upon it	Thesprotia, southern Epirus 
Styx	Circling Tartarus nine times	Mavroneri ("black water") in Arcadia, famous for its 300-m waterfall, the highest in Greece. Visiting in 1895, Sir James Frazer remarked of black waters running down cliffs of dark rock like walls of "ebon hue." 
Pyriphlegethon	River of fire	One of many Mediterranean lava flows (Chapter 42)

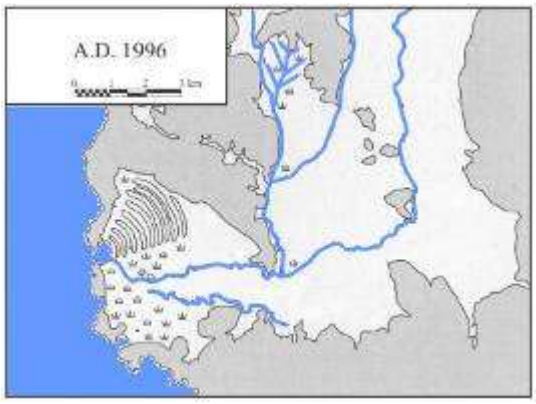
Recalling the CLASP mnemonic, we note that of the several subterranean rivers of Greek myth, only the Cocytus hasn't -- at least nominally -- made its way to the surface.

The lower Acheron valley illustrates the metamorphosis of the Peloponnesian landscape. In ancient times the river formed Lake Acherusia, a locale legendarily associated with Charon. The rivers Cocytus and Vouvos (then called Pyriphlegethon) also emptied into the lake, and then all together emptied into the vast Glukys Himen ("Sweet Harbor") noted by Strabo (Chapter 3) and mentioned by Thucydides during the stop of the fleet of the Corinthians the day before the naval battle of Syvota (433 BC).

The following four-millennia chronology of the valley is adapted from "The Lower Acheron River Valley, Ancient Accounts and the Changing Landscape," Hesperia Supplements 32, 2003, by Mark Besonen, George Rapp and Zhichun Jing.

The Ionian Sea is to the left. Today's River Acheron is the channel sweeping from the upper right. Drainage works have reduced Strabo's great Sweet Harbor to the snug moorage of Argo Janni at the Acheron mouth.





As the lore of Charon preceded Lake Acherusia's formation, the ancient ferryman didn't ply the lacustrine surface, but then again, the river flowed long before.

What keeps classicists occupied, of course, is connecting the dots. Let us summarize a bit of how this works. From James Henry Skene, "Remarkable Localities on the Coast of Epirus," Journal of the Royal Geographical Society of London 18, 1848,

> *I had occasion recently to sail into the port of Agio Janni in a small yacht, during a dark night, and blowing hard with violent squalls. In beating into the harbor I was astonished to perceive the sea become suddenly as calm as a mirror, although the wind was increasing, but the calmness lasted only for a moment, and had the appearance as if a few barrels of oil had been emptied over the waves in a particular spot. It was too late that night to make any investigation into the causes of this, but on the next morning I returned with a light breeze in search of the spot, and found a circular space of perfectly smooth water, the diameter of which might be about 40 feet; and it appeared to be raised above the surface of the surrounding sea. The water rose from beneath with such violence as to form a series of small circular waves beyond the ring diverging from the center, which was turbid, and bubbled up like a spring. We steered across it, and found that the cutter's head swerved about as in a whirlpool, which convinced me that it was occasioned by a powerful submarine source, or perhaps the outlet of one of the Katabothra, or subterranean channels, which flow out of the lake of Jannina.*
>
> *Now Pausanias mentions the fact of these phenomena existing on the coast of Argolis, and in Thesprotia, near the place called Chimerium.*

Skene now cites the day's authority on all things Greek, Col. William M. Leake. From Leake's Travels in the Morea II (1830),

> *This is a copious source of fresh water rising in the sea, at a quarter of a mile from a narrow beach under the cliffs. The body of fresh water appears to be not less than fifty feet in diameter. The weather being very calm this morning, I perceive that it rises with such force as to form a convex surface, and it disturbs the sea for several hundred feet around. In short, it is evidently the exit of a subterraneous river of some magnitude, and thus corresponds with the Deine of Pausanias* [a second century traveler whom we'll encounter in Chapter 3]*, who remarks in the Arcadics, that the waters of the plain in the Mantinice... flow towards a chasm, and that, after a subterraneous course, they re-appear at the Deine, towards the place in the Argolis called Genethlium; here sweet water rises out of the sea in the same manner as near Cheimerium in Thesprotis.*

Skene thus concludes,

> *These two phenomena, therefore, strongly resemble each other, and they may well be mentioned by the ancient geographer as being similar. The modern geographer* [once more referring to Leake], *in his travels in Northern Greece, says himself that if the remark of Pausanias were verified, he states that fresh water, similar to that of the Deine on the coast of Argolis, rose in the sea near Chimerium..., there would remain no doubt on the subject.*

Scholar A cites earlier scholar B who in turn cites ancient scholar C. Parallels between Greek myth, ancient travelers and personal observation put Skene's doubt to rest and voila! -- the ancient Acheron -- the above-ground part, that is -- is reconciled with modernity.

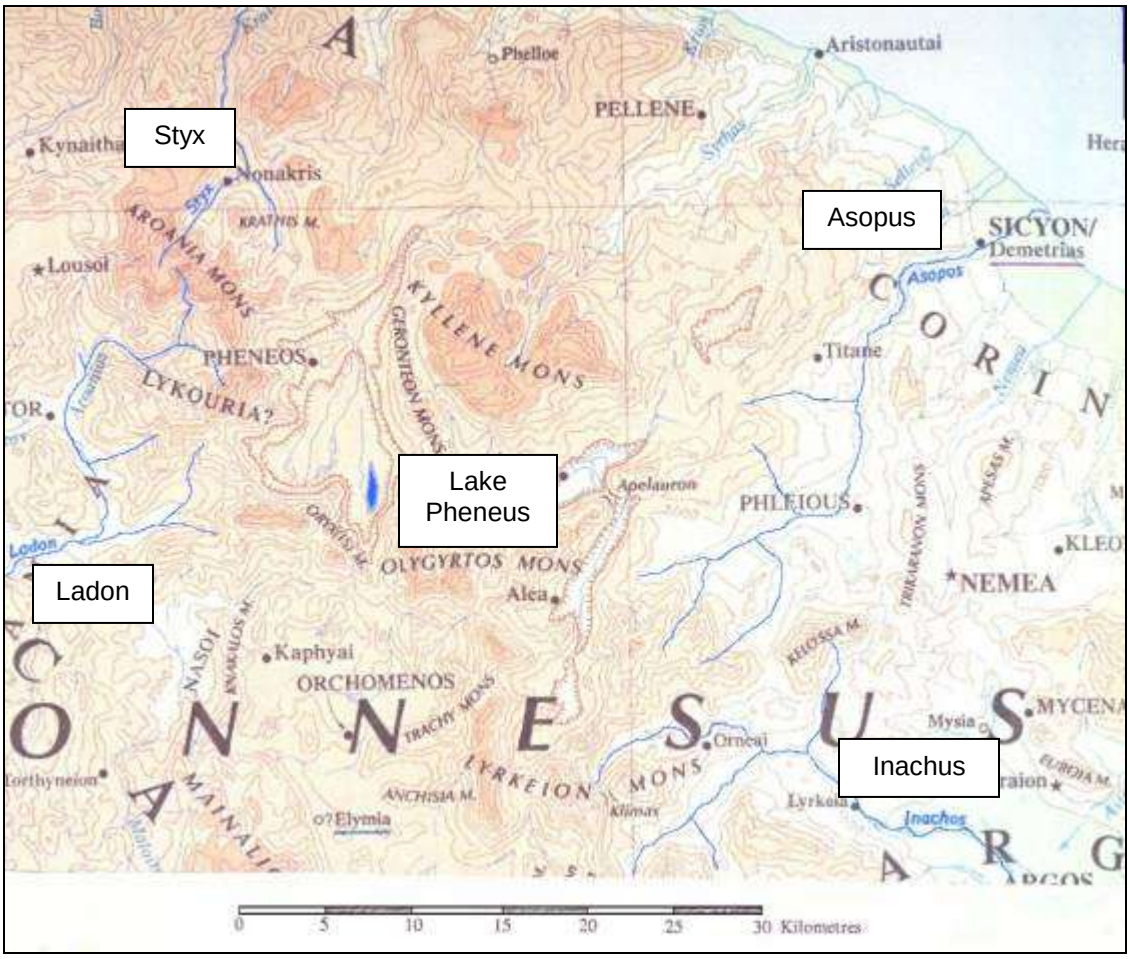
What interests us more than which ancient swamp is what current river, however, is the nature of the supposed underground watercourse popping up in the diminished bay. Were this the case, there would two Rivers Acheron, one subtending the other.

At the risk of dampening historic sleuthing, we must note that actual geo-science -- the kind that employs thermometers and such -- knows of no such sub-oceanic upwelling. Yachters need not fear a "convex surface" off the sunbather-spread white sands.

Pausanias appears to have swayed the colonel with an honored yarn and the latter likewise planted a seed in Skene's expectations.

Seek, and ye shall find, as it says in the Bible. As the chapters ahead will attest, underground rivers seem to thus be identified. Leake would have planted (or re-planted, as it were) many such literary predispositions, as his Travels in Northern Greece (1835) contains no less than 60 references to the "subterraneous."

As for correspondence to legendary sites, the map below shows modern Lake Pheneus as the grain-shaped water body near the center, said to be the excavation of Hercules.



The Styx (one of several, as we'll see in Chapter 60, A Superfluity of Surficial Stygian Streams), Asopus, Inachus and Ladon (tributary to the westerly Alpheus) encircle Lake Pheneus. Only from a topographic map can we have confidence in a river's direction, or alternatively, given a particular reach of water, can we be sure of to which basin it belongs. Only in recent mapping was it determined that the Ladon drains the region through the underlying limestone.

Nearby this Styx lies the Monastery Mega Spiel, founded in 362 upon a grotto, and Limn Kastrion Cave, 3 kilometers of underground lakes linked by waterfalls.

The photo shows one of many nearby caverns. If there was an entrance to the underworld, this Arcadian region looks to qualify.

Basins such as these keep modern hydro-cartographers employed and -- as we will see in Chapters 20-26 -- likewise the writers of pulp fiction.

To confuse an early geographer reliant on oral accounts, there are no less than three Asopus rivers:

The Asopus above,
The Asopus of Boeotia, northwest of Athens, emptying into the Euboean Gulf, and
The Asopus on the Anatolian uplands of Sakarya, modern Turkey.

Sophocles said that the Inachus of Akarnania in Epirus joined the Inachus of the Argolis.

Strabo (Chapter 3, Roman Geographers) saw the nomenclature problem of colonists transferring familiar names to make the new land seem more like the old.

> *Hecataeus ... says that the Inachus of the Amphilochi, which flows from Mount Lacmus, from whence also the Aeas descends, was distinct from the river of like name in Argolis.*

To geographers working from orally-derived accounts, however, like-names may have been thought to be re-emerged reaches of a single watercourse.

Here's the summary of a tale older than geography itself, however.

Asopus, god of the Peloponnean River and son of Oceanus, was married to Metope, daughter of river-god Ladon. Asopus' siblings included Acheron, Alpheus, Inachus, Styx and Maeander -- the latter etymologically recognizable today as a riverine pathway. Asopus and Metope had twenty daughters, several of which were carried off by other gods.

The daughters of river deity -- and not insignificantly, nieces to gods of underground waters -- are kidnapped to distant lands. Any reasonable Greek would of course expect to come upon them in his travels.

We thus have

Underground rivers inexorably woven into ancient, but flexible, myth,
Contorted fluvial geomorphology and altered names, and
Rivers observed to disappear into or rise from the ground.

What particular watercourse was denoted by a certain name at a given time may never be clear. What is clear, however, is that myth, geography and mysterious waters are already intermeshed.

In Springs and Wells in Greek and Roman Literature, Their Legends and Locations (1922), James Smith proposes that Homer's inspiration for Hades was drawn not from the Hellenist terrain, but rather from the world's western edge, Spain. Homer would have had hearsay knowledge of the River Tartessus, its modern name, the Guadalquivir.

Rising in the Sierra Cazorla Mountains, the Tartessus, according to Smith,

> *Soon developed a liking for darkness and frequently disappeared underground, coming as often again to light, but none the brighter after its burrowings through the discoloring soil; and at the end of its 360 mile course it poured dark and muddy streams into the Atlantic Ocean.*
>
> *Its lightless underground courses, all combined to make the borders of the Atlantic much more appropriate as a site for Hades than any of the other places that were suggested near the heart of Greece, places that were only relatively west to by no means a small part of the world for whom Homer sang his story.*

While the bases of Homer's geographic conceptions will be long debated, the qualitative correspondence seems sound that a significant portion of the poet's inspiration for Hades came from his awareness -- albeit legendary and fragmentary -- of rivers that truly run underground.

We've begun our journey in mythical Greece, the source which, among other things, named our planets, gave us Cupid, Chaos, Eros, Hades, the word "ocean," the Olympics. Underground rivers are very much a part of that legacy.

As the Greeks were only one of many cultures with mythology pertaining to the underground, however, we could have begun with subterranean tales from the Scandinavians, Tetons, Celts and Welsh, the Chinese and Japanese, the Arabs and Central Asians, the Native Americans, the Amazonians, Aztecs and Incas, the Australian aborigines, the Bengals and Burmese, the Micronesians, Melanesians and Malaysians, the Persians, the Buddhists and the Hindus.

Although we direct our interests toward Western culture, we must note that both myth and philosophy filtered across the Euro-Asian landmass. Sanskrit scripture written between the 16th and seventh century BC instructs,

> *These eastern rivers, dear son, flow along to the east and the western ones to the west. They arise from the ocean and merge into the ocean and become that ocean itself.* -- Chandogya Upanishad, 6.10.1-2

“Arise from the ocean” sounds very much like evaporation, and if so, the Hindus had a 3,000-year lead in the field of hydrology.

In Sumerian tradition, Enki was Snake Lord of the Abzu (Greek "abyssos," English "abyss"). His ziggurat temple, surrounded by Ephratean marshlands, was the E-engura, the "house of the subterranean streams."

But as we must sail onward, we can only tip our hats to the Snake Lord before we move to philosophy.

CHAPTER 2
GREEK PHILOSOPHERS

Let's begin this chapter -- the title of which simply replaces "Mythology" with "Philosophers," but it's still Greek -- with a summary of our journey to this point. We embarked into a shadowy underworld of murky and ill-defined rivers destined for perhaps nowhere. And as we know from Greek myth, the gods who rule such things can be rather capricious. An inauspicious start.

But there are lanterns ahead!

The Greeks' pivotal contribution to Western civilization was not the family of remembered deities. Nor was it the yet-retold epic tales of human fete. The greatest contribution was that of a natural philosophy, by which we mean the scholarly discipline that in ancient and medieval times pursued an orderly investigation of our physical world. The field today is called “science,” as contemporary philosophers have come to be seen -- perhaps incorrectly, but we're talking about public perception -- as contemplators of the intangible.

The intellectual challenge in Hellenist times was that of recognizing the patterns. As contrasted in the Introduction, whether such determination is "scientific" or "superstitious" can only be judged by one who knows reality. Most of us today have an inviolate, physically-based bias in the matter, of course, but we’ll not impose our predilections on those 2,000 years before us.

We will draw most of this chapter's illustrations from Hartmann Schedel's Nuremberg Chronicle (1493), the German reference of its time regarding matters classical. While we rather doubt that the ancient Greeks dressed as Teutonic burgomasters, the drawings serve a larger point, a theme we will again and again encounter in our journey. As cultural creatures, we're forever regarbing past beliefs.

Born in Miletus (now part of Turkey), our first three Hellenist philosophers were Milesians, the etymological source of “millers." It's doubtful that these three ground grain, however, as they weren't slaves.

Thales of Miletus (624-546 BC) is best remembered for his prognosis of a solar eclipse. Likely having traveled to Egypt where eclipses were long chronicled and observing that a year contains 365, not 360, days probably accounted for his accuracy.

Thales was a monist, one believing that all substance is derived from a single primordial matter. To Thales, the world was water, the only substance having solid, liquid and gaseous form. Moreover, nourishment for both plants and animals is moist. Water is thus an image of a cosmic unifying power. (Note the qualification, "image of," however. We'll see how Plato institutionalized the concept of duality later in this chapter.)

Sidestepping religious tradition, Thales concentrated on natural processes. "All things being full of gods," supported both religious lore and a physical River Oceanus flowing unceasingly around the earth. Under the effect of winds, waters of the seas were thrust towards the interior, elevating the pressure within and causing underground rivers to erupt through earthquake in the earth's skin.

Hydrologists think of Thales as the water-philosopher, but in larger picture, it was this philosopher who argued that for every observable effect, there is a physical cause. The term "physical" marks the onset of what we know today as "science."

Thales' disciple Anaximander of Miletus (611-547 BC) went a further step, seeing the primordial substance as “apeiron,” a substance less tangible. Realizing that the earth was curved, Anaximander concluded the earth’s shape to be that of a cylinder, but one placed within in a celestial sphere.

To the right, Anaximander holding a sundial

Anaximenes of Miletus (585-525 BC), said to be the first to distinguish between stars and planets, argued that world is composed of neither water nor apeiron, but of air itself. Compressed, it becomes water and earth.

Anaximenes reverted to the disk cosmology, stating that the sun never goes under the earth, but circles it laterally, sometimes obscured by higher parts. The sea is,

> *The source of the water and the source of the wind. For neither could the force of the wind blowing outwards from within come into being without the great main sea, nor the streams or rivers, nor the showery water of the sky, but the mighty main is the begetter of clouds and winds and rivers.*

Anaximenes explained landforms as the product of surficial collapse, a rational fitting well with the Arcadian multitude of caves. Water percolates the earth, as "in certain caves water drips down."

Not satisfied with explanations reliant on a supernatural where the eye cannot peer, the Three Milesians proposed physical, autonomous theory. If Bertrand Russell’s reflection, “It is not what a man of science believes that distinguishes him, but how and why he believes it,” in A History of Western Philosophy (1945) yet stands, the field of natural science was born in Milet.

Underground rivers (or anything physical, for that matter) are not manifestations of arbitrary powers, but are orderly, consistent and objective outcomes of natural rules.

Xenophanes of Colophon (570-470 BC) merits mention in our chronology.

> *The sea is the source of the waters and the source of the winds. Without the great sea, not from the clouds could come the flowing rivers.*

Xenophanes was onto something remarkable, that the waters of the earth are interdependent. He, of course, wasn't the first to recognize the link, but he was among the first to record the tie as a natural dependency, not as divine whim.

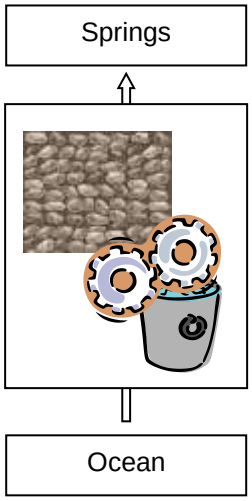
As we shall note in Chapter 4, The Cross, however, subsequent theological doctrine and uncritical observation will for another two millennia cite similar declarations to justify the uphill flow of underground rivers.

Heraclitus of Ephesus (540-475 BC) added the temporal dimension to questions of hydrology. "No man can twice step into the same river" isn't just about rivers, of course, but about development and decay, a causal chain for water's perpetual mobility.

Heraclitus noted the following.

The sun is a bowl, the concave side turned towards us, in which the bright exhalations from the sea collect and burn.
The vapor, after kindling and going out again, reappears as dark clouds and fiery water spouts resembling smoke and comes down as water.
As the sea is increased by rain, water passes into the earth.
As the sea is diminished by evaporation, the earth is proportionally liquefied.
At any moment, half of the sea is taking the downward path, having just been a fiery storm cloud, while half of it is going up, having just been earth.

We're not told the means, but we can draw a schematic.

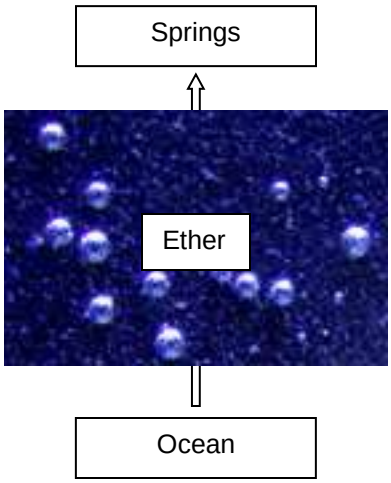


Anaxagoras of Clazomenae (500-428 BC) lived in Athens until being accused of heresy for asserting that the sun is not a god. Anaxagoras envisioned percolated rainfall gathered in subterranean caverns, hydrology's first reservoir theory.

> *Rivers depend for their existence on the rains and on the water within the earth, as the earth is hollow and has water in its cavities.*

The substratum rests on ether, the lightest of all elements, which in streaming upward, entrains cavern-trapped rain water and caries it to springheads. Streams that cease flowing in summer are fed from reservoirs too small to store enough water. Differing from Heraclitus, no new water is generated within the earth.

Here's a schematic version of Anaxagoras' model.



If the porous upper stratum is plugged by downpours, the ether may exit forcibly as an earthquake.

Democritus (460-370 BC) held that the world was round and was composed of tiny atoms. His cosmology can be summarized by words from the poet Percy Shelley (1792-1822).

Worlds on worlds are rolling ever
From creation to decay,
Like the bubbles on a river
Sparkling, bursting, borne away.

We will later turn to Democritus to explain how "salt" atoms might drive underground fresh-water rivers to mountain springs.

Hippo of Samos (c. 450 BC) wrote that all rivers, springs and wells have their source in the ocean because the sea is the deepest, a unifying physical explanation for hydrologic linkage. While invalid in light of modern hydrostatics, we're more-and-more seeing a logic that's turning toward physical law.

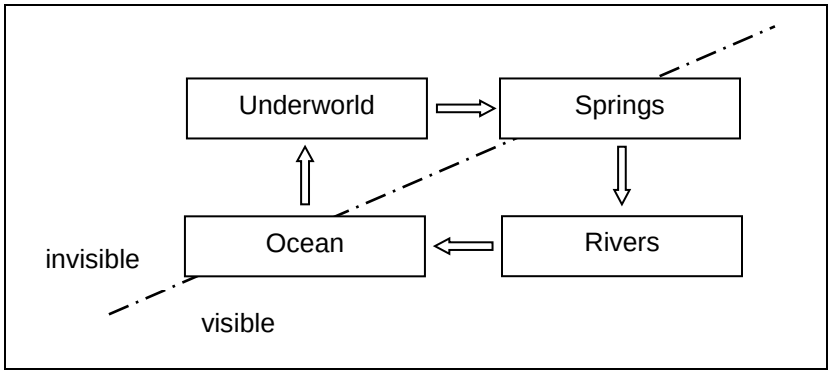
Like his mentor Socrates (470-399 BC), Plato (428-348 BC) dismissed truth by observation, seeing “form” as the essence that relates to with what it participates. Plato’s universe is the product of divine intelligence, the “Demiurge,” the personification of reflection and reason. Physical experiment is but a base art.

As did his teacher, Plato found little problem in reverting to folklore for questions of mere substance. Plato’s Timaesus tells of Atlantis, larger than Asia and Libya together, located on the far side of the Pillars of Hercules (modern Gibraltar). He visited Sicily in 387 BC to view Mt. Etna

which eleven years before had produced one of its greatest eruptions (Chapter 3), but Plato's thoughts did not stoop to geology. If anything, the devastation cemented Plato's reliance on the supernatural.

Timaesus also furthered the paradigm of microcosm and macrocosm, a world view to persist for another 2000 years. To understand the cosmos, we need only know the anatomical, physiological and psychological structure of man. We'll see the implications for underground rivers in Chapter 8, Transmutational and Bilological Engines.

The schematic suggests how Socrates and Plato would have viewed the flow of springs.



The Platonic Hydrologic Cycle

Re-label "Springs" as "Craters" and note that Etnean lava flowed as rivers to the sea and the upward arrow becomes the River Pyriphlegethon. In the case of water, Plato's visible portion is correct. It is in the unseen portion where arrows are misdirected that has come to be known as a "reversed" hydrologic cycle.

In Phaedo, Plato speculates,

> *Some* (rivers] *flow in on the opposite side from where they came out, and others on the same side, while some make a complete circle, and winding like a snake... round the earth, descend as far as possible before they again discharge their waters*

Note his use of "wider channels" from the same source, what seem to be river-like passageways.

> *But all these are in many places perforated one into another under the earth, some with narrower and some with wider channels, and have passages through, by which a great quantity of water flows from one into another, as into basins, and there are immense bulks of ever-flowing rivers under the earth, both of hot and cold.*

In Critias, written some years later, Plato refers to the Athens region in former times.

> [Rainwater was] *not lost to it, as now, by flowing from the bare land into the sea; but ... , storing it up in the retentive loamy soil, and by drawing off into the hollows from the heights the water that was there absorbed, it provided all the various districts with abundant supplies of spring-waters and streams.*

Perhaps recounting ancient Athens through the voice of Critias freed Plato's mind to ponder more of the mundane.

> *He* [Plato] *says that they all flow into each other beneath the earth through channels pierced through it, and that their original source is a body of water in the center of the earth called Tartarus, from which all waters running of standing are drawn. This primary and original mass causes the flow of various rivers by surging perpetually to and fro; for it has no fixed position but is always oscillating about the center, and its motion up and down fills the rivers. Many of them form lakes, one example of which is the sea by which we live, but all of them pass round again in a circle to the original source from which they flowed; many return to it again at the*

> *same place, others at a point opposite to that of their outflow, for instance if they flowed out from below, they return from above.*

Plato identifies Tartarus as the underworld's lowest abyss because it pierces through the whole earth. Repeating Anaxagoras, all waters begin in Tartarus and endlessly journey to return to their Tartarean source. Water does this because a liquid has no bottom or foundation; hence, it oscillates up and down as do air and winds. Points of egress and ingress may be close together or far apart.

That much said, however, we must note that Plato identified little with Homer's world view. As reality is something else, the latter's version about Tartarus was good enough. Had not Aristotle -- concerned with worldly things more than was than Plato -- not quoted his teacher as a basis for further discussion, we'd not have Plato's reference to the myth. Plato, we must suppose, wasn't arguing for the folklore's veracity as much as he was summarizing popular belief.

Plato's successors as head of his Academy, Speusippus and Xenocrates, deemed in turn that mathematics was the highest level of existence, even primary to soul. We can only speculate if such metaphysics might have segued into quantifiable science had not the Romans sacked the Academy in 86 BC.

At age 17, Aristotle (384-322 BC) enrolled in the Academy where the master soon called him the "mind of the school." Aristotle remained at the Academy until Plato's death, after which Aristotle became a teacher himself, spending two years studying marine biology on Lesbos where he recognized dolphins as mammals.

Italian Banknote, “The School of Athens” by Raphael (1483-1520)

Plato and Aristotle stand at the center. Plato (on the left) is modeled after da Vinci, another underground-river scholar with whom we will come to be relentlessly acquainted in Chapter 7, The Concept of Circulation.

An equally-unlikely representation of Aristotle, André Thevet's Les Vrais Pourtraits et Vies Hommes Illustres (1584). The philosopher in Reminiscence garb may not be that far-fetched, however, as he'd only grown more popular.

In contrast to Plato's emphasis on the abstract, Aristotle's reality was derived through the senses. The world is comprised of individuals grouped into fixed kind -- “speciation” to a modern biologist. Each individual has an inherent pattern of development toward a group-defined self-realization. Growth, purpose, and direction are thus built into nature. Humankind’s purpose is to reason. Zoology rested on Aristotle's foundation until Charles Darwin disputed the fixity of species in 1859.

The earth and the heavens are subject to unlike natural laws -- earthly things are changeable and corrupt, while the heavens are permanent. The regenerative process keeps the decaying earth in equilibrium within an eternal universe. Nature’s purpose is to maintain balance and Aristotle’s interest was that of finding the predefined function teleology each component.

Matter is of four sensible qualities: cold, hot, wet and dry. We will see the geophysical implications of transmutation in Chapter 8; it opens up a multitude of explanatory possibilities.

Aristotle's factor of tens ("decuplo") established that proportionality 1:10:100:1000 for earth, water, air and fire, respectively.

Aristotle criticized Plato's subterraneous reservoir theory, noting that Tartarus would have to be impossibly large.

> *But if anyone will picture to himself a reservoir adequate to the water that is continuously flowing day by day, and consider the amount of water, it is obvious that a receptacle that is to contain all the water that flows in the year would be larger than the earth, or, at any rate, not much smaller.*

Aristotle likewise rejected that streamflow was generated in upland lakes.

> *The fact that rivers have their sources at the foot of the mountains proves that the place accumulates water little by little by a gradual collection of drops, and that the sources of rivers are formed this way. It is of course not at all impossible that there do exist such places containing large amounts of water, like lakes; but they cannot be so large as to act in the way this theory maintains, any more than one could reasonably suppose that their visible sources supply all the water for the rivers, most of which flow from springs. It is thus equally unreasonable to believe either that lakes or that the visible sources are the sole water supply.*

Aristotle recognized that vapor from marine evaporation causes rainfall.

> *Now the sun, moving as it does, sets up processes of change and becoming and decay, and by its agency the finest and sweetest water is every day carried up and is dissolved into vapor and rises to the upper region, where it is condensed again by the cold and so returns to the earth.*

He likewise recognized the principle of a hydrologic cycle.

> *For according as the sun moves from side to side, the moisture in this process rises and falls. We must think of it as a river flowing up and down in a circle and made up partly of air and partly of water.*

Aristotle looked upon cool mountains as the site of direct condensation. The water so condensed was then held by then like water in saturated sponges to be gradually released in springs.

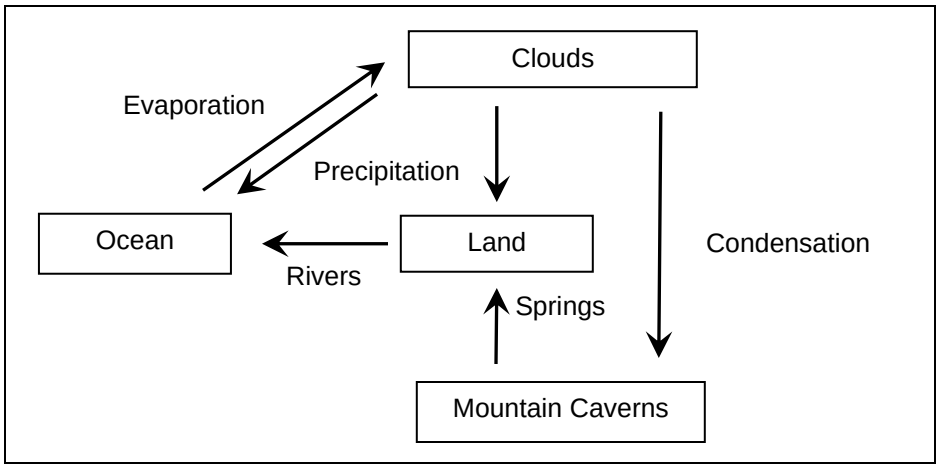
> *The process is rather like that in which small drops form in the region above the earth, and these join again others, until rain water falls in some quantity; similarly inside the earth, as it were, at a single point, quantities of water collect together and gush out of the earth and form the sources of rivers. A practical proof of this is that where men make irrigation works they collect the water in pipes and channels, as though the higher parts of the earth were sweating it out.*
>
> *Similarly, the majority of springs are in the neighborhood of mountains and high places, and there are few sources of water in the plains except rivers. For mountains and high places act like a thick sponge overhanging the earth and make the water drip through and run together in small quantities in many places. For they receive the great volume of rain water that falls... and they cool the vapor as it rises and condense it again to water.*

The question becomes, from where does such water rise?

According to Aristotle, it rises from both below and above the earth. Keeping in mind that Aristotle did not distinguish between air and water vapor,

> *It is unreasonable for anyone to refuse to admit that air becomes water in the earth for the same reason that it does above it.*
>
> *The air surrounding the earth is turned into water by the cold of the heavens and falls and rain... The air which penetrates and passes the crust of the earth also becomes transformed into water owing to the cold which it encounters there. The water coming from the earth unites with rainwater to produce rivers. The rainfall alone is quite insufficient to supply the rivers of the world with water.*

Let us reduce Aristotle's thoughts to a schematic, a much enhanced of the earlier one done for Heraclitus.



Aristotle's Hydrologic Cycle

Had Greek thought continued to advance, we can only speculate that the scientific realizations of the 17th century might have occurred much earlier. But were that the case, we'd be already approaching the end of our journey, and in counting the pages, we're not even close.

In the first chapter, we floated through the Greek underworld with little hope or comprehension. The philosophers of this chapter haven't made our journey a pleasant excursion, but they've admirably argued for an underlying order to the flow.

We keep in mind the nagging fact that in our journey so far, none of the pundits have themselves seen the waters of which we speak.

Perhaps what we need are some able note-takers, scholars who'll help us find a pattern in the fluvial underground. With that in mind, let's go to Rome.

We title this chapter "Encyclopedists" because Rome's contribution to knowledge of underground rivers largely derives from a mindset. The Roman intellectual's task wasn't to ponder, but rather to harvest. As the journey before us, we're not ourselves conceiving ideas about underground rivers; we're grouping what we find into a sequence of chapters.

We'll begin our Roman review with a reminder that the Latin starting point, while by no means one based in science, was well-footed in physical observation. We find the rainfall-runoff correspondence in the odes of Horace (65-27 BC) celebrating of the Greek poet Pindar (522-BC).

> *Like to a mountain stream rushing down in fury,*
> *Overflowing the bunks with its rain-fed current,*
> *Pindar's torrent...*

Engineer Marcus Vitruvius' (80-20 BC) greatest contribution to the Cesar's empire was not constructed works, but rather his ten-volume De Architectura, the eighth volume being De Aquis et Aquaeductu. A technology-laden page from the 1567 edition is shown to the right, testament to the lasting power of the book.

Our interests, however, pertain more to Vitruvius' allusions to rivers beneath the earth's surface. As in a hot bath, according to De Aquis, waters on the earth are heated by the sun to form vapors and clouds which when they impact the mountains,

> *Swell, and become heavy, break and disperse themselves on the earth. The vapors, clouds and exhalations which rise from the earth seem to depend on its retention of inner heat, great winds, cold moisture and large proportion of water. Then when from the coolness of the night, assisted by darkness, winds arise and clouds are formed in damp places, the sun, at its rising, striking on the earth with heat power, and thereby heating the air, raises its vapors and dew at the same time.*

Vitruvius describes the amount and taste of water which might be found in different soils and notes how mountain snowfall issues forth as springs.

> *The trees which grow in great numbers in the mountains contribute to the accumulation of snow during long periods, after which it begins to slowly percolate beneath the soil, and this same water, once infiltrated, arrives at the foot of the mountains, the location of springs.*

What we quote is reasonably correct, but doesn't move to reasons. Had Vitruvius cited a principal such as gravity, for example, subsequent natural philosophers might have had more doubt about a route from the sea to the feet of mountains.

Strabo (63 BC-24 AD), master of Greek literature, traveler and philosopher, is best known for his 17-volume Geographia, a geographical compilation from works that largely have not survived.

Strabo attributed the fire of Mt. Etna and of the volcanic island Thermessa to combustion because when the winds die, so do the flames. The wind is in turn fueled by evaporation from the sea. Incorrect, we might judge, but at least there's a hint of the type of causality espoused by the natural philosophers from whom he was drawing.

Strabo reported "the Cave of the Sibyl" within the Phlegraean Fields in the sulfurous caldera of Mt. Vesuvius near modern Naples, exactly the type of clue that fuels archeologists. Discovery in

the 1960s of a hewn tunnel descending 40 meters in hot rock to an artificial channel going nowhere may have resolved the question. The layout conforms to Virgil's description in the Aeneid of Aeneas' journey to the underworld. Quoting from the Smithsonian.com October 1, 2012 feature, "The Unsolved Mystery of the Tunnels at Baiae,"

> [The tunnel system may have] *been constructed by priests to mimic a visit to the Greeks' mythical underworld. In this interpretation, the stream represented the fabled River Styx, which the dead had to cross to enter Hades; a small boat, the explorers speculated, would have been waiting at the landing stage to ferry visitors across. On the far side these initiates would have climbed the stairs to the hidden sanctuary.*
>
> *The tunnels... might have been constructed to allow priests to persuade their patrons -- or perhaps simply wealthy travelers–that they had traveled through the underworld. The scorching temperatures below ground and the thick drifts of volcanic vapor would certainly have given that impression. And if visitors were tired, befuddled or perhaps simply drugged, it would have been possible to create a powerfully otherworldly experience capable of persuading even the skeptical.*

We'll have more to say about Leonardo da Vinci's and Athanasius Kircher's interest in Mount Vesuvius in Chapter 9 (Thermodynamic Engines).

Lime-laden geothermal streamlets lace the cliffs above of ancient Hierapolis, today's Pamukkale in southwestern Turkey. In Greco-Roman times, a cave known as Pluto's Gate -- Plutonion in Latin -- was celebrated as the portal to Hades. Pilgrims sacrificed birds in the lethal gasses -- mostly carbon dioxide -- emitting from the cave mouth. The site's temple was protected from the gas by allowing it to escape through gaps between the paving stones.

Artist's reconstruction of ancient site

Strabo made mention of Pluto's Gate in Geographia.

> *This space is full of a vapor so misty and dense that one can scarcely see the ground. Any animal that passes inside meets instant death... I threw in sparrows and they immediately breathed their last and fell.*

Asclepiodotus, c. 500 AD, mentioned the hot stream inside the cavern. Functional until the fourth century, the temple was destroyed by Christians in the sixth century.

Today, the 34-degree C effluent precipitates avulsing lime-walled channels 30 centimeters in width and up to 2 meters in depth. The cavern is large enough to allow just one person to descend to its 3-square-meter chamber under which noxious thermal water can be seen in a cleft in the rock. Fumes from the cavern still maintain their deadly toll in birds attracted by the warm air.

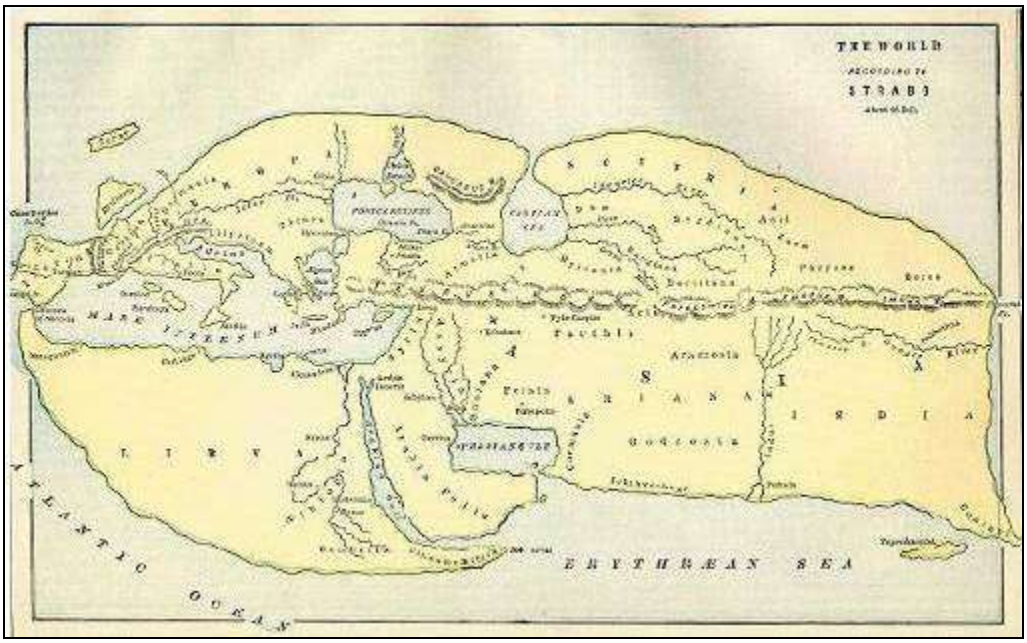
Strabo was the recorder of many "lost river" accounts, among them, the loss of the Timavo east of Trieste in a cavern and its reappearance at the coast -- a river we'll travel in Chapter 78, Underground and Balkanized. Another lost river is the subject of Chapter 29, Et In Arcadia Ego

> *Erasmus which now flows underground from the Stymphalian Lake and issues forth into the Argive country, although in earlier times it had no outlet, since the berethra* [pits*] which the Arcadians call "zerethra" were stopped up and did not admit of the waters being carried off.*

And yet another lost river reported by Strabo is the Nile, itself, subject of Chapter 14.

A lost river story rejected by Strabo is one in which "the mouth of the river empties into the sea in full view and there is no mouth [whirlpool] on the transit, which swallows it up."

Although Strabo noted what were said to be lost rivers, his encompassing geographical compilation -- his lasting contribution -- showed none.



Strabo's Geographia notes what may have been a geographical root of Charon.

> *One comes to a village [in Karia, Asia Minor], the Karian Thymbria, near which is Aornon, a sacred cave, which is called Charonion, since it emits deadly vapors.*

Strabo mentioned that Lake Copais north of the Peloponnese was drained naturally by an underground channel some 5 kilometers in length which rose again near Larymna.

From Herodotus' Persian Wars (c. 435 BC),

> *When Cleomenes had sent to Delphi to consult the oracle, it was prophesied to him that he should take Argos; upon which he went out at the head of the Spartans, and led them to the river Erasinus. This stream is reported to flow from the Stymphalian lake, the waters of which empty themselves into a pitch-dark chasm, and then (as they say) reappear in Argos, where the Argives call them the Erasinus.*

Drawing upon this, Strabo described a subterranean connection between the River Stymphalus (and, by extension, Lake Stymphalus) and the Argive River Erasinus, placing the river's emergence at a spring between Argos and Lerna. We'll have more to say about the area's hydrology in Chapter 29, Et In Arcadia Ego.

Strabo stated that at one time the sink was blocked by an earthquake, making the lake much larger. Citing the authority Eratosthenes (c. 275-194 BC), Strabo noted that the sink occasionally plugged, causing flooding near Pheneus and a flood surge downstream.

During the Battle of Mantinea, 418 BC, the Spartans were said to have flooded the path of their enemies by diverting the River Sarandapotamos to the bed of the smaller River Zanovistas and plugging the latter's sinkholes.

In like manner, when Iphicrates was besieging the Spartan town of Stymphalus some years later, it was said that he attempted to inundate the defenses by blocking the sink with sponges.

The Stymphalus was said by Diodorus of Sicily, writing between 56 and 36 BC, to descend underground through a sinkhole, flow 32 kilometers through underground passages, and resurface before emptying into the Gulf of Argos.

According to Strabo's Geographia, the Pyramus River (now the Ceyhan River in Turkey) sprang out of the earth again with such force that a javelin could scarcely be pushed into the water.

> *But the Pyramus, a navigable river with its sources in the middle of the plain, flows through Cataonia. There is a notable pit in the earth through which one can see the water as it runs into a long hidden passage undoing and then rises to the surface. If one lets down a javelin from above into the pit, the force of the water resists so strongly that the javelin can hardly be immersed in it.*

The river in bore such a quantity of sediment that, according to an oracle, its deposits would one day unite Cyprus with the mainland. Today's waterway is less dramatic, having been dammed for hydroelectric generation, flood control and irrigation

In Publius Ovidius Naso's (43 BC-17 AD) -- Ovid to us -- Metamorphoses (8 AD), the engulfed Stymphalus "glides in secret eddies underground" before returning as a lordly river in the Argive fields.

The modern Peloponnesian water tracing to the right closely agrees with the ancient record. The water flows underground until forced to the surface at Kefalari. We'll learn why in Chapter 40, Karstology.

Near the end of this chapter we'll table more of the encyclopedists' reported subterranean rivers. Most of their reporting hasn't borne out as well as has the Stymphalus-Erasinus pipeline, however.

The works of Strabo and Ovid would fuel centuries of geologic speculation. From this point onward, the world would know of Greece not only in the sense of myth and history, but also as a landscape of disappearing and reappearing waters.

Born in Spain, Annaeus Seneca (4-65 AD) came to Rome as physician to Nero, who ultimately rewarded his attendant by execution. Seneca's Questiones Naturales was an ill-sorted compilation of secondhand ideas. To the right is the cover from a 1542 edition, another hint of how lasting would be the Latin libraries. Seneca, like Vitruvius, would be considered expert in water issues for 1500 years.

A vast world exists below.

> *There exist below everything that you see above. There, too, are vast, immense recesses and vacant space, with mountains overhanging on either hand.*

Seneca attributed groundwater three sources:

1. Moisture continuously expelled within the earth.

   > *The Sea... does not get larger, because it does not assimilate the water that runs into it, but forthwith restores it to the earth. For the sea water returns by a secret path, and is filtered in its passage back. Being dashed about as it passes through the endless, winding channels in the ground, it loses its salinity, and, purged of its bitterness in such a variety of ground as it passes through, it eventually changes into pure, fresh water.*

2. Sluggish air converted into water within the earth by the forces of darkness and cold. Just as a change in atmospheric density produces rain, a change of density beneath the earth turns air into water. Locked in perpetual darkness, frigidity and inertness, the subterranean forces supply the springs above without pause.

   > *We Stoics are satisfied that the earth is interchangeable in its elements. So all this air that she has exhaled in her interior, since it was not taken up by the free atmosphere, condenses and is forthwith converted into moisture.*
   >
   > *There you have the first cause of the origin of underground water.*

   The air above ground cannot long remain sluggish and heavy for it is subject, from time to time, to rarefaction by the sun's heat or expansion by the force of the wind.

[A note regarding nomenclature: "Groundwater" and "ground water" are employed with roughly-equal frequency in both technical and popular literature. For internal consistency, we will use the former, except for bibliographic references worded otherwise. "Underground water," on the other hand, is just an adjective and noun, and written accordingly.]

3. Earth converted to water.

   > *All elements arise from all: air comes from water, water from air; fire from air, air from fire. So why should not earth be formed from water, and conversely, water from earth?*

Seneca takes the trouble to refute a standard objection to transmutation. Given the boundless supply of earth, why would water courses and springs ever dry up? His reply is that the course of the water, not its source, is often disturbed by shocks in the earth.

He dismissed the role of rainfall in springflow.

> *Some suppose that all the water that the earth drinks in from rain is sent out again into the rivers... [But] a great deal can obviously be urged in reply to this. First of all, as a diligent digger among my vines, I can affirm from observation that no rain is ever so heavy as to wet the ground to a depth of more than 10 feet... How, then, can rain, which merely damps the surface, store up a supply sufficient for rivers?*

Rain only feeds the regular rivers and creates temporary torrents. As water is "a quarter of nature," there can be no shortage of it. "Rains cannot produce; they can only enlarge and quicken a river."

Soil moisture, seen by Seneca in global perspective, moves from north to south.

> *The next account is that of Diogenes of Apollonia... The whole earth is full of perforations, and there are paths of intercommunication from part to part. From time to time the dry parts draw upon the moist. Had not the earth some source of supply, it would ere this have been completely drained of its moisture. Well, then, the sun attracts the waves. The localities most affected are the southern. When the earth is parched, it draws to it more moisture, just as in a lamp the oil flows to the point where it is consumed, so the water inclines toward the place to which the overpowering heat of the burning earth draws it. But where, it may be asked, is it drawn from? Of course, it must be from those northern regions of eternal winter, where there is a superabundance of it.*
>
> *Now, one would like to ask Diogenes, seeing the deep and all streams ire in intercommunication, why the rivers are not everywhere larger in summer? ...Another question-seeing that every land attracts moisture from other regions, and a greater supply in proportion to its heat, why is any part of the world without moisture?*

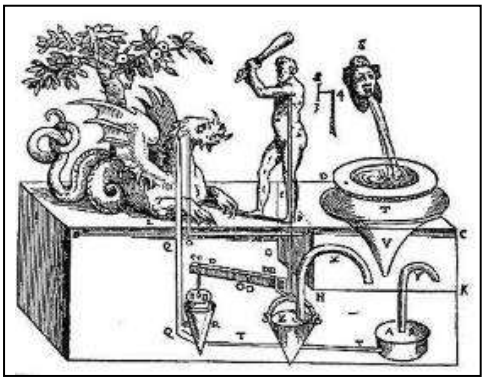
Regarding underground rivers,

> *Rivers are no less existent under the earth merely because they are not seen. You must understand that down there rivers as large as our own glide along, some flowing gently, others resounding in their tumbling over the broken ground. What then? Will you not equally allow that there are some lakes underground and some waters stagnating there without exit?*
>
> *Throughout the entire earth, one of them says, run many different kinds of water. In some places there are perpetual rivers large enough to be navigable, even without the help of rains.*
>
> *Moving air in the lower region inside the earth bursts the atmosphere, thick and complete with clouds, with the same force that clouds in our part of the world are usually broken open.*
>
> *Now permit me to tell you a story. Asclepiodotus is my authority that many men were sent down by Philip* [Philip II of Macedon (382-336 BC), father of Alexander the Great] *into an old mine, long since abandoned, to find out what riches it might have, what its condition was, whether ancient avarice had left anything for future generations. They descended with a large supply of torches, enough to last many days. After a while, when they were exhausted by the long journey, they saw a sight that made them shudder: huge rivers and vast reservoirs of motionless water, equal to ours above ground and yet not pressed down by the earth stretching above, but with a vast free space overhead.*

Heron of Alexandria (10-70) was a Greek engineer and geometer in Roman times. Hero is credited with the first documented steam engine, the "aeolipile." In Dioptra he notes,

> *In order to know how much water the spring supplies it does not suffice to find the area of the cross section of the flow which in this case is 12 square digits. It is necessary also to find the speed of the flow, for the swifter the flow, the more water the spring supplies, and the slower, the less. One should therefore dig a reservoir under the stream and note with the help of a sundial how much water flows into the reservoir in a given time.*

In the field of hydraulics, however, Heron's acknowledgement of velocity fell by the intellectual wayside.



Reconstruction of one of Heron's "automata" by Giovanni Battista Aleoti (1589). When Hercules hits the head of the dragon, the monster shoots water on his face.

In the chronologic midst of the Encyclopedists, we find Philo (20 BC - 50 AD), a Hellenistic Jew working to harmonize his faith with Greek thought. Paradise may be located, according to Philo's Questions and Answers on Genesis,

> *In some distant place far from our inhabited world, and has a river flowing under the earth, which waters many great veins so that these rising send water to other recipient veins, and so become diffused.*

Philo's fellow Hebrews would have little cared about the location of Paradise and his effort added nothing to the Roman cartographic database, but Philo's speculation illustrates the ongoing amalgamation of philosophies. As we will see in Chapter 4, The Cross, the Christians to follow would become adamant proponents of the "river flowing under the earth."

Natural historian Gaius Plinius Secundus (23-79), better known as Pliny the Elder, extracted 20,000 facts from 2,000 volumes to write Naturalis Historia, surely the most ambitious literature review of all time. His "facts" were largely travelers' tales (e.g., an account of the Monocoli monopodal race), reports of marvels (e.g., a boy commuting to and from school on a dolphin), and ancient belief (e.g., the correlation between celestial bodies and metals, the Sun being gold; Mars, iron; Saturn, lead; and the Moon, silver).

To the right is a hand-illuminated page from the 1472 printing of Naturalis Historia. By any measure, the Romans garnered a long-lasting readership.

Pliny adhered to the Oceanus theory, citing Aristotle's authority.

> *The intention of the Artificer of nature must have been to unite the earth and water in a mutual embrace, earth opening her bosom and water penetrating her entire frame by means of a network of veins radiating within and without, above and below, the water bursting out even at the tops of mountain ridges, to which it is driven and squeezed out by the weight of the earth, and spurts out like a jet of water from a pipe. This theory shows clearly why the seas do not increase in bulk with the daily accession of so many rivers. The consequence is that the earth at every point of its globe is encircled and engirdled by sea flowing round it.*

Pliny accepted Aristotle's subterranean hydrologic cycle, the proof stemming from water's preferred shape.

> *But what the vulgar most strenuously contend against is, to be compelled to believe that the water is forced into a rounded figure; yet there is nothing more obvious to the sight among the phenomena of nature. For we see everywhere, that drops, when they hand down, assume the form or small globes.*

Pliny refers to a network of veins where,

> [Water] *pushed by blasts of air and compressed by the weight of the earth... gushes forth in the manner of a pump* [siphon] *to the highest levels.*

Pliny endorses Aristotle as to "why the sea is salt" and gives qualitative description of salinity distribution with depth:

> *Hence it is that the widely-diffused sea is impregnated with the flavor of salt, in consequence of what is sweet and mild being evaporated from it, which the force of fire easily accomplishes; while all the more acrid and thick matter is left behind; on which account the water of the sea is less salt at some depth than at the surface.*

Naturalis Historia provided a compendium of subterranean streams.

> *But some rivers so hate the sea, that they actually flow underneath the bottom of it, for instance the spring Arethusa at Syracuse, in which things emerge that have been thrown into the Alpheus which flows through Olympia and reaches the coast in the Peloponnese.*

We will see more of this Syracuse connection in Chapter 29, Et In Arcadia Ego.

> *Instances of rivers that flow underground -- and come to the surface again are the Lycus in Asia, the Erasinus in the Argolis and the Tigris in Mesopotamia; and objects thrown into the Baths of Aesculapius at Athens are given back again in Phaleron Harbor* [about 10 kilometers distant]*. Also a river that goes underground in the Plain of Atinas* [in modern Turkey] *comes out 30 kilometers further on, as also does the Timavo in the district of Aquilea.*

We will see more to the Timavo connection in Chapter 78, Underground and Balkanized.

Pliny observed an underground river from Lake Vadimo in Etruria (modern Tuscany), scene of a 310 BC battle.

> *The water is sky-blue; its smell is sulfurous, and its flavor has medicinal properties, and is deemed of great efficacy in all fractures of the limbs. This lake empties itself into a river, which, after running a little way, sinks underground, and, if anything is thrown in, it brings it up again where the stream emerges.*

Pliny the Younger (61-114) reported that his uncle, commanding the fleet at Misenum, ordered his ships to cross the Bay of Naples for a first-hand look at Mt. Vesuvius where the fumes and ash became so strong that they suffocated him.

Considering the consequence of Pliny the Elder's field trip, perhaps we should be less harsh on the encyclopedists who worked from their offices in Rome.

In a letter written between 98 and 108 AD, the younger Pliny describes a peculiar spring near the modern Lake Como:

> *There is a spring which rises in a neighboring mountain, and... falls into the Larian Lake. The nature of this spring is extremely surprising. It ebbs and flows regularly three times a day. The increase and decrease are plainly visible, and very amusing to observers. You sit down by the side of the fountain, and whilst you are taking a repast, and drinking its water, which is extremely cool, you see it gradually rise and fall. If you place a ring, or anything else, at the bottom when it is dry, the stream reaches it by degrees till it is entirely covered, and then gently retires; and if you wait you may see it thus alternately advance and recede three successive times.*

Pliny first considers the behavior of a liquid poured from a narrow-necked bottle,

> *Shall we say that some secret current of air stops and opens the fountain head as it approaches to, or retires from it, as we see in bottles and other vessels of that nature when there is not a free and open passage? Though you turn their necks downwards, yet, the outward air obstructing the vent, they discharge their contents as it were by starts.*

Or subterranean winds from the sea,

> *But may it not be accounted for upon the same principle as the flux and reflux of the sea. Or, as those rivers which discharge themselves into the sea, meeting with contrary winds and the swell of the ocean, are forced back into their channels, so may there not be something that checks this fountain, for a time, in its progress?*

Or the overflow of a subterranean reservoir,

> *Or is there, rather, a certain reservoir that contains these waters in the bowels of the earth, which while it is recruiting its discharges, the stream flows more slowly and in less quantity, but when it has collected its due measure, it runs again in its usual strength and fullness.*

Or some sort of subterranean counterbalance,

> *Or, lastly, is there I know not what kind of subterraneous counterpoise, that throws up the water when the fountain is dry, and stops it when it is full. You, who are so well qualified for the inquiry, will examine the reasons of this wonderful phenomenon. It will be sufficient for me if I have given you a clear description of it. Farewell."*

This final hypothesis correctly points to a siphon, the subject of Chapter 46, but Pliny did not understand the mechanism.

Pausanias (110-180) left us his Descrittione della Grecia di Pausania, the original travel guide. A 1593 edition is shown to the right.

Pausanias traveled to Arcadia, famous for its closed depressions and perennial springs, where he noted the river Styx.

Pausanias repeated with more topographical detail Strabo's information on the Stymphalus, the combined origin of the Alpheus and the Eurotas, and the further course of the Alpheus to Syracuse.

He recorded an occasion when drifted timber blocked the sink at Stymphalus and the plain became a lake for a width of 75 kilometers. A huntsman following a deer into the marsh was said to have caused the blockage to break apart and be drawn into the sink.

We'll return to Arcadia's depiction in poetry in Chapter 29.

Pausanias wrote that the Helicon River, after a course of 13 kilometers disappears into the earth at the foot of Mt. Olympus and after another 4 kilometers, rises again as the Baphyra, navigable to the sea. Legend told that the women who killed Orpheus wished to cleanse the bloodstains and the river sank underground to avoid being an accomplice.

We're unsure to which modern stream this refers, but modern classicists never stop searching. Pausanias recorded an Arcadian cave in which was lost to history until 1964, but more fundamental than geographical modernity is this segment from Pausanias' sojourn in Epirus,

> *Near Cichyrus is a lake called Acherusia, and a river called Acheron. There is also Cocytus, a most unlovely stream. 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.*

It's Pausanias' tip of the hat to Homer.

The Spring of Castalia rises in the mountains and, though obviously fed by snowmelt, was said to come from the subterranean Styx.

Pausanias, however, had a better story, one involving cakes.

I have heard another account, that the water was a gift to Castalia from the river Cephisus. So Alcaeus has it in his prelude to Apollo. The strongest confirmation of this view is a custom of the Lilaeans, who on certain specified days throw into the spring of the Cephisus cakes of the district and other things ordained by use, and it is said that these reappear in Castalia.

The geographer Eratosthenes supposed that the Egyptian marshes of Rhinosoloura between the Mediterranean and the Red Sea were formed by the Tigris and Euphrates, 1,000 kilometers away.

Following are other Mediterranean-basin rivers said to disappear and re-emerge at locations locatable on modern maps.

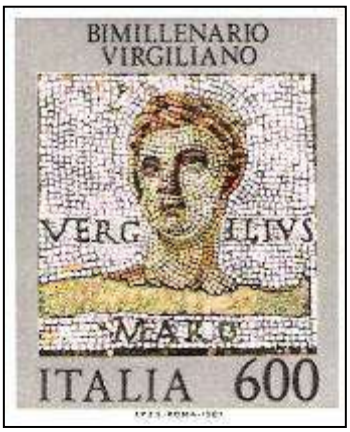
Reported Disappearance	Reported Reappearance
Arcadian Alpheus entering 2 kilometers of bushy wetlands at the Ionian Sea. We'll revisit the lore of Arcadia in Chapter 29.	Arethusa Spring near Syracuse, Sicily, or alternatively, on the Aegean island of Tenedos, south of the Dardanelles.
Asopus flowing through Sicyon, northwest of Corinth	Both Boeotia of modern Greece and Anatolia of modern Turkey.
Inachus in Epirus	Peloponnesus.
Waters in Italy	Sicilian springs
The turbid Acheron in Epirus	Acheron at Hercales Pontica (modern Eregli, Turkey), seen by the Argonauts
Caspian Sea	Black Sea
The Jordan at the Dead Sea	
"Lost rivers" in western Spain.	
The Tigris near its source in Anatolia	

The map traces some of the reported subterranean connections. Dots mark reported submarine springs tabled below.

Reported Submarine Springs

Dulcis Portus on the west coast of Epirus
Spring of Deine in the Argotic Gulf.
Cape Matapan, the southernmost point of Peloponnesus, perhaps a version of the actual cavern discharge at Pirgos Diru.
Between the island of Aradus and the Phoenician mainland, 2 miles off the coast from Tripoli.
Between Baia and Ischia (island west of Naples) or near Pozzuouli, near Naples
Off the coast of Lycia on the southwestern Turkish Anatolian coast.
Côte d'Azuris or 20 kilometers southeast of Marseille
Near Cadiz in the Atlantic.

We'll return to such sites in Chapter 44, Submarine Springs and Submarine Rivers.



Publius Vergilius Maro (70-19 BC) is better known as Virgil. Although his Georgics (29 BC) refers to rivers which issue from caverns as homes to Nymphs, we include this Roman in our study of underground rivers for his contribution of the Aeneid (19 BC), a tale written in praise of the Roman state.

Unlike the encyclopedic works we've cataloged above, the Aeneid is but a story. But in with the encyclopedic works, it's not particularly original. In fact, it's but a re-spin of... -- well, take a guess.

The Aeneid begins with Aeneas' escape during the Trojan War and follows his descent into an underworld of river familiar to us. And whom do we meet? Charon, the curmudgeonly ferryman!

That will be two obols, sir.

The Aeneid parallels the Odyssey in structure, romanizes the characters and expands upon the incidents, but it's Homer's saga. Here's Virgil's Charon in verse.

There Charon stands, who rules the dreary coast --
A sordid god, down from his hairy chin
A length of beard descends, uncombed, unclean;
His eyes, like hollow furnaces on fire;
A girdle, foul with grease, binds his obscene attire.

As noted earlier in this chapter, both Strabo and Pliny spoke of the subterranean Timavo River. So does the Aeneid. From Edward Fairfax Taylor's translation

Safe could Antenor pass the Illyrian shore
Through Danaan hosts, and realms Liburnian gain,
And climb Timavus and her springs explore,
Where through nine mouths, with roaring surge, the main
Bursts from the sounding rocks and deluges the plain.

We will wait until Chapter 78, however, Underground and Balkanized, to pull the Roman accounts into geographical relationship.

In the manner of the table in Chapter 1,

	 Odyssey (c. 855 BC)	 Aeneid (19 BC)
Author	Homer	Virgil
Protagonist	Odysseus	Aeneas
Setting	Mythical Mediterranean, mythical times	
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Arms, and the man I sing, who, forc'd by fate, and haughty Juno's unrelenting hate, Expell'd and exil'd, left the Trojan shore.*
Characters	Lotus Eaters Cyclops Sirens	Odyssey survivor's tale
Rivers	Acheron Cocytus Styx Lethe Pyriphlegethon	*To deep Acheron they take their way, whose troubled eddies, thick with ooze and clay, are whirl'd aloft, and in Cocytus lost.* Between the living and dead. On the far side, Aeneas' descendants

By the late third century, Rome was intellectually spent, the Empire having spun itself into two segments, the western half to be the foundation for the European Middle Ages and the eastern half to become the Byzantine Empire.

But before advancing to Chapters 4-6 to see what became of the Greco-Roman legacy, let's summarize our journey to this point.

Greek mythology laid down a rich lore of underground rivers.
Greek philosophers molded the tales into explanatory patterns based on reason.
Roman encyclopedists dutifully cataloged numerous instances of such waters.

One might think that the topic of underground rivers is now resolved, but the Greeks and Romans were just feeding our curiosities.

CHAPTER 4
THE CROSS

In this and the next two chapters we will chronicle

The first millennium. How the nature of underground rivers fell into the domain of Christian theology.

The change of millennia. How Greek thought regarding such waters was preserved by the Arabs.

The early second millennium. How the Church reinterpreted what flows beneath the earth.

To begin, we'll summarize the Christian interpretation's Hebrew formulation in an environment where water and cultural destiny intertwine. The tribe controlling the water sources is the tribe that survives.

The Book of Genesis

As would have most early Christians addressing the workings of nature, we'll start with Creation,

The world's water originated within the earth, as chronicled in Genesis 2:6.

But there went up a mist from the earth, and watered the whole face of the ground.

The "mist" is "ed" in Hebrew which also means flow, stream or spring. Etymology points to the Sumerian/Akkadian "id," the cosmic river, as in "from the mouth whence issues the waters of the earth and brought her sweet water from the earth," in the Sumerian story of Enki and Nihursag.

Genesis 2:10-14 enumerates what have come to be known as the "Four Rivers of Life," the Pison, Gihon, Hiddekel and Perath.

And a river went out of Eden to water the garden; and from thence it was parted, and became into four heads.
The name of the first is Pison: that is it which compasseth the whole land of Havilah, where there is gold;
And the gold of that land is good: there is bdellium and the onyx stone.
And the name of the second river is Gihon: the same is it that compasseth the whole land of Havilah.
And the name of the third river is Hiddekel: that is it which goeth toward the east of Assyria. And the fourth river is the Perath.

The Hiddekel and the Perath are likely the Tigris and Euphrates. As "Havilah" means "stretch of sand," the Gihon is associated with desert and thus, the Nile. (Jerusalem's Gihon Springs -- which we'll visit in Chapter 65, Subterranean Aqueducts -- was named from the Genesis story, not the other way around.)

The modern identity of the Pison is disputed. The Ganges, the Araxes and the Uizhun have been proposed as well as the now-dry Wadi Bisha in Kuwait. Early Syriac commentators endorsed the Danube. The Hebrew scholar Nahmanides thought the Pison to be the Indus.

While the Book of Genesis makes no assertion that any of the rivers flowed underground, the need for such a pathway seems sound. As Yi-Fu Tuan notes in The Hydrologic Cycle and the Wisdom of God (1968),

The Garden of Eden is without weather. Ideally Eden is a balmy and sunny place having more or less the climate of sub-tropical desert, and yet watered by four perennial streams. Such geography demands a subterranean source for surface water.

Topographia by Cosmas Indicopleustes, a sixth-century Christian merchant, describes the Red

Sea and Indian Ocean as having rivers beneath them which "cleave a passage through the ocean and spring up in this earth."

> *Divine scripture, with a view to show the diameter of Paradise, how great it is, and how far it extended eastward, mentions the four rivers only, and thence we learn that the fountain which springs up in Eden and waters the garden, distributes the residue of its waters among the four great rivers which cross over into this earth and water and a large part of its surface.*

We'll inspect Cosmas' sub-oceanic river map in Chapter 14.

Let us turn to Genesis 4:11-12.

> *And now art thou cursed from the earth, which hath opened her mouth to receive thy brother's blood from thy hand. When thou tillest the ground, it shall not henceforth yield unto thee her strength; a fugitive and a vagabond shalt thou be in the earth.*

Note the change of adverb in the chronology of translations.

King James Version	1611	in the earth
American Standard Version	1901	in the earth
Revised Standard Version	1946	on the earth
New International Version	1973	on the earth
New King James Version	1982	on the earth
21st Century King James	1994	on the earth

Are we on the earth, or are we inside it? We'll speculate in Chapter 15, Hollow Earth Geophysics.

Genesis 11:7 concerns Noah's Flood.

> *The same day were all the fountains of the great deep broken up, and the windows of heaven were opened.*

"Fountains of the deep," will come to be a favorite phrase of those striving to assign a Biblical basis to the science of hydrology.

The Book of Exodus

Subterranean waters made the Second Commandment, Exodus 20:4.

> *Thou shalt not make unto thee any graven image, or any likeness of anything that is in heaven above, or that is in the earth beneath, or that is in the water under the earth.*

“Water under the earth” was physically known to the Hebrews. They knew of hand-dug qanats, (Chapter 65) in Armenia and Persia. Hebrew land extended to the River Jordan, the eastern source said to emerge fully-formed from an iron-red limestone cliff at the foot of Mt. Hermon.

After the Hebrews' escape from Egypt, the refugees

> *Came to Elim where there were twelve wells of water, and threescore and ten palm trees; and then encamped there by the waters."* -- Exodus 15:27

When the refugees needed more water, God told Moses at Mt. Horeb (modern Sinai).

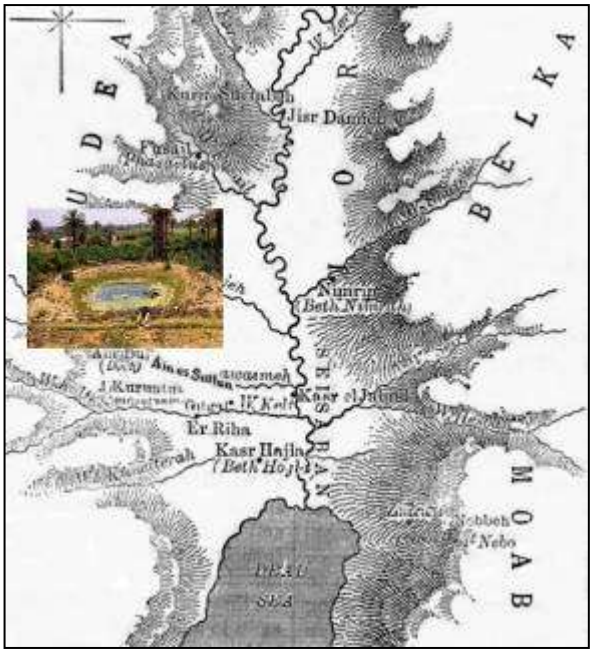
> *"And thou shalt smite the rock, and there shall come water out of it, that the people may drink."* -- Exodus 17:6.

The Spring of Elim at Wadi Tayyib al-Ism is said to be that water.

The Second Book of Kings

Today's Ain-es-Sultan, the Sultan's Spring near Jericho, is the spring "healed" by Elisha's casting of salt (II Kings 2:21) and the source of Barada (the Biblical "Abana"). Syrians still escape modern Damascus to enjoy the apricot, apple and walnut trees. According to the he International Bank for Reconstruction and Development,

> *The principal emergence of the spring, which has been enclosed in a structure since Roman times, resembles an underground river several meters across which flows up and out of the limestone formation of the mountain. The total flow has averaged 8.63 cubic meters per second.*



Jordan Valley, from The Bible Educator (1870) with overlay of modern Ain-es-Sultan

The Book of Psalms

Hebrew geography was Babylonian, the sea encircling the earth and hidden channels to "the great deep" from which all waters derive (Psalms 136:6). Hebrew/Babylonian floods came from below, not from above. The vassal-treaties of Esarhaddon declare, "May a flood, an irresistible deluge, rise from the bowels of the earth and devastate you."

The Book of Ecclesiastes

Ecclesiastes 1:7 cemented the early Christian opinion concerning underground waters.

All the rivers run into the sea,
Yet the sea is not full;
To the place from which the rivers come,
There they return again.

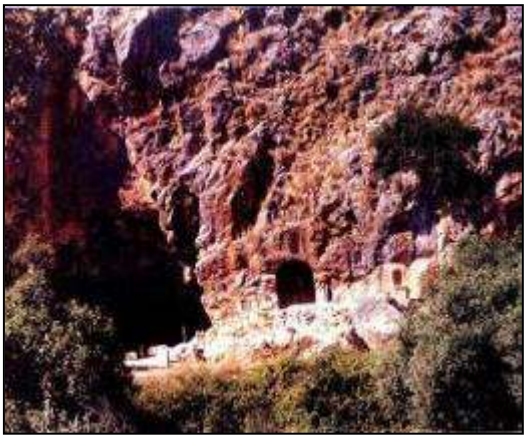
How the rivers return is not specified, but as such conduits are not visible on the surface, it stands to reason that they must be below.

The term “rivers” of this verse is the Hebrew “nhl,” flash flows in wadies after heavy rainfall. “Nhr,” Hebrew for a river continually flowing, was not used for streams in Palestine, but was used for the Tigris and Euphrates. Ecclesiastes 1:7 speaks metaphorically of the vain course of human nature, for those seeking scriptural explanation of nature, the verse would provide 2000 years of mindset. We'll get back to metaphors in Chapter 30.

And now we must move on to the New Testament, which is to say, welcome the Greeks.

The Early Church

Jesus made what must have been an arduous trip to "the Gates of Hades" in Caesarea Philippi (Mathew 16:13), at least a full day uphill from Bethsaida. The gate was the Cave of Pan with its Paneion Springs, a 15 by 20-meter cavern which in pre-Roman times was taken to be an entrance to the underworld. King Herod built a marble edifice dedicated to Caesar at the entrance.



Reference to an underground Hell is nonexistent in the Old Testament. Hebrew tradition was not particularly concerned with questions of the afterlife; "She'ol" is where all go. To a Jew such as Matthew, "the Gate of Hades" was to a Greek Hades.

The early Christians thus advanced a hydrologic perspective based on the authority of the Hebrews, Greeks and Romans.

De Providentia by Bishop of Cyrus Theodoretus (393-457) instructs the faithful that water rises to the mountain tops in “obedience to the word of God.”

In the diagram to the right, it's the will of God -- angel power, we might say -- that moves waters from the sea to hillside springs. Nothing more need be said regarding the physics, as the Church had more important matters with which to deal. The noun "Agnostic," for example, is from "agnus" (lamb) and "Stygis," our very own River Styx. "Agnostic" was applied to those who thought the specific miracles of Christianity to be improvable and thus by reason of the Lamb of God, neither believing nor disbelieving, would be left stranded on the riverbank.

Emerging in the fifth century, the monastic movement was about prayer, not the workings of nature, but nonetheless, monastic transcriptions over the subsequent 800 years preserved medical manuals, a small portion of Plato’s writings, astrological charts and Latin comprehendi,.

The scriptorium was generally situated near the monastery kitchen to prevent frozen fingers.

A Syrian, a Greek, a Spaniard, a Roman, a Celt and a Frank

We can catch the intellectual flavor of the era from a geographic spread of dutiful men of the cloth.

Ephraem the Syrian (306-373), a theologian of the in the Syriac Orthodox Church, had this to say in Commentary on Genesis.

> *The four rives, then, are these: the Pison, which is the Danube; the Gihon, which is the Nile; and then the Tigris and the Euphrates, between which we dwell. Although the places from which they flown are known, the source of the spring is not* [known]. *Because Paradise is set on a great height, the rivers are swallowed up again and they go down to the sea as if rivers through a tall water duct and so they pass through the earth which is under the sea into this land. The earth then spits our each one of them; the Danube, which is the Pison, in the west; the Gihon in the south; and the Euphrates and the Tigris in the north.*

To Ephraem, all four Rivers of Life are subterranean.

Bishop of Hippo and author of Confessions, Augustine (354-430) provided emerging Christianity a philosophical -- as opposed to purely theological -- basis. According to Augustine, Plato's acquiescence to things supernatural was well-suited for a faith based on grace. Aristotelian eternalism, on the other hand, seemed incompatible. Plato's world-view allowed divine will, while Aristotle's mechanistic arrangements constrained God's holy hand. Unlike Aristotle's "motionless mover," a Neo-Platonic cosmology featured a creator who shares his goodness from pre-existent and co-eternal matter.

To seal Plato's supremacy in matters philosophical,

> *Nothing is to be accepted save on the authority of Scripture, since greater is that authority than all the powers of the human mind.*

The meaning is simple: Believe what is told, not what is noticed. The fact that Platonic philosophy is not as conducive to the study of nature as is an Aristotelian viewpoint poses little problem a St. Augustine disinclined to study nature. Despite being translated into Latin by Boethius (475-524), Aristotle's observational -- often biological -- world-view was thus relegated to disrepute.

Although Augustine had less interest in worldly questions, his writings occasionally spilled in that direction. Consider, for example, The Works of St. Augustine: A Translation for the 21st Century (2002), edited by John Rotelle.

> *Since the actual site of Paradise totally escapes human ken, the waters from it are indeed divided into four parts, as the utterly trustworthy testimony of scripture assures us, but that those rivers whose sources are said to be known have gone underground somewhere, and after wending their way through extensive regions have gushed out in other places, where their sources are held to be known. Is anybody unaware, I mean, that there are streams which regularly do this? But it only comes to our attention where they do not flow underground for any great distance.*

Though God created but four rivers, how can we now have many? One would doubt this to be a pressing question in its own merit, but here a bishop could not concede an incomplete Holy Word. A springhead is not a source, but one of many outlets from one of four underground waterways, the good bishop instructs.

Augustine's philosophical framework would gird the evolving Church. As we will see shortly, his passing mention of streams flowing underground would likewise guide the yet-to-come science.

The Spaniard, Isidore of Seville (570-639), produced the encyclopedic Etymologies, the seminal compendium of secular knowledge of his period. More than 1000 manuscripts in length,

Etymologies cataloged the seven liberal arts identified by the Roman Encyclopedist Varro (Chapter 3) plus,

Medicine
Law
The Calendar
Theology
Anthropology (including monstrous races)
Geography
Cartography
Cosmology
Mineralogy
Agriculture

As Etymologies strove to reconcile the world with Genesis, fossils were the remains from Noah's flood.

Isidore's opinion regarding springs and rivers was that of the Pliny the Elder (Chapter 3) who in turn was repeating the Greeks.

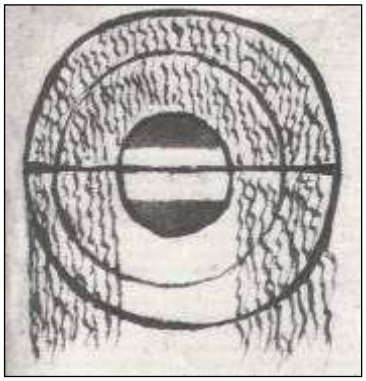
> *Moreover that the sea does not increase, though it receives all streams and all springs, is accounted for in this way; partly that its very greatness does not feel the waters flowing in; secondly, because the bitter water consumes the fresh that is added, or that the clouds draw up much water to themselves, or that the winds carry it off, and the sun partly dries it up; lastly, because the water leaks through certain secret holes in the earth, and turns and runs back to the sources of rivers and to the springs.*

It's a wordy Ecclesiastes 1:7.

> *The abyss is the deep water which cannot be penetrated; whether caverns of unknown waters from which springs and rivers flow; or the waters that pass secretly beneath, whence it is called abyss. For all waters or torrents return by secret channels to the abyss which is their source.*

Streamflow is thus a combination of rainfall and underground "secret holes."

Ambrosius Theodosius Macrobius' (395-423 AD) had argued that if rain doesn't fall toward the earth's center -- contrary to lore regarding Columbus, scholars back to the Greeks recognized the earth to be spherical -- precipitation missing the edges must ascend toward the heavens. A scribe's illustration is to the right.



But such thought experiments were becoming lost to Platonic disinterest as unexamined pathways of nature came to be put forth as de-facto proof of physically-untestable divine law.

John the Scot (800-880) proposed in De Divisione Naturae (866) a sacred steadiness in the course of all creation. Ecclesiastes 1:7 served his argument against ungodly material progress,

> *Divine goodness... flows downward like a stream, first into the primordial causes, bringing them into being. Next, continuing downward through these primordial causes, ineffable in their workings, but still in harmony with them, they flow from higher to lower, finally reaching the lowest ranks of the All. The return flow is through the most secret pores of nature by a most concealed path to the source.*

Analogy to flow "through the most secret pores of nature by a most concealed path" may illustrate John's opinion about divine goodness, but it is one more illustration of theology intermingled with subterranean waters.

The Frank, Bernard of Clairvaux (1090-1153), a theologian of mystical bent, compared the sea to Christ.

> *The sea is the source of fountains and rivers; the Lord Jesus Christ is the source of every kind of virtue and knowledge.*

In a sermon from his Cantica Canticorum, the subterranean water course becomes an Ecclesiastic metaphor for spiritual operation.

> *If all waters seek incessantly to return to the sea, making their way thither sometimes by hidden and subterranean channels, so that they may go forth from it again in continual and untiring circuit, becoming visible once more to man and available for his service, why are not those spiritual streams rendered back constantly and without reserve to their legitimate source, that they may not cease to water the fields in our hearts? Let the rivers of diverse graces return from whence they came, that they may flow forth anew.*

Metaphor notwithstanding, Bernard bemoans his generation as dwarfs standing on the shoulders of Greek giants, unable to see farther by individual brilliance, but through mastery of the classics.

Conclusion

As fewer and fewer Europeans thought about more than basic needs and religious ritual, ancient texts were left to decompose. Instances can be uncovered of sequestered intellectualism -- we tip our hat to Macrobius -- but critical thought in large part was increasingly stifled by dogma.

The imaginative richness associated with underground rivers had faded. No one was retelling the tale of Charon, compiling novel encyclopedias, thinking about rainfall missing the earth, peering into caverns. Ecclesiastes 1:7 posed no an intellectual invitation.

Physically out of sight, intellectually out of mind, thought about underground rivers approached extinction.

CHAPTER 5
THE CRESCENT

We will see in Chapter 41, Sinkholes, how scuba divers successfully linked two systems of underground waterways to form in combination the world's longest underground river.

The Arabs of 600-1200 were likewise linkers of underground rivers, their curation being the bridge from a faltering Western legacy to the concepts we recognize today.

We should qualify our employment of the term "Arabic" in its geo-political, not ethnic, sense. Subjects of Arabic rule included Persians, Negroid Africans, Christians of many stripes, Jews and others.

The original Hebrews had no ethnic advantage in attention to water. All desert peoples accorded water cultural importance. The Shari'a, the source of Islamic law -- and thus the crux of Arabic identity -- literally means "source of water." Qur'anic verses alluding to water underground include,

> *And give glad tidings to those who believe and do righteous good deeds that for them will be Gardens under which rivers flow. -- 2:25.*
>
> *For such, the reward is Forgiveness from their Lord, and Gardens under which rivers flow, wherein they shall abide forever. -- 3:136.*
>
> *I will remit from them their evil deeds and admit them into Gardens under which rivers flow. -- 3:195.*
>
> *But, for those who fear their Lord, are Gardens under which rivers flow. -- 3:198.*
>
> *Lo! Allah will cause those who believe and do good works to enter Gardens under which rivers flow.* -- 22:23.
>
> *He sendeth down water from the sky, so that valleys flow according to their measure.* -- 13:17.
>
> *And We* [Allah] *have placed therein gardens of the date-palm and grapes, and We have caused springs of water to gush forth therein.* -- 36:34.
>
> *Hast thou not seen how Allah hath sent down water from the sky and hath caused it to penetrate the earth as water springs... Lo! Herein verily is a reminder for men of understanding.* -- 39:21.
>
> *If all your water were to disappear into the earth, who then could bring you gushing water?* -- 67:30.

The degree to which ancient texts lend themselves to modern interpretation is a never-ending challenge.

Consider, for example, "tajri min tahtiha al-anhar," the Arabic phrase common to the above texts translated as "under which rivers flow." In contextual Arabic, the phrase suggests rivers running through gardens surrounding an elevated dwelling, the palaces of Paradise in this case. Shehzad Saleem addresses our question directly in "Will Paradise have Underground Rivers?" Renaissance, January 2012.

> *In order to understand the Qur'anic description of Paradise, it may be noted that the Arabs of the times of the Prophet (peace and mercy upon him) had a special taste regarding gardens. To them, the most scenic of gardens and orchards were those which were situated at some height above the ground level on some mountain or hill such that rivers and streams would flow around and beneath them at a lower altitude. The height not only adds to the beauty of the orchard, but also secures it from floods and similar calamities.*

Thus the words do not mean that the gardens of Paradise would have underground rivers. The words here signify a relative lower altitude of the rivers and not their being underground. The following verse portrays such a garden,

> *And the likeness of those who spend their wealth, seeking to please Allah and to strengthen their souls is as a garden high and fertile: heavy rain falls on it but makes it yield a double increase of harvest, and if it receives not heavy rain, light moisture suffices it. Allah sees well whatever you do. (2:265)*

At another place, the Qur'an has mentioned the various types of rivers that will flow in Paradise:

> [Here is] *a description of the Paradise which the righteous are promised: in it are rivers of water incorruptible; rivers of milk of which the taste never changes; rivers of wine, a joy to those who drink; and rivers of honey pure and clear. (47:15)*

Paradise, we are thus informed, thus does not necessarily include underground rivers.

But our debt to Islam isn't the answer to that question, had it occurred to us to wonder. The debt is much greater; it's for preserving the Hellenistic roots of Western culture.

A side-by-side timetable helps tell the story. The political events highlight the rise and fall of Arabic influence. The intellectual events relate to the stewardship of Greek understanding.

Highlights of Middle Eastern Political and Intellectual History

	Political Highlights	Intellectual Highlights
476	Fall of Rome	
489		The Persian school of Jundishapur gives refuge to Nestorian Christians.
529		Refuge given to those from Plato's Academy
c. 610	Muhammad receives first vision.	
630-642	Muslims capture Mecca. Arabia vows allegiance to Islam. Arab armies take Egypt, Syria, Palestine, Mesopotamia, North African coast and portions of Persia and Byzantium.	
710	Arab armies invade Spain from North Africa.	
732	Battle of Tours thwarts northward Arabic advance.	
c. 750	Maximum extent of Arabic Empire 	
Late eighth century		Persian, Greek and Jewish scholars in Baghdad begin translating classical Greek works into Arabic. The center of intellectual thought passes from Europe to the Middle East

822	.	Caliph al-Ma'mun founds the Bayt al Hikilometersah (House of Wisdom), a center for the translation of philosophical and scientific works from Greek to Arabic.
Ninth and tenth centuries		Revival of learning at Constantinople
981-1037		Persian physician ibn Sina, known to the West as Avicenna
1060-1087		First systematic translation of Arabic texts into Latin by Constantine the African at Mt. Cassino, Italy
Mid 11th century	Apex of the Arabic Golden Era	
1096-1099	Crusaders conquer Jerusalem and establish principalities along the eastern Mediterranean.	
1125-1200		Translation of Aristotle from Arabic into Latin by Spanish Jews, a high point for multiculturalism.
1126-1298		Iberian-Arab Ibn Rushd, known to the West as Averroes
1187	Crusaders defeated near Jerusalem and Crusader enclaves begin to crumble.	
1453	Ottoman Empire captures Constantinople, renaming it Istanbul, and continues to expand until the Turks control much of the Middle East.	
1492	Christians reclaim Granada, expelling Muslims and Jews.	

As the Dark Ages enshrouded the West, the eastern world was in ascent and Arabic scholarship was free to procure what seemed worthy. Core to our timeline are the right-hand entries flagging Greek works and ideas preserved by Arab institutions. Knowledge from many vassal states would have been archived, of course, but much of it would have faded from interest.

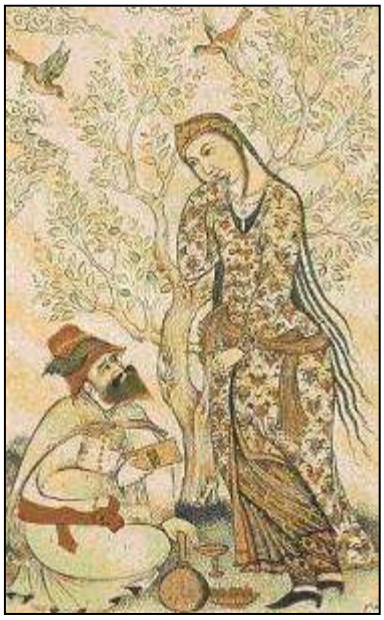
But the dustbin was not the fate of the Greco-Roman collection. Hebrew scholars, also "People of the Book," were welcomed into the caliphs' courts to sort through the intellectual booty.

Had Islam not been politically secure and able to afford intellectual diversity, pagan myths of underground rivers might have been discarded from translations of Aristotle. This is not to imply that the Arabs believed the Greek, but they recognized the meaning of Charon. Had not the Arabs been actively constructing a philosophy compatible with Islam, questions posed by the Greeks would not have been weighed.

Ecclesiastes 1:7 isn't Qur'anic, but the Hebrew question wasn't particular to a single race.

Particular to our interest in underground rivers are two Arabs named in the timeline.

As a reward for curing his ruler's illness, Avicenna (981-1037) was allowed use of the Royal Library of the Samanids and from such study, wrote at least 400 works, the most important being the Book of Healing and the Canon of Medicine. Exceeding its title, the first was based on Euclid's Elements and dealt with logic, natural sciences, psychology, mathematics and music. The second became the most famous volume in the history of medicine, the source book for Renaissance practitioners.



Although the drawing shows Avicenna getting wisdom from a muse, most of his knowledge began in the library.

Avicenna considered a question similar to one asked by Aristotle. If nature continually erodes material from the mountains to the sea, what then regenerate the continents? Avicenna concluded that the forces of earthquakes and volcanoes recreate the land, in the process moving marine fossils to mountain tops. Presumably seeing a relationship with the period of the zodiac, he estimated the cycle of erosion and regeneration to be 36,000 years.

Avicenna's reiterated Aristotle's picture of river-perforated terrestrial subsurface. When 500 years later when Europe would at last look at geology, Avicenna's Aristotelianism would be a point from which to begin.

We'll note ibn Rushd (Averroes, 1126-1198), a Muslim from Cordoba, not for a particular pronouncement regarding our underground rivers, but for recognizing the fallacy in forcing physical insight into a mold of theological preconception. Averroes sought to integrate the more profound aspects of Islam with Greek thought, his Grand Commentaries advocating the principle of twofold truth: religion for the unlettered multitude and philosophy (Aristotelian tinged with Neo-Platonism) for the chosen.

Lesotho postage stamp, 1999. Averroes translating Aristotle.

As an aside, we'll revisit Raphael's famed "School of Athens," the painting mentioned in Chapter 2 with reference to its two central figures, Plato and Aristotle. To the left, looking over shoulder of Pythagoras, is Averroes.

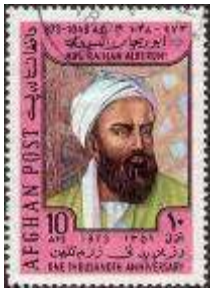
At least many scholars think the turbaned scholar to be Averroes. The argument to the contrary rests on the fact that he's grouped with Pythagoras, not Aristotle himself. Individual identity perhaps matters little; the overarching point is Raphael's attribution to Arabic membership in the glorified Athenian tradition.

The Extraction of Hidden Waters to the Surface by Persian mathematician Al-Karaji (953-1029) distinguishes between phreatic, confined and perched groundwater. Without reference to hydrostatic pressure, Al-Karaji properly interpreted the physical basis for springs and artesian wells. He recognized the hydrologic cycle.

The transformation of water into air in the hot regions and air into water in the cold regions creates a constant cycle which guarantees the prosperity of the lands.

Soviet postage stamp, 1993

Astronomer and geographer Al-Biruni (973-1048) was more explicit, explaining water level in springs and artesian wells by the principle of water finding its own level via interconnecting subterranean channels.



Afghan postage stamp, 1973

The Islamic contribution to the study of underground rivers was thus twofold.

Unlike Christian appropriation of Hebrew scriptures, Qur'anic text lent itself to interpretation consistent with what we now know as the hydrologic cycle

Islamic scholarship freed natural philosophy from theology. Speculation about underground rivers hinged on logic and experience, not revelation. As we will see in the chapter to come, such allowance would likewise come in the West, but more slowly and with more disputes.

Millions of pilgrims each year drink water from the Zamzam Well, 20 meters east of the Kaaba in Mecca. Tradition holds that Abraham's wife, Hagar, ran seven times between the hills of Safa and Marwah in search of water for her infant son Ishmael, but could find none. When the baby's foot scraped the earth, however, the Zamzam was miraculously generated. Another version of the story says that the angel Gabriel kicked the ground with his heel. The Zamzam is held to be the point of origin for underground streams flowing under the Seven Towers of Satan.

"Herodotus II, 28 on the Sources of the Nile," Journal of Hellenic Studies 73 (1953) by G.A. Wainwright makes reference to

A pilgrim who lost his drinking-cup in the well Zemzem at Mecca and recovered it in the spring of el-Gebel in Syria.

In 771, a marbled dome was built above the well; the current enclosure dates to 1499. The wellhead is not accessible to the public, but the water is pumped to the eastern part of the mosque, where it is made available to believers.

A pulley for lifting Zamzam water dating to the end of the 14th century.
A brass bucket used in the 13th century.

W.B. Seabrook speaks in Adventures in Arabia (1927) of secret caverns beneath the shrine at Sheik-Adi on Mt. Lalesh in modern Iraq with a subterranean river which the Kurds believe to flow from the Zamzam.

> *We found ourselves in a vaulted cavern, partly natural, it seemed, and partly hewn from the rock, and around a corner the sound of rushing water -- a sound which we had heard as a murmur in the upper temple, but had supposed to come from some near-by stream flowing down the mountainside.*
>
> *We could not see the whole of the cavern, or guess how far it extended. Its floor at the foot of the steps was covered with water, which I guessed from the slope to be not more than ankle-deep. But the priest made it an excuse to deter us from going farther, declaring that there was no use getting our feet wet, since there was nothing more to see.*
>
> *Our partial penetration of it was interesting chiefly as establishing the fact that the whole temple edifice was constructed over subterranean caverns and streams and springs, some of the water of which was led into the pools we had seen in the temple and courtyard above. I learned later that the Yezidees believed these waters flowed by a subterranean river across all Arabia, underneath the desert from the miraculous spring of Zem-Zem in Mecca.*

Lore of subterranean connection yet remains, as evidenced by Bruce G. Privratsky's Muslim Turkistan: Kazak Religion and Collective Memory (2001).

> *The wells at Muslim shrines in Central Asia are held in popular belief to be connected by a mystical underground river with the well in Mecca from which miraculous zam-zam water is drawn by pilgrims.*

Folklore aside, the Zamzam is derived from the nearby Wadi Ibrahim. The shaft is roughly 30 meters in depth and 1.1 to 2.7 meters in diameter. The upper half is in sandy alluvium lined with stone masonry; the lower half, in bedrock. Between the alluvium and the bedrock is a 0.5-meter weathered stratum. The Zamzam has never gone dry, but has been deepened in times of severe drought.

The water is 3.2 meters below the surface. A 24-hour pumping test at 8 cubic meters/second showed a drop of 13.4 meters, after which the level stopped receding. When pumping stopped, the water level recovered 12.7 meters in only 11 minutes, indication of a highly permeable aquifer.

Zamzam water has a distinct taste similar to seawater

.

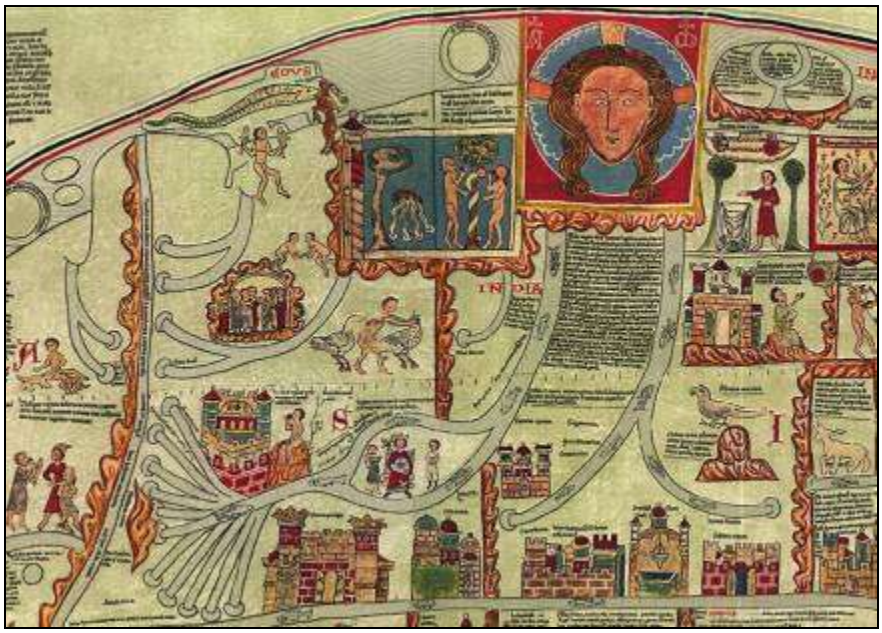
At its climax, Islamic scholarship had surpassed Greek learning in many fields and created new branches of mathematics and natural philosophy. But with the beginning of the second Christian millennium, religious and political forces began to call us again westward.

CHAPTER 6
AND BACK TO THE CROSS

How was the world viewed through Western eyes as Christendom moved into its second millennium? To the right is a copy of the Ebstorf Map (c. 1234) of Gervase of Tilbury (c. 1150-1228). East is to top

At the heart of the world lies Jerusalem, but our focus is the map's top, the detail shown below. The Garden of Eden is guarded by towering mountains which flow the four rivers of Paradise, of which the Pison splits into eleven tributaries of the Ganges.

Although many lands had been discovered since the founding of the Church, the metaphysical world view wasn't that different.



Aristotle's Meteorologica was translated from Arabic to Latin before 1200, but the Church was adverse to Islamic interpretation of a pagan philosopher. As we will see in Chapter 13, Hydrotheology/Theohydrology, Christendom would be heavy-handed in classical reincorporation for centuries yet to come, but at last the intellectual gate was re-opening.

Advocates of a more-pragmatic Christian world made known their challenge to Aquinas' tilt toward Plato. The fundamental challenge wasn't one of science, of course, as science hadn't been invented; it was one of theology.

To make Aristotle acceptably-Catholic -- to the Philosopher's post-mortem protest, we must assume -- took an agile most.

Thomas Aquinas (1227-1274) saw Aristotle's Prime Mover as a foundation for Christian thought and Aristotle's pragmatic world as better suited to God's will than the hazy world of Plato.

Aquinas thus came to regard Aristotle as the greatest of philosophers unexposed to revelation.

Aquinas sought to prove that God did not violate natural law, and thus, sensory experience. While some aspects of reality may not be accessible to rational thought, Aquinas exuded confidence in the ability of reason to describe observable events and thus come to an improved understanding of God.

Aquinas used a form of medieval argument known as scholasticism, first stating the arguments against, then for, the side he wishes to defend, and then pointing out the arguments in favor and the weaknesses for the other side.

Aquinas' Summa Theologiae (1265-75) presented Aristotle so formidably that subsequent scientific realizations came to be criticized simply because they were not penned by Aristotle himself.


SUMMA
TOTIUS THEOLOGIÆ
S. THOMÆ
AQUINATIS,
DOCTORIS ANGELICI,
ORDINIS PRÆDICATORUM.
PRIMÆ SECUNDÆ PARTIS
VOLUMEN PRIMUM.
PATAVII, MDCCLXXXI.
Ex Typographia Seminarii.
SUPERIORUM PERMISSU.

Less fundamental in theological/philosophical perspective, but most pertinent to our underground river journey, would be Aquinas' regard of the Edenic rivers,

> *It is supposed that since the site of Paradise is far removed from the knowledge of men... The rivers whose sources are said to be known have gone underground and after traversing vast distances have issued forth in other places... That some streams are in the habit of doing this is something that everybody knows.*

Aristotle had admitted his proposition of subterranean streamflow to be a Hellenist pass-along, not a verified fact and certainly not a metaphysical principal. Aquinas does much the same, blithely kicking forward the thoughts of the trusted Greek.

The concluding line, "That some streams are in the habit of doing this is something that everybody knows," tells all. Aquinas takes the pronouncement for granted, common knowledge. The intellect of St. Aquinas, the progressive theologian, is directed toward more lofty subjects.

The Condemnation of 1277, proclaiming divine will as sufficient explanation for all phenomena, was the conservative's last attempt to stifle Aristotelian heresy, but for reasons both pragmatic and intellectual -- but not what we can call scientific -- the Condemnation was repealed in 1325. Aristotelianism provided theology a garb of objectivity and had become Vatican dogma, at least where it didn't blatantly contradict biblical wording.

In issues of biblical wording, however, there could be but one interpretation.

Bartholomaeus Anglicus (c. 1250) acknowledged that the sun could evaporate some water from the sea or that the winds might skim water off its surface but the chief cause of streamflow lay in the subterranean connections. From a 1470 English translation of his De Proprietatibus Rerum,

> *The fresh water than rains into the sea is consumed and wasted by the heat of the sun until it becomes food and nourishment for the sea's salinity. But Ecclesiastes, the maker of waters, says that they* [the waters] *come again in secret veins of the earth to the well heads and out of the mother that is the sea, welling and springing out in well heads.*

Ecclesiastes 1:7 explains all that requires explanation.

More than any cleric, however, it was Dante Alighieri (1265-1321), a poet astute in the theo-politics of his day, who brought classical lore into line with pious orthodoxy. Dante saw Christian mores in Greek legend.

Where Odysseus sported quasi-god-like qualities, Dante's Inferno (1314) follows the quest of a mortal through the levels of hell in accord with the ideas of the medieval Church.

Herman Melville's copy

Within an ancient mountain ("Dentro dal monte") of Crete stands the broken statue of an old man who forewarns Dante and his companion Virgil of the rivers below.

> *"Their course falls from rock to rock into this valley. They form Acheron, Styx and Phlegethon, then, by this narrow channel, go down to where there is no further fall, and form Cocytus: you will see what kind of lake that is: so I will not describe it to you here."*

> *I said to him: "If the present stream flows down like that from our world, why does it only appear to us on this bank?"*
>
> *And he to me: "You know the place is circular, and though you have come far, always to the left, descending to the depths, you have not yet turned through a complete round, so that if anything new appears to us, it should not bring an expression of wonder to your face."'*
>
> *And I again: "Master, where are Lethe and Phlegethon found, since you do not speak of the former, and say that the latter is formed from these tears?"*
>
> *He replied: "You please me, truly, with all your questions, but the boiling red water might well answer to one of those you ask about. You will see Lethe, but above this abyss, there, on the Mount, where the spirits go to purify themselves, when their guilt is absolved by penitence."*

Dante's Lethe, we find, isn't beneath his feet; it's a cleansing stream in Paradise. (Similar translocation of a stream from the underground would be declared by H.M. Howell, "Christian

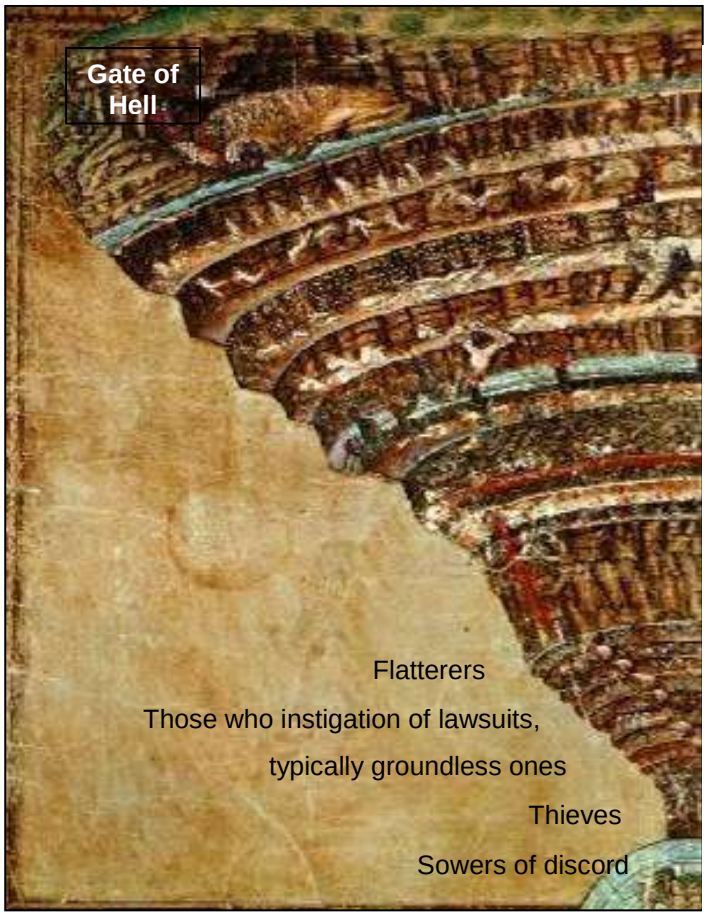
Educator," author of The Kosmic Problem Solved (1895), who placed the Edenic rivers within the caves and chasms of ancient Greece. The Pyriphlegethon, however, being of fire and not suitable for a Christian Educator's Eden, was excluded.)

That there is a measurable difference between body and the soul is made clear when the Stygian boatman denies Dante passage because of the weight of his body.

To catch the flavor of Dante's poetry, below are excerpts from three English translations.

	Longfellow (1867)	Cary (1805)	Mandelbaum (1982)
Acheron	*Upon the dismal shore of Acheron*	*Beside the woeful tide of Acheron*	*The melancholy shore of Acheron*
Styx	*A marsh it makes, which has the name of Styx*		*Forming a swamp that bears the name of Styx*
Pyriphlegethon	*The river of blood, within which boiling is whoe'er by violence doth injure others*	*The river of blood approaches, in the which all those are steep'd*	
Cocytus	*Thereby Cocytus wholly was congealed*	*Cocytus to its depth was frozen.*	*And all Cocytus froze before those winds*

Below is half of Sandro Botticelli's c-1480 Inferno illustration with sins ranked by depth.



River Acheron

Virtuous unbaptized

Lustful

Gluttonous

Hoarders and squanderers

River Styx

Walls of the City of Dis

River Phlegethon

Wood of Suicides

The Abominable Sand

Panderers and seducers

Those who pay for sacraments and holy office

Hypocrites

Counselors of fraud

Falsifiers

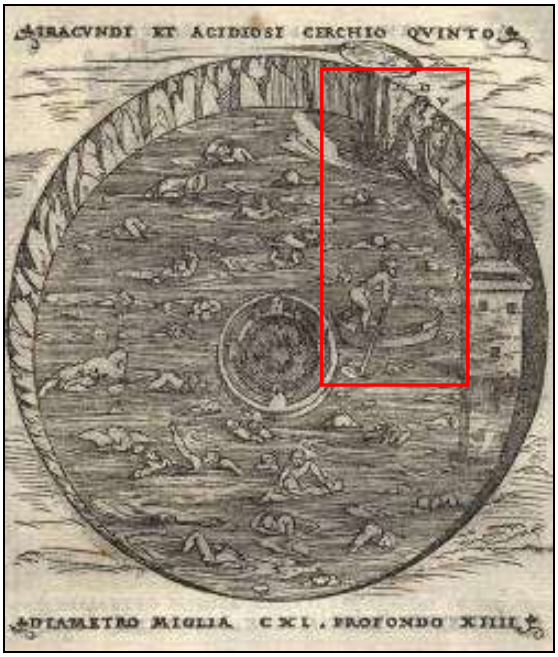
Traitors to their kindred, country, guests and lords

The page following shows slices from Botticelli's work with enlarged details of the boatman, the topic of Chapter 34, Twenty-Five Centuries of Subterranean Portraits.

The River Acheron.

The River Styx.

Below is Bartolomeo di Fruosino's tempera, gold, and silver on parchment (c. 1430). The gates of Hell are in the center, the scarlet row of open sarcophagi before them. Devils orchestrate the movements of the wretched souls.



"D" and "V" in the 1544 woodcut are Dante and Virgil.

The Inferno's Cocytus is not a river, but rather a lake, and a frozen one at that. We'll discuss ice caves in Chapter 42, Underground Rivers in Caverns other than Karst, but compared to Gustave Doré's 1890 engraving (right), photographic illustrations aren't as gripping.

Below are works from the 19th and 20th centuries depicting the travelers overlooking the waters.

Gustave Moreau

Domenico Mastroianni

But are Dante's rivers underground?

Botticelli's is the standard physiographic interpretation of the Inferno's landscape, a funnel-shaped pit. The Illustrations of Chapter 34 generally portray sky -- not rock -- arching the scenes, but that may be because painters prefer light. "Dentro dal monte" is Dante's nod to classical underpinnings, but his Acheron, Styx, Phlegethon and Cocytus aren't particularly subterranean.

But are Dante's rivers even rivers?

The first English translation, Charles Rogers (1782),

> *In la palude va c'ha nome Stige*
> A marsh it makes known by name of Styx

"Palude" can likewise mean bog, swamp or morass. Dante's Styx is a more-significant deviation from ancient lore than simply its undergroundedness, to coin a term. The writer bows to the dictates of Rome where a Charon wouldn't have authority to shepherd the repentant for

remuneration, a job for which holy ordination is the qualification. Dante's Styx isn't a boundary, but a quagmire of torment, a circle of Hell itself. The rivers are pools of perpetual punishment.

Styx and Phlegethon from Treatise on Anti-Christ, Judgment, Heaven and Hell (c. 1450-1470).

"The Torments of Hell," Codex of Christoro de Predis (c. 1486)

Should we thus disqualify the Inferno's Styx as but a sorrowful swamp, not a subterranean river?

> No, we shouldn't. Reinterpretation is not redefinition. Subterranean rivers they originally were, and subterranean rivers they will always be.

In the manner of earlier chapters, following are correspondences to Homer's saga.

	 Odyssey (c. 855 BC)	 The Divine Comedy (1314)
Author	Homer	Dante
Protagonist	Odysseus	Dante
Setting	Mythical Mediterranean, Mythical times	Inferno, Purgatorio and Paradiso, 1300
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Midway upon the journey of our life I found myself within a forest dark, For the straightforward pathway had been lost.*
Characters	Lotus Eaters Cyclops Sirens	 *Hearing the Sirens, thou mayst be stronger.*
Rivers	Acheron Cocytus Styx Pyriphlegethon	Ferried across Lowest circle of Hell, a lake frozen by the flapping wings of Lucifer Surrounding the lower part of Hell Phlegethon

Summary

So let us summarize what transpired in this and the previous two chapters, three segments of time, each in the range of 500 years.

The early Church assumed a neo-Platonic bent, elevating spiritual understanding above insight mired in worldly observation. To whatever minor degree the corrupted world merits consideration, so would hydrology, but the theology demands our attention.

The Arabs preserved a more-phenomenological Aristotelian world view and within that context, the lore of underground rivers expressed of Greek and Latin writings.

Intellectual vitality, both Arabic and European, came with the recognition of Greek legacy, a spectrum extending from the highest order of cosmology to the deepest channels within the earth.

Resurgent Christendom emerged more Aristotelian, more empirical. Underground rivers with mythical underpinning were again instruments of Christian instruction, albeit within the era's Christian bounds. Ecclesiastes 1:7 remained the pulpit theory of subterranean streams, but an awakened intellectualism was beginning to seek a broader understanding of the workings of God's world.

CHAPTER 7
THE CONCEPT OF CIRCULATION

This chapter, The Copncept of Circulation, and the two following, Subterranean Mechanisms and Superterranean Metrics, together trace the formation of hydrology as a physically-based science, and thus a means to assess the flow of water underground.

We could sequentially march through several centuries of scientific history, noting who solved what challenge at what time. To continue our journey a bit more thematically, however, we'll do it in three passes.

In this chapter we will follow the concept of circulation through the Renaissance and into the formative age of science. We will note the problem of rainfall perceived to be less than streamflow and how a vast subterranean abyss might serve as a logical solution. We will see how a dual hydrologic cycle seemed to bring everything together.

In the next chapter, Subterranean Engines, we'll concentrate on how subterranean resupply might work. Perhaps seawater is squeezed upward by the earth's weight. Perhaps it's by electricity. We'll see some innovative causality when data's not of concern.

And in the following chapter, Superterranean Metrics, we'll note what was realized once observers began to measure the observables. We'll see rudimentary numbers, but once there was data, subterranean sea-to-spring piping began to seem less necessary.

We should pause, however, to recall the roots of this chapter in what was fairly well established in by late-medieval Christian interpretation.

Adelard of Bath (1080-c. 1152) contributed the first full Arabic-to-Latin translation of Euclid's Elements, a work not printed however, until the 14th century. To the right, the frontispiece shows a woman -- Sophia, we might imagine --teaching geometry to monks.

Adelard's Questiones Naturales, written as a dialogue between the author and his nephew, includes questions regarding rivers.

> *For neither do all rivers flow down into the sea, nor do none of them. But as some flow down into it, so also others are born from it. Thus if, while it receives, it gives back, a perceptible increase in its volume does not occur. In fact, since many underground rivers arise from the sea, and the quaffing of the planets takes away a large part of the water, some people have been puzzled about how the sea does not suffer a loss, and how it receives sufficient water in compensation.*

> *In a circular process there is neither a beginning nor an end. For anything to which this can apply can be returned into itself. Rivers which flow perpetually, in case you are unaware, have naturally acquired a circular movement. They therefore return into themselves, and what has flowed away in their going, they give back by returning. Hence the Satirist, in making fun of the stupidity of the common people, says:*

> *"The country bumpkin waits for the river to flow away, but it flows and will flow, rolling on forever."*
>
> *Since the rivers divide into many different courses in the bowels of the earth, it can happen that they sometimes meet a terrain which is obstructed on all sides by rocky outcrops and forces them to flow upwards, if the only exit is in that direction. So when they are always ascending, they always flow out.*

Cardinal Bonaventure of Bagnoregio (1221-1274) preached on the Holy Spirit's gift of grace.

> *Upon this Ecclesiastes: "To the place, whence the rivers go forth, they return."* [St. Bernard] *says, that "the origin of springs is the sea, the origin of virtues and sciences is Christ."*
>
> *For as the spring does not have length, unless it has a continuous conjunction with its origin, so also light; thus the grace of the Holy Spirit cannot grow in the soul unless through its reversion to its own original Principle.*

The Cardinal likewise is speaking of circulation.

The Renaissance

The term "circulation" derives from the Greek "kirkos" for circle. In generalized mythology, the circle said to be,

> *A symbol of the Self. It expresses the totality of the psyche in all its aspects, including the relationship between man and the whole of nature. It always points to the single most vital aspect of life, its ultimate wholeness.* -- Marie-Louise von Franz in Carl Jung's Man and His Symbols (1979)

To Jungian psychologists, through "decensus" and "ascensus" we find meaning.

We routinely envision the Renaissance -- "rebirth" in Italian, the cultural movement spanning the 14th to 17th centuries -- in terms of art, but our journey is about intellectual forays, in particular about waters flowing beneath the earth. We'll look at the Renaissance in terms of how it applied the circle to that question.

As Marjorie Nicolson observes,

> *No metaphor was more loved by Renaissance poets than that of the circle, which they had inherited from Pythagorean and Platonic ancestors, who in turn had borrowed it from Orientals, to whom the serpent, swallowing its tail, was a Hieroglyphick of eternity.* The Breaking of the Circle (1962)

Core to the Renaissance was the rediscovered Greco-Roman culture. By cleaning and sharpening the tools of antiquity, observers could refocus their own eyes. We must keep in mind, however, that no eye, then or now, can peer below the earth. The patterns mapped our consciousness may be significantly unlike what a drilling rig might puncture. The problem of perception isn't, of course, confined to issues of proper illumination. Science is a story of peering through the muddle of sensibilities.

Turning from the clerics' abstract speculation about the afterlife, the Renaissance was marked by interest in the visible, in tactile knowledge. Freed inquiry was more important to the future of thought than immediate specification.

The Florentine polymath Leonardo da Vinci (1452-1519) merits centerpiece status in our underground sojourn if for no other reason than his encyclopedic curiosity. Da Vinci's "primo motore" lies squarely within the Christian god's perceived role for the era. Da Vinci's doctrinal dues thus paid, he was somewhat of a pantheist, largely excluding the divine from his musings. Aristotle would have concurred.

The c 1513 sketch shows the elder artist pondering the flow of water. The backwards-inscribed text reads,

Observe the motion of the surface of the water, how it resembles that of hair, which has two motions -- one depends on the weight of the hair, the other on the direction of the curls; thus the water forms whirling eddies, one part following the impetus of the chief current, and the other following the incidental motion and return flow.

Despite da Vinci's oft-cited, "In talking about water, remember to call upon experiment and then on reasoning," rarely, if ever, did he subject his concepts to physical test, again falling in with Aristotle. Da Vinci honored the here-and-now, but not to the point of getting his hands wet.

But da Vinci's experimental shortcoming didn't inhibit his greatest strength. "Do you not see that the eye embraces the beauty of the whole world?" The visual is pre-eminently the real. What da Vinci saw he never doubted -- Aristotelian to the fullest.

To da Vinci, water is "il vetturale di natura," the vehicle of nature. In his First Book on Water (one of his few manuscripts written thematically, not as happenstance observations), da Vinci writes.

Water is sometimes sharp and sometimes strong,
sometimes acid and sometimes bitter,
sometimes sweet and sometimes thick or thin,
sometimes seen bringing hurt or pestilence,
sometimes health-giving and sometimes poisonous.
It suffers change into as many natures as are the different places through which it passes.

Unfortunately for focused scholarship, da Vinci's "many places" was indeed many.

If you chose to say that the rains of the winter or the melting of the snows in summer were the cause of the birth of rivers, I could mention the rivers which originate in the torrid countries of Africa, where it never rains -- and still less snows -- because the intense heat always melts into air all the clouds which are borne thither by the winds.

> *And if you chose to say that such rivers, as increase in July and August, come from the snows which melt in May and June from the sun's approach to the snows on the mountains of Scythia and that such meltings come down into certain valleys and form lakes, into which they enter by springs and subterranean caves to issue forth again at the sources of the Nile, this is false; because Scythia is lower than the sources of the Nile, and, besides, Scythia* [Asia as far as India] *is only 400 miles from the Black Sea and the sources of the Nile are 3000 miles distant from the sea of Egypt into which its waters flow.*

From da Vinci's writings concerning subterranean waters,

> *Very large rivers flow underground.*
>
> *The body of the earth, like the bodies of animals, is intersected with ramifications of waters which are all in connection and are constituted to give nutriment and life to the earth and to its creatures. These come from the depth of the sea and, after many revolutions, have to return to it by the rivers created by the bursting of these springs.*

In the chapter to follow we will discuss da Vinci's comments regarding mechanisms of underground rivers, but for now let us simply note that never was he scientifically correct, and when his understanding drew close to what we now know, elsewhere he'd argue to the opposite.

Da Vinci's contradictions are understandable in a world where science had yet to be invented. Why not have multiple reasons for the same behavior? Though da Vinci's subterranean rivers existed no more in reality than did those of Aristotle, the latter's claims were little but rehashed mythology. Da Vinci's waters were phenomenological propositions with nary a courteous nod to Charon.

Concerning the hydrologic cycle, da Vinci employed the circular metaphor of his day.

> *Thus the movement of the water inside and outside varies in turn, now it is compelled to rise, then it descends in natural freedom. Thus joined together it goes round and round in continuous rotation, hither and thither from above and from below, it never rests in quiet, not from its course, but from its nature.*

And,

> *That which to the utmost admiration of those who contemplate it raises itself from the lowest depth of the sea to the highest summits of the mountains and pouring through the broken veins returns to the deep sea and again rises with swiftness and descends again, and so in course of time the whole element circulates.*

Da Vinci turned to the Nile for proof.

> *And do you not believe that the Nile must have sent more water into the sea than at present exists of all the element of water? Undoubtedly, yes. And if all this water had fallen away from this body of the earth, this terrestrial machine would long since have been without water. Whence we may conclude that the water goes from the rivers to the sea, and from the sea to the rivers, thus constantly circulating and returning, and that all the sea and the rivers have passed through the mouth of the Nile an infinite number of times.*
>
> *Therefore it may be said that there are many rivers through which all the element has passed and have returned the sea to the sea many times.*

By the time of Columbus, there was no opposition to the proposition that the sun was the engine for the cloud-fed portion of the dual cycle. According to da Vinci,

> *Moreover the elements repel or attract each other, for one sees water expelling air from itself, and fire entering as heat under the bottom of a boiler and afterwards escaping in the bubbles on the surface of the boiling water. And again the flame draws to itself the air, and the heat of the sun draws up the water in the form of moist vapor, which afterwards falls down in thick heavy rain.*

> *And these are carried by the winds from one region to another, until at last their density gives them such weight that they fall in thick rain. But if the heat of the sun is added to the power of the element of fire, the clouds are drawn up higher and come to more intense cold, and there become frozen and so produce hail.*

And here, da Vinci is at his best.

> *The element of fire by its heat always draws to itself damp vapors and thick mists as opaque clouds which it raises from seas as well as lakes and rivers and damp valleys; and these being drawn by degrees as far as the cold region, the first portion stops, because heat and moisture cannot exist with cold and dryness; and where the first portion stops, the rest settle, and thus one portion after another being added, thick and dark clouds are formed.*
>
> *At times it is bathed in the hot element and dissolving into vapor becomes mingled with the air, and drawn upwards by the heat it rises until it reaches the cold region and is pressed closer together by its contrary nature, and the minute particles become attached together.*

We'll return to more of da Vinci's circle-driving inspirations in the chapter to follow, but before we begin to think mechanically, let us look ahead regarding a darker view of circulation.

Robert Hooke (1635-1703), whose name is applied to the law of elasticity, was the son of a minister who “died by suspending himself." From Hooke's dismally-titled The Earth Grows Old and Less Fruitful (1705),

> *Nature... is, as it were, a continual circulation. Water is rais'd in Vapors into the Air by one Quality and precipitated down in drops by another, the Rivers run into the Sea, and the Sea again supplies them. Generation creates and Death destroys. Winter reduces which summer produces... All things almost circulate and have their Vicissitudes.*

Hooke imputes no special virtue to the circulatory process; it's simply a law of nature, a glum Ecclesiastes 1:7 which today we would call it the Second Law of Thermodynamics.

The Perception of Precipitation Insufficient to Sustain Streamflow

In beginning of this chapter, we noted a flawed perception, that precipitation is less than streamflow. No free-thinker standing on the banks of a mighty waterway on a drizzly Renaissance day thought other than, "Flumen est maioribus quam pluvia." The river flows more than the rain.

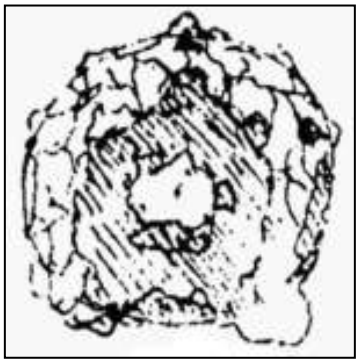
Were water not circulatory -- if water simply came into existence as needed -- the system would have little need for an underground conduit. And if nature didn't need the latter, there would be no need for a subterranean resource to supply the underground river.

But as the rivers flow full, there must be the unseen replenishment, and thus there must be the deeper source.

By 1500, Aristotle, not Plato, was the designated pre-Christian philosopher, but Plato's Tartarean abyss yet had reason to exist.

And once again we note that it's hard to keep a good story down.

The Abyss



The concept of a great void in the earth center goes back to Plato, but its Biblical basis -- depending on how the reader takes the Bible, of course -- propelled the concept into nearly-modern times.

To the right is a da Vinci cross-section of the distribution of land, mountains, oceans, lakes and rivers at the surface and a water ball in the interior.

In his words,

> *This is meant to represent the earth cut through in the middle, showing the depths of the sea and of the earth; the waters start from the bottom of the seas, and ramifying through the earth they rise to the summits of the mountains, flowing back by the rivers and returning to the sea.*
>
> *The great elevations of the peaks of the mountains above the sphere of the water may have resulted from this that a very large portion of the earth which was filled with water, that is to say the vast cavern inside the earth, may have fallen in a vast part of its vault towards the center of the earth.*

"A vast cavern," to fire our imaginations! We'll see where the fiction writers take the topic in later chapters.

Arts des Fontaines et Science des Eaux (1665) by Jesuit Jean François (1582-1668) endorsed the presence of great subterranean caverns.

> *The earth's crust, dried out, ends by cracking. The water underneath expands and exerts pressure against the vault of the orb, which will break into pieces and fall into the abyss. The cracked crust, weakened, breaks up; water gushes violently out, in proportion to its mass and the space it had just occupied.*

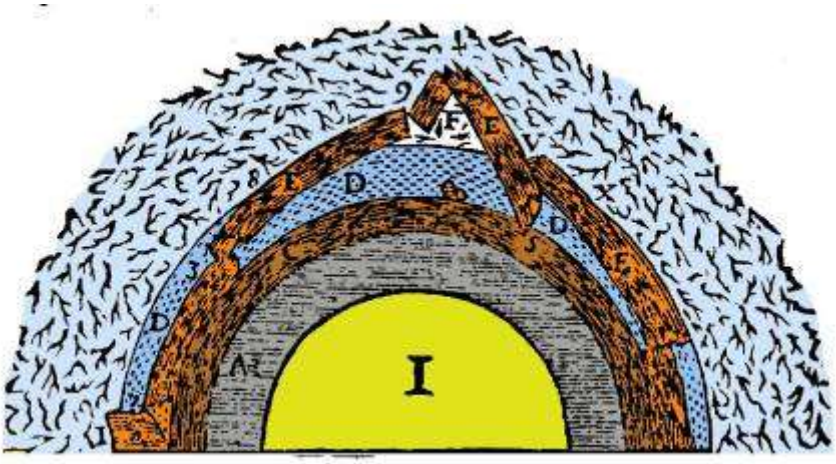
Jean François' student, René Descartes (1596-1650) soldiered and traveled before embracing solitude to pursue his treatises. His proof of the equivalence of Euclidian geometry and the algebraic geometry still stands. His principle of the constancy of universal "momentum," on the other hand, died with the publication of Newton's Principia in 1687.

As we might expect, the author of "Cogito, ergo sum" would apply the power of reason to the problem at hand. According to Descartes, the sun-like core of the earth was originally surrounded by a shell of metals which in turn was enclosed by progressive spheres of water, earth and air. As the inevitable decay of earthly materials began, portions of the shell cracked and collapsed into the water below, the rocky protrusions becoming the modern continents and the sunken earth, the sea floor.

The figure below illustrates the process.

> *But there being many crevices in the body E, which enlarge more and more, they are finally become so great that it cannot be longer sustained by the binding of its parts, and that the vault which it forms bursting all at once, its heaviness has made it fall in great pieces on the surface of the body C. But because this surface was not wide enough to receive all the pieces of this*

body in the same position as they were before, some fall on their sides and recline, the one upon the other. -- Discours de la Méthode (1637)



As a result, we may think of the bodies B and F as nothing other than air, that D is the water and C, a very solid and very heavy crust upon the earth's interior, from which come all the metals, and finally that E is another, less massive, crust of the earth, composed of stones, clay, sand, and mud.

Note the resultant sites of D, the water, some upon the surface, other beneath the earth. Plato's abyss has found a degree of quasi-scientific sense.

Principles of Philosophy (1644),

There are great cavities filled with water under the mountains where the heat of the sun continually raises vapors which, being nothing more than fine particles of water strongly shaken one from another, escape through pores in the earth and go to higher plains and mountains, regroup themselves in the interior of fissures near the surface which when filled, cut through the soil and form springs which run to the lower valleys, and converge into rivers which flow to the sea. Now in spite of this process, much water continuously flowing from these cavities under the mountains never empties them; this is due to the existence of numerous conduits by which seawater flows to these caverns in the same proportion as that which exits to the springs.

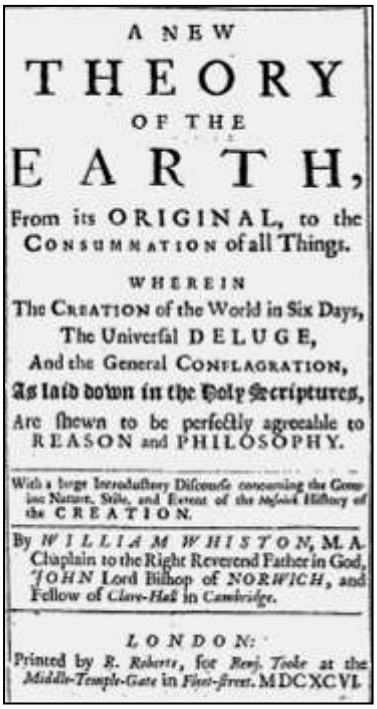
A macabre historical note: After his natural death, Descartes' head was detached from his body and it was recorded that the anterior and superior regions of his skull were rather small, leading German phrenologist Johann Gaspar Spurzheim (1776-1832) to suggest that Descartes could not have been as great a thinker as previously believed.

As a variation more in keeping with Biblical chronology, Englishman John Woodward (1665-1722) explained that the earth was a watery spheroid with a solid crust that broke apart and dissolved in Noachian food to re-sediment into the topography we now know.

There is a mighty collection of Water enclosed in the Bowels of the Earth, constituting a huge Orb in the interior or central Parts of it; upon the Surface of which Orb or Water the terrestrial Strata are expanded. This is the same which Moses calls the Great Deep or Abyss; the ancient Gentile Writer, Erebus, and Tartarus. -- An Essay toward a Natural History of the Earth and Terrestrial Bodies, Especially Minerals, as also of the Sea, Rivers and Springs. With an Account of the Universal Deluge and of the Effects that it had upon the Earth (1695)

Other 17th-century works such Georges Fournier's Hydrographie Contenant la Thiorie et la Pratique de Toutes les Parties de la Navigation (1667) gave similar accounts of rivers and reservoirs within earth's interior.

William Whiston (1667-1752) was the best-known British author dealing with the genesis of the earth. Succeeding Newton as Professor of Mathematics in Cambridge, Whiston edited and published Euclid's geometry and wrote textbooks on astronomy and physics.


A NEW
THEORY
OF THE
EARTH,
From its ORIGINAL, to the CONSUMMATION of all Things.
WHEREIN
The CREATION of the World in Six Days,
The Universal DELUGE,
And the General CONFLAGRATION,
As laid down in the Holy Scriptures,
Are shewn to be perfectly agreeable to REASON and PHILOSOPHY.
With a large Introductory Discourse concerning the Genuine Nature, Stile, and Extent of the Mosaick History of the CREATION.
By WILLIAM WHISTON, M.A. Chaplain to the Right Reverend Father in God, JOHN Lord Bishop of NORWICH, and Fellow of Clare-Hall in Cambridge.
LONDON:
Printed by R. Roberts, for Benj. Tooke at the Middle-Temple-Gate in Fleet-street. MDCXCVI.

Availing himself of Newtonian ideas, Whiston's A New Theory of the Earth, from its Original, to the Consummation of All Things (1696) explained geological catastrophe, not by human sin, but by a water-tailed comet which on November 28, 2349 BC which distorted the crust, making "Gaps and Clefts ... quite through it" and opened "the fountains of the great deep."

The waters eventually receded due to two causes:

> *First by a wind which dried up some and secondly, by their descent through those fissures, chaps and breaches, (at which part of them had before ascended) into the bowels of the earth, which received the rest. To which later also the wind, by hurrying the waters up and down, and so promoting their lighting into the before-mention'd fissures, was very much subservient.*

Benjamin Franklin (1706-1790) was of similar opinion regarding a primordial crust floating on a fluid interior.

> *Thus the surface of the globe would be capable of being broken and disordered by the violent movements of the fluids on which it rested.*

Ukrainian Johannes Herbinius' (1633-1676) Dissertationes de Admirandis Mundi Cataractis et Subterranis (1678) called the earth a "terraqueous globe," porous, full of cracks, holes, openings, galleries, tunnels and cracks ("Terra est corpus internè & externè porosum, rimarum, foraminum, cuniculorum & hiatum plenum"), but hedged regarding causality. The reason for continuous flow through the "great central abyss" may be God, angels, stars, the spirit of the earth or perhaps the air within. Herbinius held that ocean water circulates continuously from the North to the South Pole via the center of the earth and attributed tides to the periodic ejection of water from reservoirs beneath the poles. An engraving shows a "Hydrophylacium Subterraneum" but gives no indication of magnitude.

Concerned with public health, Bernardino Ramazzini (1633-1714) accounted for the "wonderful springs of Modena" in De Fontium Mutinensium (1691).

> *I think 'tis probable the matter is so in our Fountains, to wit, the Water flows out of some Cistern plac'd in the neighboring Mountains, by subterraneous Passage.*
>
> *But 'tis, by far, more probable, that the Water is sent from the sea into such Claim, than from Showers, or melted Snows, seeing Rain and Snow-waters run away for the most part by Rivers above Ground; neither can they enter into the ground so deep; as Seneca also testifies.*

Regarding the origin of waters,

> *As I have deduced from the Origin of this Water from the Sea, so I do not deny, that many Fountains owe their Origins to Rains and melted Snow; yet with this difference, that the Fountain which have their Spring from the Sea by hidden Passages continue perpetual, but those which run from Showers and temporary Springs at some time of the year, are diminished and quite dry up.*

> *I thought beat therefore to fetch the Origin of these Waters from another source, viz. From some secret Cistern of Water placed in the inner parts of the Apennine Mountains. And it is certain, that the inner parts of the Mountains are cavernous, and that there are in them Cisterns of Water, from whence Fountains and Rivers drawn their Origin.*
>
> *The arms for the springs are two arms, their motto: "Avia, Pervia," the path of the wanderers.*

By 1700, geology had evolved into an emerging objective science in which physical observation demanded logical, mechanistic and consistent explanation. Whereas Biblical accounts could never -- according to long-held theology, that is -- be false, God's execution of that truth was via the forces of nature. And in what power of nature might better explain the remnants of prehistory -- fossils in the mountains, being an example -- than God's direction of water?

Thus the 18th and 19th-century geological theory of Diluvialism, the intellectual attempt to reconcile the geological record by reference to Noah's Flood.

John Hutchinson (1674-1737) believed all terrestrial matter at creation was suspended in a hollow spherical mass of water, in the middle of which was a central mass of air. The solid matter then separated from the water to form a crust over the central air and beneath the water. When light was ordained, the internal air expanded and burst out, being replaced by the water.

The Flood itself was caused by an increase in atmospheric pressure, produced by God, which forced air back into the abyss, displacing the water. According to The Philosophical and Theological Works of John Hutchinson (1749), the water then drained partly through holes in the bottom of the sea and partly via "Fissures, Swallows, and Cracks in the Strata," eroding them into caves. He believed similarly that the water of springs and rivers comes from the abyss, rising through the fissures that had been made by retreating water of the Flood.

Hutchinson's disciple Alexander Catcott noted that the water in Wookey Cave (Chapter 56, The Tourist Trade Worldwide) "may in some measure indicate the free communication there must be with the waters in the abyss in this place."

Catcott's work appeared in A Treatise on the Deluge; containing ... Natural Proofs of the Deluge, Deduced from a Great Variety of Circumstances, on and in the Terraqueous Globe, and ... the Cause of Caverns or Natural Grottos; with a Description of the Most Remarkable, Especially those in England (1761).

> *From the consideration of things upon the surface of the earth, let us now descend into the inside, and see what proofs we can aduce from thence of an Universal Flood. And here let us enter the subterranean Kingdom by those easy and convenient passages, -- the natural Caves and Holes in the Earth: and in the first place collect what evidence we can for the point in question from the Caves themselves.*
>
> *Proof that these caverns were formed by water, or, that rapid currents of that fluid have passed through them, may be drawn from the multitude of in-land pebbles that are to be found in most of them ... they are not only to be found at the bottoms or in the lower parts of these Caves, but even high up in the niches and covered cavities in the sides, and many of these pebbles consist of a different kind of stone from that of the rock of the cavern, so that they must have come from far, and the streams that brought them been rapid and strong.*

The cave-forming action of the violent drainage surged to and fro, thus having repeated effect.

> [The water] *returned from off the earth continually ... in going and returning; inflowing backwards and forwards, in fluctuating here and there; for as the Airs began to ascend before the Waters began to descend, they would of course impede and in part drive back the waters and so cause afluctuating or reverberating motion in them*

The "airs" which occupied the abyss while the water flooded over the earth would have interfered with the draining down in the manner that water emptied from a flask is interrupted by air bubbles rising against its flow.

Streams today in caves could not possibly have been responsible for their formation.

> *And lest anyone should imagine... that ... swallets in general might have been formed by river water, let it be remembered that they are commonly found upon the tops of the highest mountains, especially such as have extensive flats, where neither river nor rain-water could have any force to tear such Cavities, and therefore they could not owe their origin to such a Cause.*
>
> [Fissures connecting with the abyss] *serve as canals for the Water which supplies Springs and Rivers to run in.*

Alexander's brother Georgeheld a similar opinion.

> *In the Roof of these Caverns, and upper Parts of the Sides, are a great Number of Cavities in the solid Rock, in Form of inverted Funnels, which as they widen in Proportion to their Depth, prove they could not have been made by Art* [i.e. mining}, *(as some have absurdly asserted) but by the Retreat of the Waters which flow thro' them, into the great Abyss beneath, at the Time of the universal Deluge.--* A Descriptive Account of a Descent Made into Penpark-Hole (1772, 1775).

History, Habits, and Instincts of Animals (1835) by William Kirby, one of the Bridgewater Treatises we'll revisit in Chapter 13, illustrates the persistence of the Abyssians, if we can coin the term.

> *The word of God, in many places, speaks of an abyss of waters under the earth. Scientific men in the present day seem to question this.*

The author then shows how the Old Testament disproves the "Scientific men of the present," after which he considers the nature of the abyss itself.

> *The Hades of Scripture -- usually translated Hell, but distinct from the Gehenna or Hell of the New Testament -- is synonymous with the abyss. As is further proved by the following passage of the book of Job.*
>
> > *"Hast thou entered into the springs of the sea? Or hast thou walked in the search of the abyss? Have the gates of death been opened unto thee, or hast thou seen the gates of the shadow of death?"*
>
> *In this passage the springs of the sea, the abyss, the gates of death, and the gates of the shadow of death, seem nearly synonymous, or to indicate, at least, different portions, of the womb of our globe. The bottomless pit, or rather the pit of the abyss of the apocalypse, also belongs to the same place. The word rendered pit means also a well. Schleusner, in his lexicon, translates the phrase by "Puteus sen fons abyssi," so that it seems to indicate a mighty source of waters. But as the terms abyss and great abyss are applied to the receptacle of waters exposed to the atmosphere, as well as to those which are concealed in the womb of our globe, it is evident that they form one great body of waters in connection with each other.*

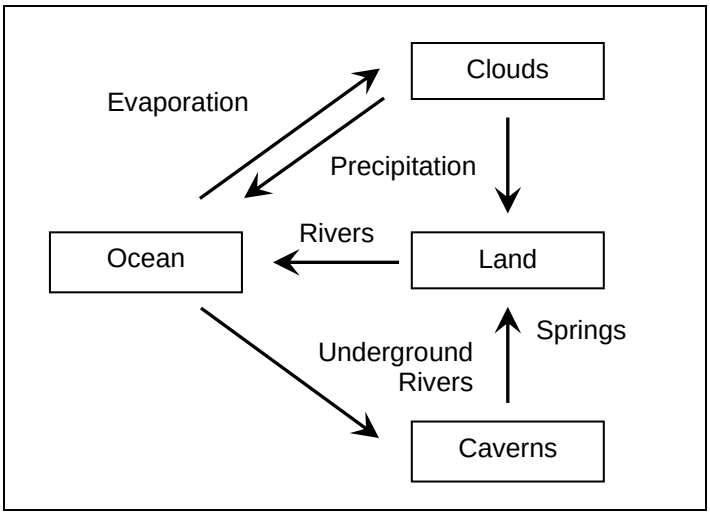
By this time, however, few scholars saw reason piece together God's doings in that week of creation. The task at hand for the "Scientific men of the present," was that of finding a model that explained observable nature.

There was need to reconcile three perceptions regarding rivers.

The circle as an unbroken expression of God's holiness,
An Aristotelian impressions that streamflow exceeds rainfall, and
The Platonic belief in subterranean reservoirs and channels.

The Dual Hydrologic Cycle

As put by Ramazzini, "The arms for the springs are two arms," the hypothesis of the dual hydrologic cycle.



The Dual Hydrologic Cycle

The upper loop, that which can be observed upon or above the earth's surface, agrees with modern pluvial theory, though today we'd include factors such as a box representing vegetation.

The lower loop, that which is within the earth, disagrees with modern evidence, but we not hold it against those working in an era before evidence was considered. We'll bring the diagram up to date in Chapter 39, Hydrogeology.

A dual cycle made sense in a time when water was thought to have opposing effects: water from above eroding of the continents and water from below rejuvenating the mountaintop.

The Tuscan Ristoro d'Arezzo (1223-1283) proposed in his treatise La Composizione del Mondo (1282) that the central cause of mountains resides with the stars. The heavens have a mountain and valley character, and where there is a mountain in the heavens, there is a corresponding valley on the earth. (We will see something similar when we consider the "contrapositionality" of hollow earth hydrocartography, Chapter 27.) The “virtues of the heavens” call water to rise as a magnet attracts iron.

Da Vinci drew upon La Composizione del Mondo, explaining how water washes gravel down-slope to raise valley elevations while subterranean streams bear earth upward on a seasonal basis.

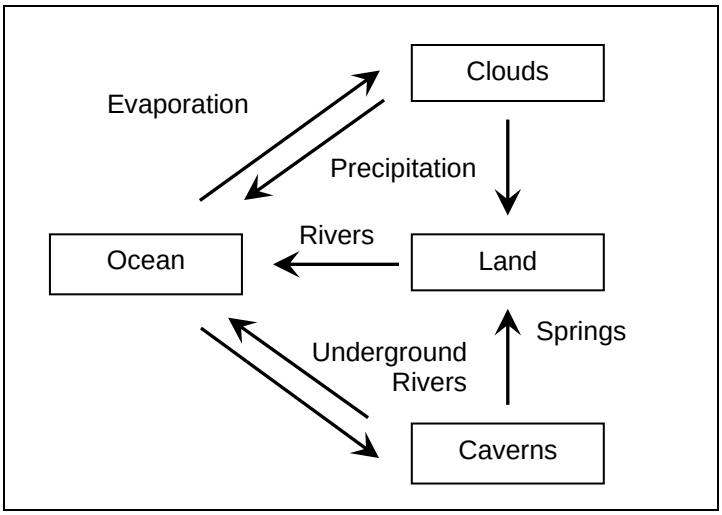
Bernard Varenius, author of Geographia Generalis (1692), the day's standard reference on physical geography, saw the cycle as dualistic.

> *Therefore the waters of Fountains proceed partly from the Sea or Subterranean waters, partly from Rivers, and Dew, that moisten the Earth. But the water of Rivers partly proceedeth from Springs, and partly from Rain and Snow.*

A dual cycle could even explain closed basins, watersheds such as that of the Dead Sea having no visible outlet to the sea. From Jean Henri Hassenfratz' Les Presses de l’Ecole des Mines (1806)

> *Africa and Asia are in the shape of a cone dug out at the summit. The waters flow out in part into the center; they are reunited into the great lakes or interior seas from which they are transported to the sea, either by evaporation, or by underground conduits.*

To let the sumps of Africa and Asia drain to the abyss from where flow returns to the sea, we need only add an upward lower-left arrow to our schematic.

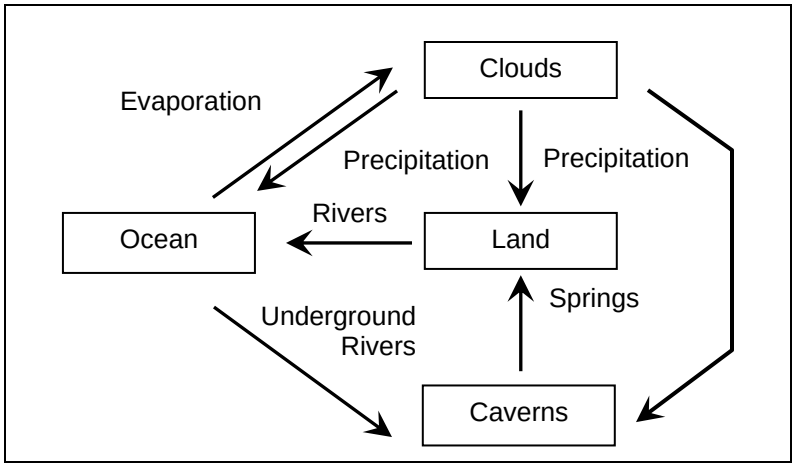


The Dual Hydrologic Cycle with Ocean Return

Isaac Vossius (1618-1689) was a Latin scholar who edited Pliny's Naturalis Historia. Vossius' Aliorum Fluminum Origine (1666) allowed that caverns in fact might be directly fed by rainwater.

> *All Rivers proceed from a Colluvies of Rendezvous of Rain-water, and that, as the Water that falls upon the Hills, gathers more early together, than that which falls in Plaines, therefore it is that Rivers ordinarily take their Sources from Hills.*

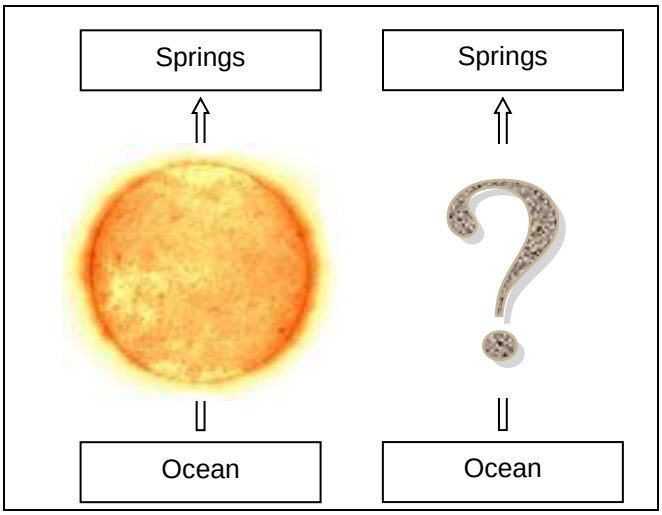
Our schematic needs but right-side arrow.



The Dual Hydrologic Cycle with Rain-Fed Caverns

But we'll not advance our schematic beyond the thoughts of the times. The challenge isn't that of drawing arrows; it is that of explaining how the arrows work.

The diagrams below illustrate the dual mechanisms by which water returns from the sea to upland streams, Ecclesiastes 1:7 as schematic. The superterranean means was agreed upon by all -- it is the sun's power that draws water upwards. The motor on the left, the energy propelling subterranean streamflow -- for of course it's down there -- was yet unknown.



As we'll see in the chapter ahead, we've had lots of ideas about circulation. As Ramazzini would have phrased it, "Avia, Pervia!"

CHAPTER 8
TRANSMUTATIONAL AND BIOLOGIC ENGINES

Having arrived on the shores of scientific inquiry, let us take stock of where we've traveled. The myth of underground rivers has been rooted in Western culture since the time of the Greeks. According to the Romans, there were many such rivers in distant lands. Reinterpreted in accordance with medieval theology, belief in such waterways acquired parochial authority.

But few pondered what powers such waters to the elevations of efflux? According to Aquinas, "streams... in the habit of doing this" are "something that everybody knows."

To Renaissance thinkers, however, the aesthetic of circular watercourses -- down the mountain slope and back up the interior -- begged for envisionable explanation.

It fell upon infant science, still laden with mythological legacy, but at last beginning to seek objectivity, to deduce the mechanism of rivers that were presumed to run underground.

Conceptual mechanization was by no means a straight-forward process, as noted as late as the 17th century by mathematician, physicist and magician Gaspar Schott (1608-1666). From his Anatomia Physico-Hydrostatica Fontium ac Fluminum Explicata (1663),

> *Sea water may be carried through subterranean canals to the surface of the earth and quite frequently to the top of the highest mountains. How this takes place in something which hitherto has baffled the minds of all and has led to an almost interminable amount of conjecturing.*

As to what might drive subterranean rivers upward, Schott has this to say in Athanasii Kircheri (1660), his commentary on a contemporary with whom we'll soon become better acquainted.

> *We are of the opinion that some springs and rivers have their origin from subterranean air and vapors which have been condensed into water. Others from rain and snow which has soaked into the earth, the greatest number and the most important rivers, however, from sea water rising through subterranean passages and issuing as springs which flow continuously. And so the sea is not the only source, at least it does not distribute its water through underground passages to all these springs and rivers.*
>
> *But this statement would seem to run contrary to the clear teaching of Holy Writ found in Ecclesiastes, chapter 1 and verse 7, All rivers run to the sea; yet the sea is not full; unto the place whence rivers cone, thither they return again.*

We're well acquainted with the Holy Writ, of course, from Chapter 6, but Schott, who was also a Jesuit, was in pursue of the "real meaning."

> *The real meaning of these words however seems to be: All rivers run into the sea, from the place out of which they come, to it they flow back again. Consequently these which enter the sea have issued from the sea, and those which have issued from the sea return to it and enter it that they may flow out of it again. But all enter it and all return to it, therefore all have issued from it. But it does not follow that some, as we believe, have not come out of the sea by another road than that just mentioned. I am, therefore firmly of the opinion and again repeat, all rivers do not issue from the sea -- at least all do not make their exit directly out of the ocean into*

the depths of the earth and from there rise through subterranean channels to their fountain heads.

Schott evokes a grab-bag of underground flow mechanisms: up from the sea, except for that which derives from rain, snow or subterranean air. The era's "conjecturing" was indeed "almost interminable," but if we step back from the specifics, we find an engaged intellectual community sorting through the possibilities.

In this chapter we will sort through the first of many propositions easily dismissed in light of what's now text-book science, but mechanisms seemingly possible to intellectuals newly enamored with the concept of "mechanism." We'll consider a mechanism attractive to the Platonists, one of transmutation, and an alternative more attractive to the Aristotelians, a turn to biology.

In the two chapters to follow, we'll introduce explanations somewhat more mechanical, ones employing heat, force, electricity, topics today we classify as "physics." As Renaissance thinking didn't preclude wandering rationale, we will encounter da Vinci throughout.

As noted in the introduction, the difference between science and superstition can be slight.

Transmutation

Perhaps ocean water becomes another element, rises through subterranean conduits to springheads and then reconverts to water. Pythagoras' speech in Ovid's Metamorphoses proclaims that although the elements have their natural seats, all likewise transmute.

Of these are made, to these again they fall.
Received earth to water rarifies;
To air extenuated waters rise;
To air, when it itself again refines,
To elemental fire extracted shines.
They in like order back again repair;
The grosser fire condenseth into air;
Air into water; water, thickening, then
Grows solid and converts to earth again.
None holds his own: for nature ever joys
In change and with new forms supplies.

A 15th-century representation of the four elements: fire, air, water and earth

When burned, a substance -- wood, for example -- resolves into its elements. The fire is seen by its own light. Its smoke becomes air. From the ends of wood, water boils off. Ashes are the nature of earth.

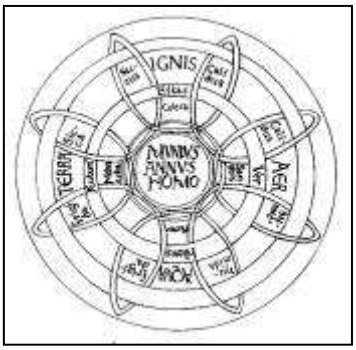
Plato's elements were not distinct substances; they were principles. Fire was not the actual flame, but rather the principle of combustion. Water was the principle of fluidity; earth, the principle of solidarity. Air was that which filled vacant space.

Aristotle's universe was -- as we'd expect -- more physical. Finite and spherical, the globe was made of earth, air, fire and water proportioned 1:10:100:1000. Each element moves naturally in a straight line -- earth downward, fire upward -- toward its proper place determined by "heaviness." Terrestrial motion thus must come to a halt. The heavens, on the other hand, move endlessly in circular motion. The heavens are of a fifth element, either, a superior element incapable of change other than in circular movement.

Aristotle used the “primary qualities” of heat cold, moistness and dryness, to explain elemental natures,

hot + dry = fire
hot + wet = vapor
cold + dry = earth
cold + wet = water

As wetness cools, vapor becomes water. Because it is the nature of heat to rise, the heat in the vapor ascends to free itself. The cold in the vapor, having driven away the heat, presses itself closer together, restoring it to its natural liquid state.



Isidore of Seville’s De Responsione Mundi (1492) diagrams the primary qualities.

Neo-Platonist Christian mystic Gregory of Nyssa (332-396) pondered the question of Ecclesiastes 1:7. Why does the sea grow no larger? The answer: because God transmutes earth into water and water into earth.

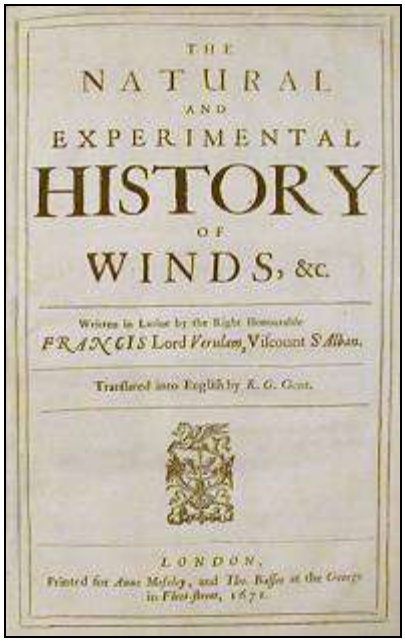
With the revival of Aristotelian sensibility (Chapter 6), however, transmutation by divine will was intellectually unsatisfactory. In Lecturae super Genesim (1385), Henry of Langenstein (1363-1382) proposed a three-fold explanation of springflow that was two-thirds correct. To wit,

> Springs issue from pores in the earth in which vapor has condensed or to which water has seeped from mountain places or has been drawn from within the earth.
>
> The pores also serve as entrance for surface waters returning to the sea.
>
> Some water in deep and obscure pores is influenced by the generative process of the earth and is transformed into metals and gemstones.

What is meant by "the generative process of the earth" isn't clear, but it's clearly transformation.

Da Vinci accepted elemental transmutation as fact, justifying the occurrence of water at high elevations as a product of elemental air. Wind is likewise explained where there was water.

> *The elements are changed one into another, and when the air is changed into water by the contact it has with its cold region this then attracts to itself with fury all the surrounding air which moves furiously to fill up the place vacated... But if the water is changed to air, then the air which first occupied the space into which the aforesaid increase flows must needs yield place in speed and impetus to the air which has been produced, and this is the wind.*



THE
NATURAL
AND
EXPERIMENTAL
HISTORY
OF
WINDS, &c.

Written in Latin by the Right Honourable
FRANCIS Lord *Verulam*, Vilcount *S. Alban*.

Translated into English by *R. G. Gent.*

LONDON,
Printed for *Anne Moseley*, and *Tho. Basset* at the *George*
in *Fleet-street*, 1671.

In Historia Ventorum (1622), Francis Bacon (1561-1626) wrote that air emitted from the earth's interior transformed itself into rain.

> *Winds do contract themselves into rain,... either being burthened by the burthen itself, when the vapors are copious, or by the contrary motions of winds, so they be calm and mild; or by the opposition of mountains and promontories which stop the violence of the winds, and by little and little turn themselves against themselves; or by extreme colds, whereby they are condensed and thickened.*

Pierre Cureau de la Chambre (1631-1693), on the other hand, made the distinction between constituent and state. From Discours sur les Causes du Desbordement du Nil (1666),

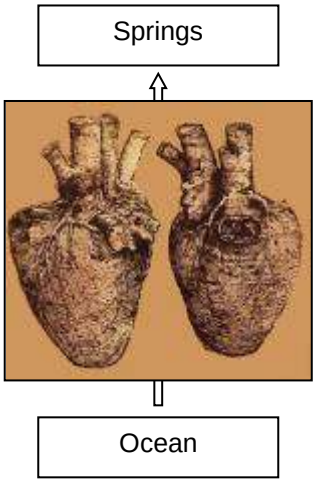
> *When nitre is heated by the heat of the sun, it ferments and mingling with the water, troubles it, swells it, and makes it pass beyond its banks; after the same manner as the spirits in new wine render it troubled and make it boil in vessel.*

The observation that the nitre (saltpeter) is mingled in the water -- as opposed to being derived from it -- signals the end of transmutation as hydrologic explanation, however. A quasi-chemical basis for flooding speaks to the times, if not the fact, but it at least doesn't involve created water.

As more-pragmatic science replaced Plato's natural philosophy, transmutational underground rivers fell from serious consideration.

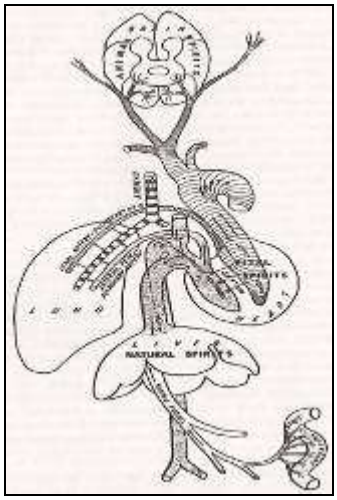
Much more attractive were models based on biology, ill-understood as it was, but in the mind of the Church, an implementation of God's will.

Terrestrial Arteries



Plato's analogy between the "macrocosm" of the cosmos and the "microcosm" of humankind strives to reduce a complex universe into some intelligible scale, and thus give unity to the whole.

Aristotle was a crypto-biologist, seeing the earth a living organism. It took budding mechanists little effort to follow the philosopher's path -- a macrocosmic earth working as a microcosmic human body. Our schematic shows da Vinci's drawing of a human heart.



Galen (129-199), the most significant physician of the ancient world after Hippocrates, believed in two separate "tides" of blood, the arterial and the venous, independently driven by the heart. Arteries carry the "vital" spirits to the tissues. Veins convey the "natural" spirits.

As an engine for underground rivers, Galen's model of the heart -- pumping ever upward as it must -- made sense.

Drawing upon an unattributed 13th century source, William Caxton (1422-1491), the first English printer, subscribed to the blood model in Mirror of the World.

> *All is likewise as the blood of a man goeth out & issueth in some place, all in likewise runneth the water by the veins of the earth and soundeth and springeth out by the fountains and wells; from which it goeth all about that, when one delveth in the earth deep in meadow or in mountain or in valley, men find water.*

The centerpiece of da Vinci's world view was the earth as a living, self-sustaining organism. From his unfinished Treatise on Water,

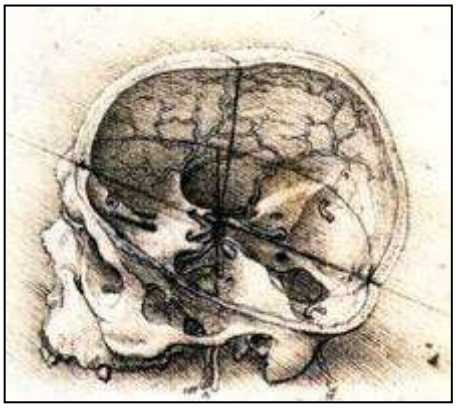
> *By the ancients man has been called the world in miniature; and certainly this name is well bestowed. Inasmuch as man is composed of earth, water, air, and fire, his body resembles that of the earth.*

Da Vinci seems to be preparing to argue for something transmutational, but instead he turns to metaphor.

> *So that we might say*
> *That the earth has a spirit of growth;*
> *That its flesh is the soil,*
> *Its bones are the arrangement and connection of the rocks of which the mountains are composed,*
> *Its cartilage is the porous rock,*
> *And its blood is the springs of water.*
> *The pool of blood which lies round the heart is the ocean,*
> *And its breathing, and the increase and decrease of the blood in the pulses, is represented in the earth by the flow and ebb of the tide.*

Da Vinci recognized, however, the analogical difficulty. While both the globe and the human body consist of earth, water, air and fire, the correspondence of macrocosm to microcosm can only work if the globe possesses a mechanism comparable to the heart. Da Vinci came close discovering the circulation of blood, but in the end, could not break free from Galen.

> *Just as the natural heat of the blood in the veins keeps it in the head of man, and when the man is dead the blood sinks to the lower parts, and as when the sun warms the man's head the amount of blood there increases and grows so much with other humors, that by pressure in the veins it frequently causes pains in the head; in the same way with the springs which ramify through the body of the earth and, by the natural heat which is spread through all the -- containing body, the water stays in the springs at the high summits of the mountains.*



Giordano Bruno (1548-1600) considered geographical features not as accumulations of inert matter, but as spirits of life corresponding to the bones, intestines, veins, arteries, flesh and nerves of the earth. As explained in De l'infinito Universo et Mondi (1584), fog, rain, lightning, thunderstorms and earthquakes are terrestrial diseases. Without underground rivers, the world would perish for lack of blood. Bruno was burned at the stake for errors in theology.

Sir Walter Raleigh (1552-1618), remembered for his gallantry with Elizabeth I, promoted a doctrine of organic microcosm in The History of the World (1616), written while imprisoned in the Tower of London.

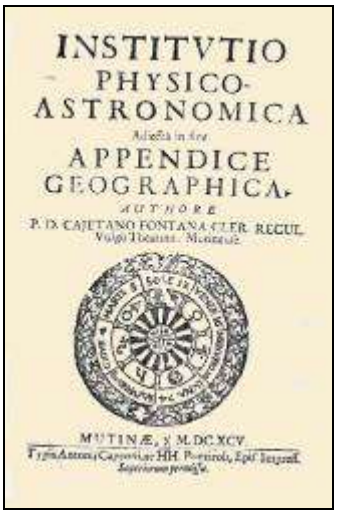
> [Man's] *blood, which disperseth itself by the branches of veins through all the body, may be resembled to those waters which are carried by brooks and rivers over all the earth, his breath to the air, his natural heat to the enclosed warmth which the earth has itself.*

Raleigh saw the hydrologic cycle as an illustration of God's power, the theme we'll pursue Chapter 13.

> *For as it is God's infinite power and everywhere presence ... that giveth to the sun power to draw up vapors, to vapors to be made clouds; clouds to contain rain, and rain to fall: go all Second and instrumental causes, together with nature itself, without that operative faculty which God gave them, would become altogether silent, virtueless, and dead.*

William Harvey (1578-1657) saw the pervasiveness of circular processes in nature as the noblest form of motion. Like Aristotle, Harvey believed that both sublunary bodies and living organisms aspire to the pattern displayed by the orbits of heavenly bodies. Harvey's Exercitatio Anatomica de Motu Cordis et Sanguinis (1628) drew attention to the hydrologic cycle.

> *The moist earth, warmed by the sun, evaporates; the vapors drawn upwards are condensed, and descending in the form of rain, moisten the earth again; and by this arrangement are generations of living things produced... And so, in all likelihood, does it come to pass in the body, through the motion of the blood; the various parts are nourished, cherished, quickened by the warmer, more perfect, vaporous, spirituous, and, as I may say, alimentive blood; which, on the contrary, in contact with these parts becomes cooled, coagulated, and, so to speak, effete; whence it returns to its sovereign the heart, as if to its source, or to the inmost home of the body, there to recover its state of excellence or perfection...* [All] *this depends on the motion and action of the heart... The heart, consequently, is the beginning of life; the sun of the microcosm, even as the sun in his turn might well be designated the heart of the world.*


INSTITVTIO
PHYSICO-
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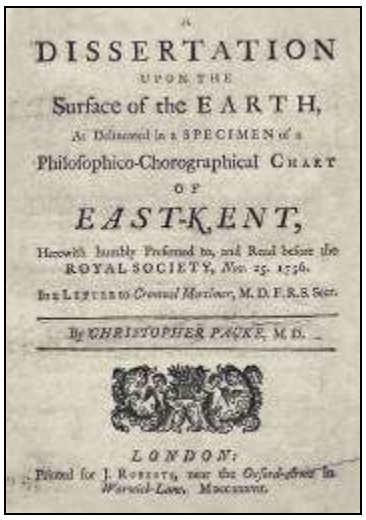
P. D. CAJETANO FONTANA CLER. REGUL.
MUTINÆ, A M.DC.XCV

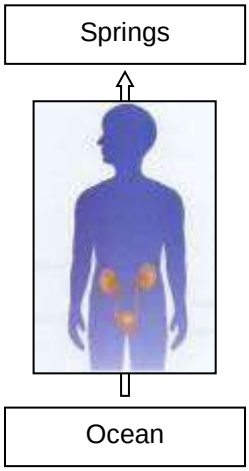

A
DISSERTATION
UPON THE
Surface of the EARTH,
As Delineated in a SPECIMEN of a
Philosophico-Chorographical CHART
OF
EAST-KENT,
By CHRISTOPHER PACKE, M.D.
LONDON:

Cajetano Fontana wrote in Instituto Physico-Astronomica (1695) that fountains rising within the earth are actuated by “anima of the Geocosmos,” the economy of nature, just as human blood is moved by the “anima” of vital principle.

Reluctant to be retired, the arterial analogy received a hearing in London's Royal Society as late as 1736 when Christopher Packe (1686-1749) commended glowingly the "concerted Regularity” of the valleys in Kent, likening them to the veins of the body, and hinted at a subterranean network of channels, "analogous to the arteries," published the year following as Dissertation upon the Surface of the Earth, as Delineated in a Specimen of a Philosophico-Chorographical Chart of East Kent.

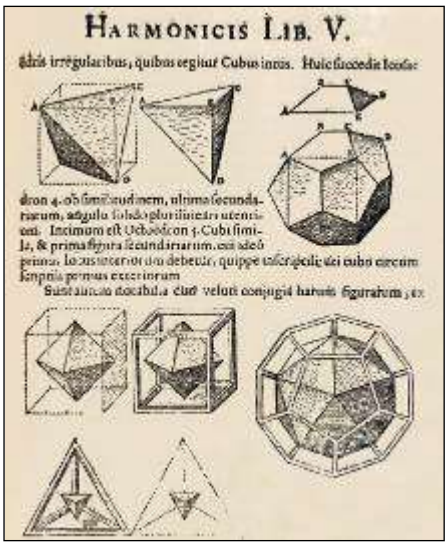
In retrospect, analogy to human blood wasn't bad science for Leonardo's day. It mimicked observable natural function and, like Newtonian physics, sought physical law independent of scale. The model's persistence for another two centuries is more difficult to justify, however.

The Urinary Tract



The urinary-tract model never got too far. Were it not associated with a respected scientist, we'd drop it from our list, but on the other hand, it's creative.

German astronomer Johannes Kepler (1571-1630) called the moving cause of planets an “anima motrix” (moving soul) in his Mysterium Cosmographicum (1596). Although in the second edition he replaced “anima” by “vis” (force), his Harmonices Mundi (1619) persisted with the metaphor.



The globe contains a circulating vital fluid... Every particle of it is alive. It possesses instinct and volition and even the most elementary of its molecules, which attract and repel each other according to sympathies and antipathies. Each kind of mineral substance is capable of converting immense masses of mater into its own peculiar nature, as we convert our aliment into flesh and blood. The mountains are the respiratory organs of the globe, and the schists its organ or secretion.

Kepler's metabolic model was well suited for the passage of subterranean waters.

The Earth forever drinks in water from the sea... and that groundwater and springs are the end products of the Earth's metabolism.

As urine from the bladder, rivers flow from the mountains.

Kepler is best remembered for his heliocentric laws of planetary motion, not his insight regarding geohydrology.

The Earth's Sap

While the early mechanists were more likely to envision the earth as an animal, not a vegetative organism, the vine metaphor was sometimes employed to describe underground streams.

Da Vinci suggested that spring water “rises from the low roots of the vine to its lofty head, falls through the cut branches upon the roots and mounts anew to the place whence it fell." His evidence was as follows.

The same cause which stirs the humors in every species of animal body and by which every injury is repaired, also moves the waters from the utmost depth of the sea to the greatest heights and just as the water [sap] *rises from the inferior parts of the vine to the cuts higher up.*

Likewise the water that rises from the low roots of the vine to its lofty head falls through the cut branches upon the roots and mounts anew to the place whence it fell.

> *As the water rises from the lowest part of the vine to the branches that are cut, so from the lowest depth of the sea the water rises to the summits of mountains, where, finding the veins broken, it pours out and returns to the bottom of the sea.*

We've modeled underground rivers powered by both transmutation and biology, but there are ever so many more possibilities.

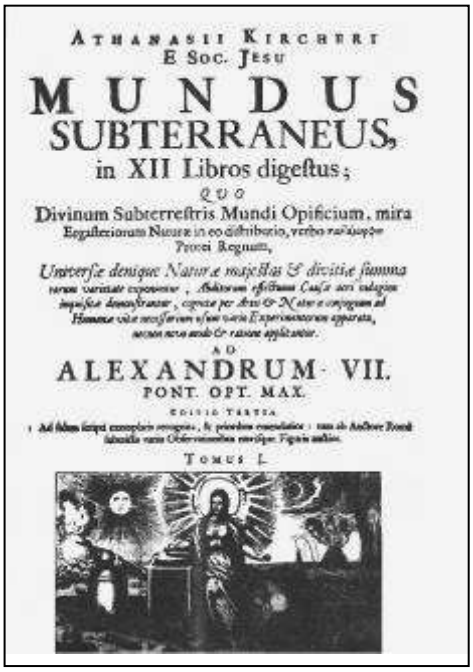
CHAPTER 9
THERMODYNAMIC ENGINES

This chapter deals with underground rivers powered by heat, but in before we ignite the hearth, we need an ample reservoir of water.

Hydrophylacia

Athanasius Kircher (1602-1680), a prolific polymath, was the world's first scientist to support himself through his writings. His syncretistic scholarship paid little attention to disciplines. A Jesuit living in an age still rocked by Reformation, Kircher heeded the Holy Scriptures, but from Kircher's viewpoint, a "Turris Babel" reaching the heavens seemed impractical. By his reckoning, it would require 3,000,000 tons of building material just to reach the moon. But worse, the edifice would pull the earth from the center of the universe.

Kircher's two-volume Mundus Subterraneus (1665) was the first printed work on geophysics. Not constrained by its title, however, the work included maps of the solar surface, global ocean circulation and Atlantis.


ATHANASII KIRCHERI
E SOC. JESU
MUNDUS
SUBTERRANEUS,
in XII Libros digestus;
QUO
Divinum Subterrestris Mundi Opificium, mira
Ægyptiorum Naturæ in eo distributio, verbo
Protei Regnum,
Universæ denique Naturæ majestas & divitiæ summa
AD
ALEXANDRUM VII.
PONT. OPT. MAX.
EDITIO TERTIA
TOMUS I.

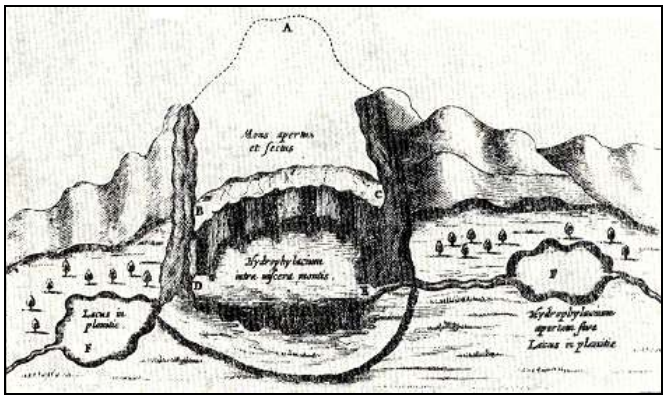
Regarding the subterraneus,

> *The Underground World is a well framed house with distinct Rooms, Cellars, and Storehouses, by great Art and Wisdom fitted together.*

Kircher's theory of holes on the ocean floor connecting to underground brooks was embellished with mention dragons and gargantuan lizards.

Kircher's most-dramatic contribution to geologic graphic art is the hollow-mountain water cavern, the "hydrophylacium," "phylacium" being Latin for "storehouse." That Kircher placed such caverns above sea level suggests that he believed them to drain by gravity.

Mundus Subterraneus was widely reprinted with altered graphics, but no matter the particular artist, the hydrophylacia are central to the composition. Three of the four illustrations shown here are geographically explicit.



We'll look more closely at the lower-left illustration in Chapter 14, Fountains of the Nile.

The hydrophylacia model was old, however, even in Kircher's era. Conrad von Megenberg's Das Buch der Natur (1349-1351), the first illustrated book on nature, included a description of the big-cavity hydrology.

> *Some* [waters] *originate in the big hollow mountain which is cold and rocky. The watery steam dissolves here into water drops which mix with the soil, with the daily rain and the snow. So the water drops collect in the cavities and form a rivulet; many rivulets form a big stream which seeks an exit from the mountain and eventually breaks through. This is the spring of flowing waters or of a well on the mountain, or a lake on the mountain.*

As the hydrophylacia are above sea level, Kircher needed to explain how seawater attained the elevation. The fact that that temperature increases with depth in dry mines guided his ideas.

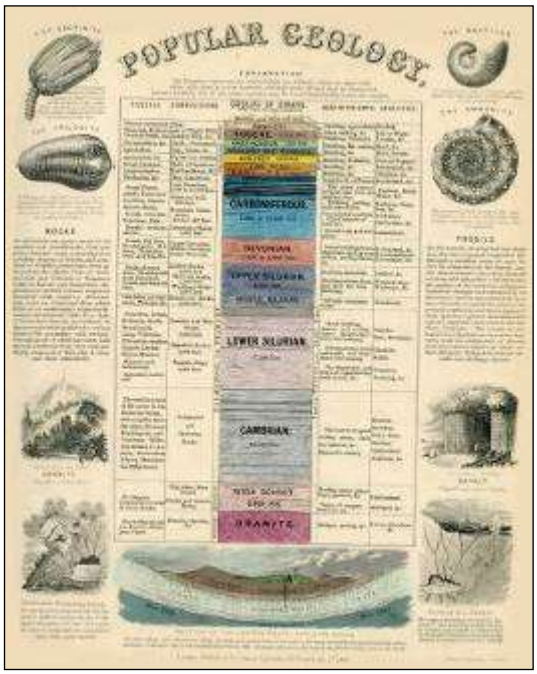
> *The central fire pours out surging and burning exhalations to each and every part by fire-carrying channels. Striking the water-chambers it forms some into hot springs. Some, it reduces to vapors which, rising to the vaults of hollow caves, are there condensed by cold into waters which, released at last, give rise to springs and rivers.*

An event in 1678 seemed to support the existence of hydrophylacia. Flash flooding of the Garonne River, which issues from a spring in the Pyrenees, without there having been local rainfall, was attributed to collapse within the mountain displacing an underground lake.

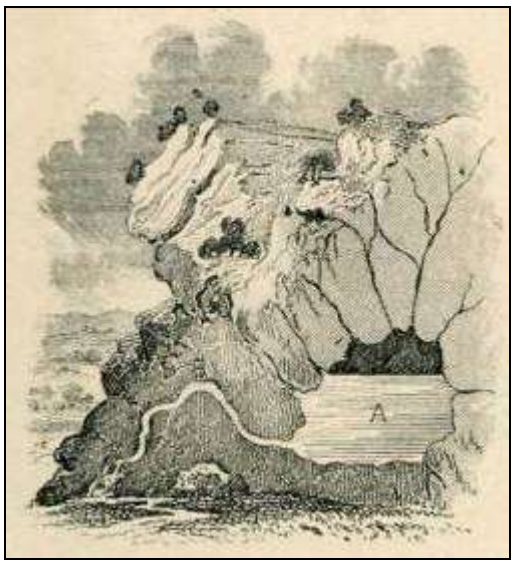
> *So this Mass of the Mountain in its settling all at once upon the Water of the Gulphs or Subterraneous Lakes, which are under the highest Pyrenean Mounts ... do force the Water to gush out all together with great violence to the same quantity with the Bulk of that part of the Mountain which is settled into the Subterraneous Lakes, which is the cause o/this Prodigious over flowing.*

A dye study described in Chapter 49 would later show the Garonne's subterranean reach involves no such hydrophylacium, but Chapter 49 wouldn't have been available at the time.

For centuries to follow, Kircherian drawings -- the cavernous hydrophylacia being a trademark -- have proven to be almost impossible to suppress. We cite, for illustration, "Popular Geology, a Complete Summary of the Science, with Many Illustrations," engraved by John Emslie, published in Reynolds' Twelve Geological Diagrams (1860), a portfolio of plates to be passed around a lecture hall or posted for edification.

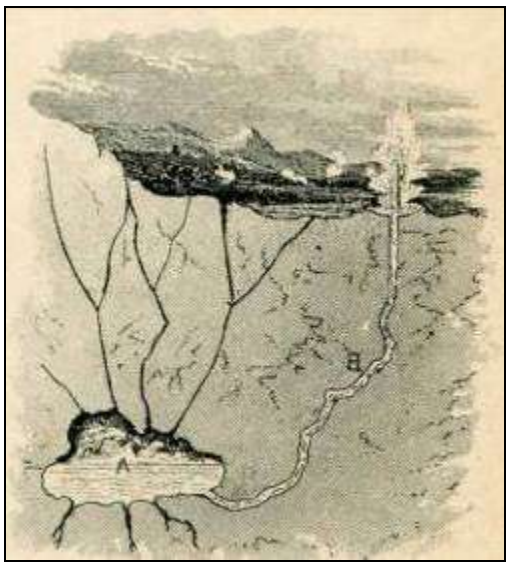


The enlargements of the lower left and right figures bear the hydrophylacia stamp of our irrepressible Jesuit.



Section of a Reciprocating Spring

The rain by percolating the rock fills the cavity A until it reaches the top of the bend B, the spring will then flow until the water is exhausted, the same phenomena being again repeated.



Section of a Geyser

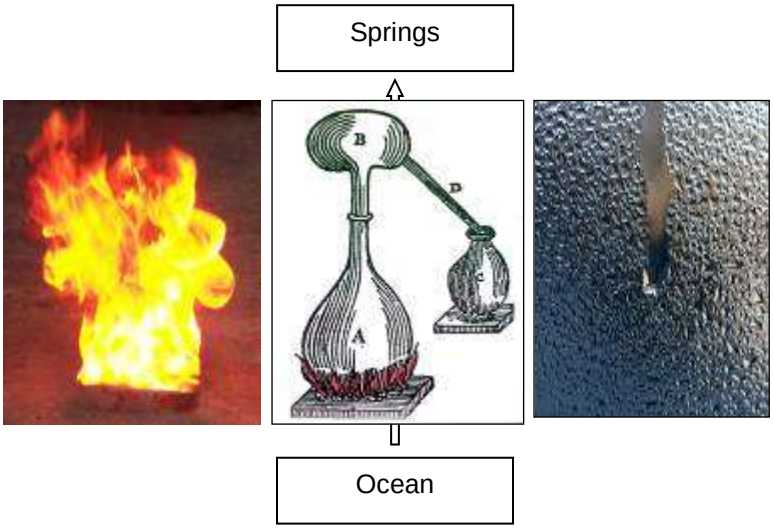
The water percolating the rock fills the cavity A and becoming greatly heated by volcanic action, steam is formed, which by its elastic force drives the water up the channel B whence it issues as a fountain.

Descartes (Chapter 7), a Kircher contemporary who equated Jesuitical intellectualism with the Inquisition that imprisoned Galileo and executed Bruno, described Kircher as "more quacksalver than savant."

If Kircher was quacksalver -- a charlatan -- he was at least an engaging quacksalver.

A hydrophylacium may also be required for non-thermal geophysical engines of underground flow, but we'll get to those possibilities in the chapter to follow.

The Heat of the Earth



We show three mechanisms -- fire, an alembic and condensation -- which while together describing the same physical process, were differently emphasized by early writers.

Mt. Etna had a major eruption in 475 BC and another in 396. In 1669, lava destroyed the town of Nicolosi and Catania. Other pre-1800 eruptions occurred in,

1797-1801, 1791-93, 1787, 1780-81, 1776, 1770, 1763-67, 1752-59, 1747-49, 1744-45, 1735-36, 1732-33, 1723-24, 1702, 1693-94, 1688-89, 1682, 1651-56, 1646-47, 1643, 1633-38, 1614-24, 1603-10, 1595, 1579-80, 1566, 1554, 1540-41, 1536-37, 1494, 1446-47, 1444, 1408, 1381, 1350, 1333, 1329, 1284-85, 1250, 1222, 1194, 1169, 1164, 1160, 1157, 1063, 1044, 1004, 911, 859, 814, 812, 644, 417, 252, 80, 39, 10 AD and 10, 32, 36, 44, 49, 56, 61, 122, 126, 135, 141, 350, 396, 424-25, 476-79, 565, 695, 735 and 1500 BC.

Mt. Vesuvius near Campania is one of the world's most dangerous volcanoes. Pre-1800 eruptions occurred in,

1796-1822, 1783-94, 1770-79, 1764-67, 1744-61, 1732-37, 1724-30, 1712-23, 1706-08, 1701-04, 1696-98, 1685-94, 1682, 1654-80, 1637-52, 1631-32, 1500, 1347, 1270, 1150, 1139, 1073, 1049, 1037, 1007, 999, 991, 968, 787, 685, 536, 512, 505, 472, 379-95, 222-35, 203, 172, 79 AD and 1500 BC.

The Island of Stromboli, north of Sicily, has been in almost continuous eruption for over 2,000 years. Larger than normal eruptions over the recent 240 years include those of,

2006, 2003, 1998-2000, 1993-96, 1989-90, 1985-1986, 1975, 1971, 1966-68, 1959, 1956, 1949-54, 1943-44, 1941, 1936-37, 1934, 1930, 1919, 1915, 1912, 1905-07, 1903, 1900, 1895-98, 1891-1893, 1888-89, 1885, 1881-82, 1879, 1874, 1855, 1850, 1833, 1822, 1778, 1770 and 1768.

Mt. Vesuvius

Stromboli

Mt. Etna

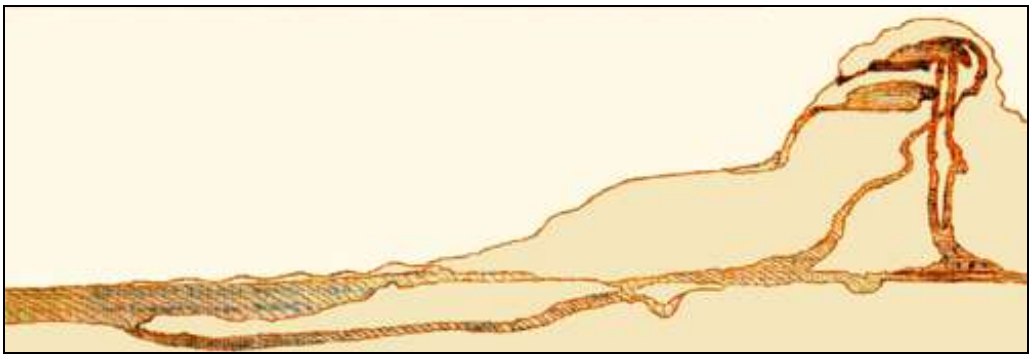
To speculators steeped in classical history, the earth's igneous power seemed more than sufficient to pump hillside fountains. Da Vinci argued initially that water is drawn upwards through subterranean passages by the heat of the sun, but the heat source did not please da Vinci for two reasons.

As mountain crests are closer to the sun, flowing water shouldn't be frigid.

The solar engine should work best in the summer when water is warmer, but the summer is often when springs diminish.

Aware of the 1494 Mt. Etna eruption and the 1500 event of Mt. Vesuvius, da Vinci turned toward an interior fire as a better explanation of spring water.

> *Now the same heat which holds up so great a weight of water as is seen to rain from the clouds, draws them from below upwards, from the foot of the mountains, and leads and holds them within the summits of the mountains, and these finding some fissures, issue continuously and cause rivers.*
>
> *And this water, which passes through a closed conduit inside the body of the mountain like a dead thing, cannot come forth from its low place unless it is warmed by the vital heat of the spring time. Again, the heat of the element of fire and, by day, the heat of the sun, have power to draw forth the moisture of the low parts of the mountains and to draw them up, in the same way as it draws the clouds and collects their moisture from the bed of the sea.*

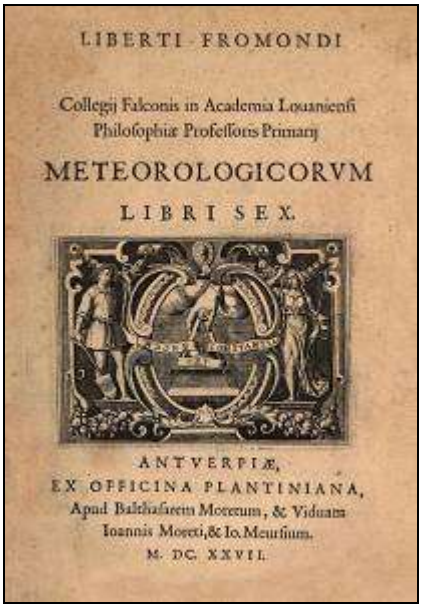


Da Vinci suggests how seawater can rise toward a mountain peak because of subterranean fire.

> *The heat of the spirit of the world is the fire which pervades the earth, and the seat of the vegetative soul is in the fires, which in many parts of the earth find vent in baths and mines of sulphur, and in volcanoes, as at Mount Aetna in Sicily, and in many other places.*

Georg Bauer (1494-1555), "Agricola," recognized in De Ortu et Causis Subterraneum (1546) that springs are largely supplied by rainwater, but,

> *Being heated it can continually give off halitus* [steam]*, from which arises a great and abundant force of waters. Halitus rises to the upper parts of the canales, where the congealing cold turns it into water, which by its gravity and weight again runs down to the lowest parts and increases the flow of water if there is any.*
>
> *If any find its way through a canales dilatata* [expanded] *the same thing happens, but it is carried a long way from its place of origin. The first phase of distillation teaches us how this water is produced, for when that which is put into the ampulla is warmed it evaporates, and this balitus rising into the operculum is converted by cold into water, which drips through the spout. In this way water is being continually created underground.*
>
> *And so we know from all this that of the waters which are under the earth, some are collected from rain, some arise from balitus, some from river-water, some from seawater; and we know that the halitus is produced within the earth partly from rainwater, partly from river water, and partly from seawater.*


LIBERTI FROMONDI

Collegij Falconis in Academia Louaniensi
Philosophiæ Professoris Primarij

METEOROLOGICORVM

LIBRI SEX.

ANTVERPIÆ,
EX OFFICINA PLANTINIANA,
Apud Balthasarem Moretum, & Viduam
Ioannis Moreti, & Io. Meursium.
M. DC. XXVII.

In Meteorologicorum Libri VI (1627) Belgian Libert Froidmont (1587-1653) described mountains as alembics, a distillation apparatus familiar to alchemists.


ARCHITETTVRA
D' ACQVE
DI
GIO. BATTISTA BARATTIERI
INGEGNERE.
PARTE PRIMA

ALL' ILLVSTRISSIMO SIG.
FERDINANDO SANTI

PIACENZA

In his Architettura d'Acque (1656), Giovanni Battista Barattieri endorsed the geological alembic, although he included melting snow's contribution to springflow based on observation.

On a visit to southern Italy, Kircher -- who surely knew of the igneous demise of Pliny the Younger (Chapter 3) -- was lowered into the crater of Mt. Vesuvius, then on the brink of eruption, to examine its interior. More fortunate than Pliny, the Jesuit emerged alive.

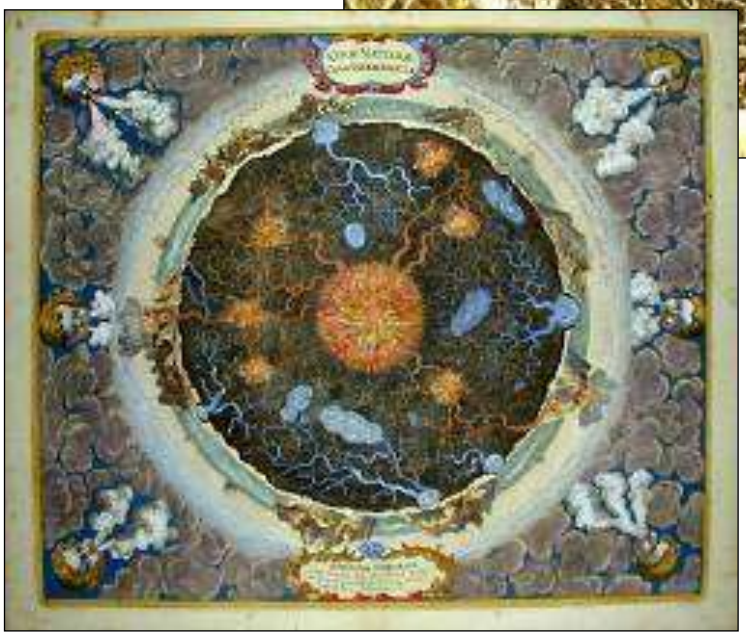
The driving force in Mundus Subterraneus is the central fire, diffusing with igneous exhalations heated water from hydrophylacia filled with water, fog or air converted to steam, which, in turn rise to the highest mountains.

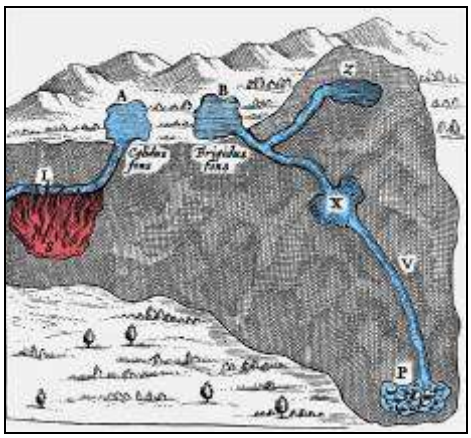
> [The] *Associates, and Agents of Nature* [fire and water] *sweetly conspire together in mutual service, with an inviolable friendship and wedlock, for the good of the whole in their several and distinct private-lodgings...* [creating] *minerals, juyces, marles, glebes, and other soyls, with ebullitions, and bubblings up of fountains.*

Kircher accused Aristotle of opposing scripture by denying that springs and rivers originate in the sea, but remained Aristotelian in terms of causal structure.

The formal cause is fire.
The material cause is "Sulphur, Bitumen, Pit-Coals, and also Allom, Salt, Nitre, Coaly Earth, and Calcanthum or Vitriol, and such kind of Metals." in the dark recesses.
The instrumental cause is "the Cavernous nature of the place... oppressed with Sulphureous Smoak and Soot."
The efficient cause consists of "Winds and Blasts" from the cavernous interior.

Kircher's graphics catch the flavor of the fiery underground. Pyrophylacia (fire caverns) connect with the earth's "central fire" through a network of chambers, underground reservoirs, fountains and twining passages through which water and lava escape to the surface.





Kircher included the seabed as a source of springflow because snow and rainfall are seasonal, whereas rivers are not. To disprove the mechanism of subterranean condensation, he referred to the lake at Mt. St. Gotthard lacking the covered vault that condensation would necessitate.

As an orientologist (among his myriad of interests), Kircher pursued reports from his fellow Jesuits regarding far-off Asia. His illustration in China Monumentis (1667) is another case of the fiery global engine.

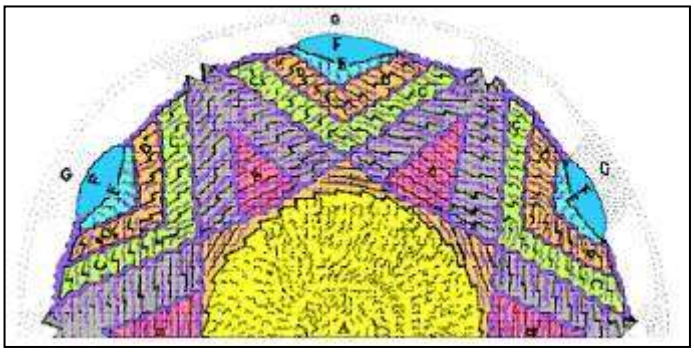
Thomas Robinson's The Anatomy of the Earth (1694) and New Observations on the Natural History of the World of Matter (1696) described vapors from the sea condensing into mountain showers that cause rivers to flood. Other waters move upward through a maze of subterranean "dikes" to mountain tops where they emerge as springs.

Robinson rehashed da Vinci's analogy between the bursting forth of mountain top fountains and the breaking of a blood vessel. Mountain tops, Robinson instructs, are more subject to accidents (tempests and thunder) than are flat plains where the veins are thickly buried.

> *The windings and turnings of the greater Veins... through which the whole mass of subterranean Water Circulates. The Lesser Fibers, or Ramifactions, filling all the flat Strata with feeders of Waters, which breaking out upon the Surface of the Earth cause Springs.*
>
> *And thus, in our Bodies, 'tis much easier to break a Vein in the Neck or Arm, where they lye nearest the skin; than in the Buttocks, or any other such Fleshy-part.*

Robinson's diagram explains the matter.

A Central Fire
B Mountains
C Heaths
D Plains
E Channels of the Sea
F Seas with rivers flowing into them from the tops of mountains "swelling them into a Gibbosity and causing in them a Continual Fermentation."
G Vapors arising from the Seas

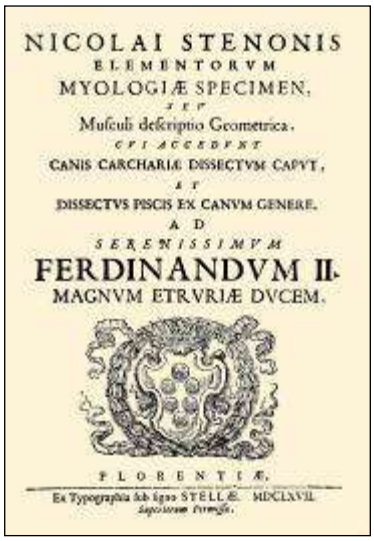


Johann Joachim Becher's theory, put forth in Physica Subterranea (1669), placed the evaporation in a single cavity at the globe's center, the Abyss, not in individual caverns beneath mountains. Condensation, on the other hand, mostly occurs inside mountains because hills are more cavernous than the rest of the earth.

The first occasion on which the condensation theory can be traced to actual observation in a cave was when Nicolas Steno (1638-1686) wrote in Canis Carchariae (1669)

> *I have seen an abundance of water dropping from many caverns where every part of both roof and floor was solid.*

The water could not have come through the rock but must have "condensed from the upper atmosphere ... which I believe is very common."



Apart from their comparisons of rainfall and streamflow, Perrault and Mariotte (Chapter 12, Superterranean Metrics) discussed how springs could maintain a reasonably-constant rate. Perrault, perhaps influenced by Steno, argued the case for subterranean condensation in De l'Origine des Fontaines (1674).

> *It is reasonable to believe therefore that in the earth evaporation takes place which can produce water, either through heat communicated by the Sun ... or by cold or by currents of air within the earth, The water which occurs in caverns and channels at the foot of mountains is thus raised inside them to their summits where, because of the numbing induced by the cold which it encounters, is reduced to little drops of water, which join with each other" and so appear as springs.*

In The Motion of Water and Other Fluids ... Being a Treatise of Hydrostaticks (1718), Mariotte dismissed the capacity of condensation, and in any case "it is deny'd that there are many such hollow places in mountains," a refutation of the entire hydrophylacia concept.

The alembic theory of mountain springs faded, but as will be noted in Chapter 48, Subterranean Geophysics, the fiery-earth model is part-and-parcel of modern geophysics.

A fire smoldering within a cavern nicely, if incorrectly, explains the report in Adams County [Iowa] Free Press, October 18, 1913.

> *A peculiarity of some of the streams on Switzerland is that a number of them have their source from canyons which are underground passages. One at Ragaz, known as the Taminaschlucht, comes out at the foot of a mountain, and a foot way has been constructed so that it may be entered for a distance of about half a mile to a place where the stream gushes our of a subterranean opening to its full capacity, and at one side there is a second opening from which hot water flows.*

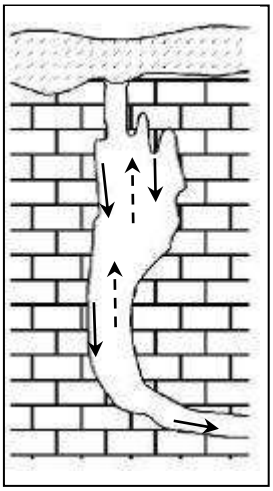
The Taminaschlucht gorge is 100 meters deep and 10 meters wide. A tunnel leads to a grotto having a 37°C thermal spring.

In at least this instance, hypothesizers of hot and cold subterranean plumbing were close to the mark.

What we now know of geophysics supports in loose degree even a transmutational basis for springflow, if one allows chemical reactions to count as transmutation. Some hot-spring effluent is "juvenile," newly formed by volcanic or tectonic processes.

While condensation may be inconsequential in most groundwater environments, again the early speculators were onto a legitimate idea.

The micro-hydrologic water balance in large cave systems -- especially ones in which there are large differences in temperature -- can be significant. In certain Crimean and Caucasian karst regions, between 0.1 and 20 percent of dry-season runoff is said to be derived from subterranean condensate, the illustration to the right serving as an illustration.



The heat of the earth does not drive underground rivers uphill, but in limited cases, geothermal energy plays a role in groundwater flow. The hydrophylacia so well advertised by Kircher do not exist, but again in select cases, subterranean streamflow passes through mammoth subterranean cavities.

And we're not done with subterranean hydrologic engines, or at least imaginative propositions for the task.

CHAPTER 10

GEOPHYSICAL, PNEUMATIC AND ELECTROMAGNETIC ENGINES

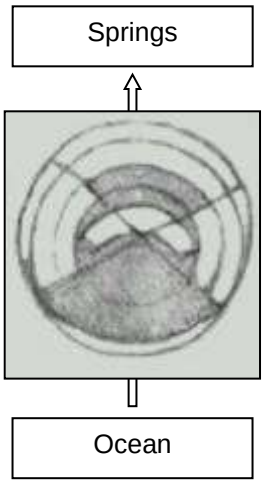
This chapter concludes our survey of misdirected explanations for the mechanism of subterranean streamflow. We will discuss nine additional hypotheses, all physically based, at least in superficial sense. The flaws in some schemes are apparent to the modern eye; others may appear plausible until a few numbers are crunched. All, however, made sense to progressive thinkers of their own day.

Our engines will derive from

Terrestrial Asymmetry,
The Weight of the Sea,
Siphoning,
Sloshing,
The Earth's Compressibility,
Capillary Action,
Earthquakes,
Pneumatics and
Electromagnetism

While several of the above inter-relate, their proponents may not have recognized the relation and we wish to do our best to look -- at lest for a moment -- through the eyes of the advocates.

Terrestrial Asymmetry



If the sea were higher than the land, ocean water would flow downhill to the mountaintops.

Job 37:10, Jeremiah 5:22 and Proverbs 8:29, assuring that God fixed the sea's boundaries so that it will not overflow the land, were sufficient to satisfy the curiosity of most medieval thinkers gazing from the shore. The eye arbitrates what seems level and the arc of horizon indeed looks high.

But for Christians drawn to natural philosophy, there must be a physical rule to which the Biblical speaks.

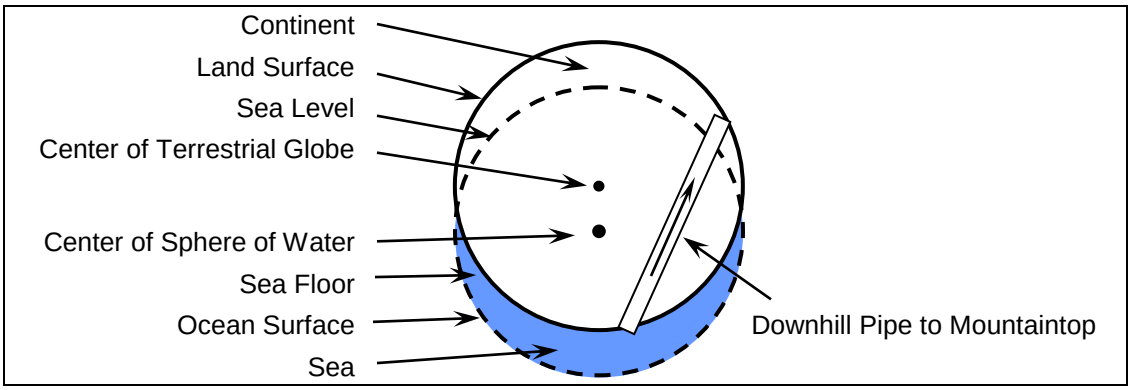
The first physically-based theory of the separation of sea and land was a marvelous exercise of human intellect. Jean Buridan (1295-1358) was a disciple of William of Ockham, remembered for the principle of ontological parsimony, Ockham's Razor.

> Entia non sunt multiplicanda praeter necessitatem.
> When competing explanations seem equally plausible, the simpler is more likely to be correct.

In Compendium totius Logicae, Buridan proposed that the earth is asymmetric, such that land occupies most of one hemisphere and oceans occupy primarily the other (plausible, given the geographic knowledge of the day). The geocentric requirement of his times -- that the earth lies at the center of the universe -- posed a problem, however, as sediment accumulation at the bottom of the sea would shift the earth's center of mass. To remain universally centered, the earth must thus shift as a whole towards the land hemisphere, raising it out of the water and thus rebuilding the mountains.

Albert of Saxony (1316-1390), primarily a logician (as opposed to a natural philosopher) extended the offset-spheres model. Appealing to the authority of his "revered masters from the Faculty of Arts at Paris," his Questiones in Aristotelis Libros de Caelo et Mundo explained earthquakes, tidal phenomena, and geology in terms of an "asymmetry preordained by God since eternity for the good of animals and plants."

Da Vinci's off-center geosphere didn't require God's ordination. The figure below, a labeled version of the sketch he used to illustrate the idea, shows why the sea remains offshore, and why the pipe is downhill from ocean to mountain slope.



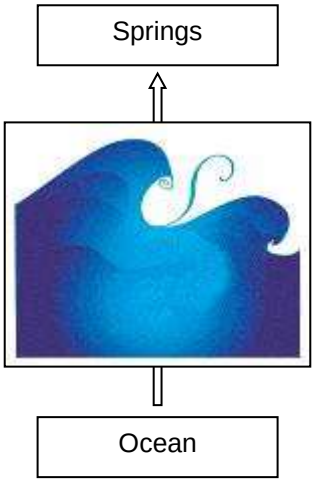
> *Perhaps you will say that water can only rise the same distance as it descends; and that the surface of the sea is higher than the summits of the highest mountains. The answer to this is that the exact opposite is the case, for the lowest part visible to the sky is the surface of the sea, since water does not move of itself unless to descend, and so descends when it moves; as therefore the rivers which stretch from the summits of the mountains to the sea are everywhere in movement they are therefore everywhere descending, and when they come to the sea they stop and end their movement; for which reason one must conclude that they arc stationary in the lowest reaches of the river.*

In another twist of the higher-than argument, da Vinci argued,

> *The Mediterranean Sea, a vast river placed between Africa, Asia, and Europe, gathers within itself about three hundred principal rivers, and in addition to that it receives the rains which fall upon it over a space of three thousand miles. It returns to the mighty ocean its own waters and those that it has received; but doubtless it returns less to the sea than what it receives; for from it descend many springs which flow through the bowels of the earth and vivify this terrestrial machine. This is so because the surface of this Mediterranean is farther from the center of the world than the surface of this ocean.*

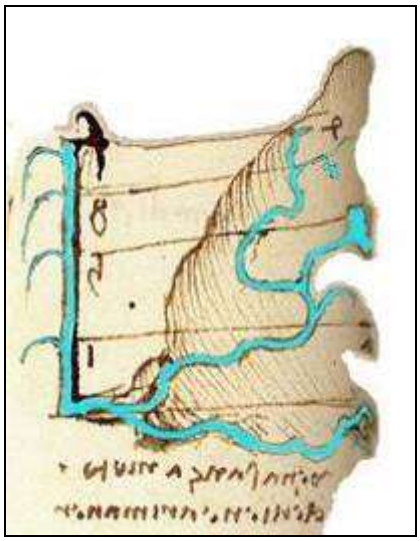
It would take the simplicity of Newtonian physics to explain that even if the earth were asymmetrical (which to some degree it is), there's only one downhill direction.

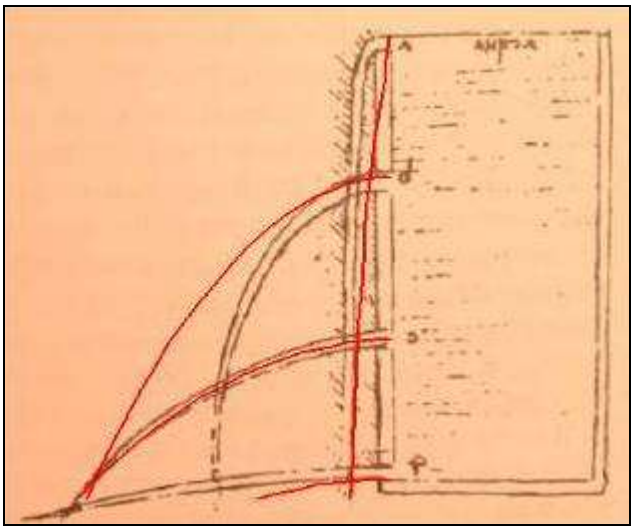
Weight of the Sea



Perhaps the sea's very weight propels underground rivers. Heraclitus, a Greek we met in Chapter 2, was onto the concept, but again we'll jump to da Vinci.

Da Vinci's two illustrations of hydrostatic pressure are shown below. The sketch on the left, clearly representing underground channels, is fundamentally incorrect, as the parabolic outflow trajectories are independent of elevation. The right-hand sketch, however, catches the distinction. The red overlay shows what hydrostatic theory predicts.

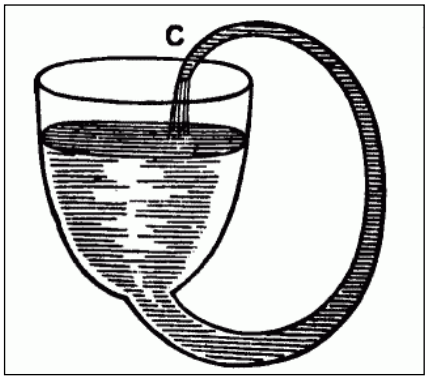




Aristotelian humanist Julius Caesar Scaliger's (1484-1558) posthumous Commentaries on Theophrastus' de Causis Plantarum (1566) argued that springs result from the infiltration of sea water into the earth under the pressure of the oceans.

Daniel Sennert (1572-1637), Célèbre Professeur de Médecine à Wittenberg proposed in Epitome Naturalis Scientiae (1651) that aided by tides, the weight of the ocean could push water to the mountain tops.

It's the "hydrostatic paradox" in which the larger weight on the diagram's left forces water down and around the narrow neck where the weight is less, pushing it up and from the orifice at the top.



The weight-of-the-sea hypothesis wasn't long held, however

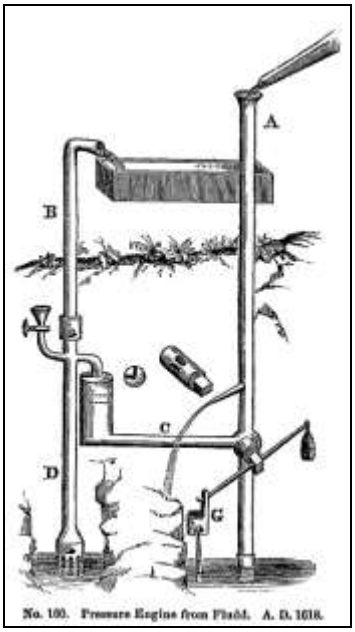
.

Robert Fludd (1574-1637) was an influential “kabbalist,” an alchemist in modern parley. The “chaotic four elements” in his theory of Macrocosm and Microcosm were heat, chill, moisture and dryness. The four aspects are heat (life), light (mind), electricity (kamic), and the synthetic essences.

De Naturae Simia Seu Technica Macrocosmi Historia (1618)

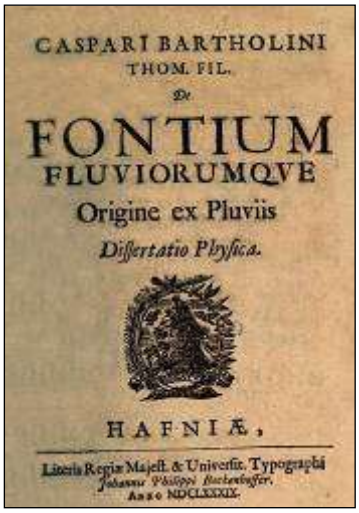
A water-powered pump was described by Fludd in De Naturae Simia Seu Technica Macrocosmi Historia, likely inspired by what he may have observed in German mine works. While Fludd is remembered for his esoteric theories, this particular machine not a scheme for perpetual motion.

To the right, a sketch of Fludd's pump from Descriptive and Historical Account of Hydraulic and Other Machines for Raising Water (1850) by Thomas Ewbank. Water is dumped in at a given elevation and water from another source (presumably of better quality) is drawn up to a lower elevation. To put it concisely, A is above B.



We include the pump as evidence that by the 17th century, even a kabbalist was aware that a closed system consumes more energy than it yields.

In De Fontium Fluviorumque Origine ex Pluviis (1713), Danish naturalist Thomas Bartholini (1616-1680) saw the same constraint.


CASPARI BARTHOLINI
THOM. FIL.
De
FONTIUM
FLUVIORUMQVE
Origine ex Pluviis
Dissertatio Physica.
HAFNIÆ,
Literis Regiæ Majest. & Universit. Typographi
Anno MDCLXXXIX.

> *Furthermore, that no fountains ever burst forth at the summit of a mountain, or near its head; but that always some portion of still higher land from which water may be supplied to them, overtops the fountains.*

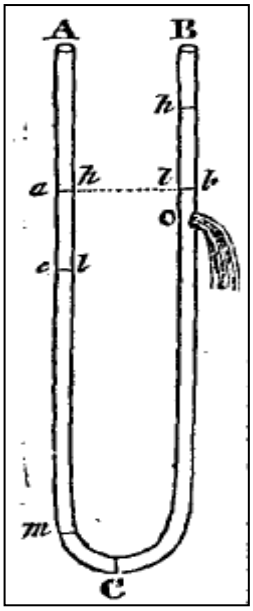
Another subterranean motor discarded.

Discarded, but to yet lurk.

Following are two pieces from the 1800s, long after the weight-of-the-sea model had been refuted by Newtonian physics. Refuted, perhaps, but still marketable.

"On the Cause of Fresh Water Springs, Fountains, &c.," American Journal of Science and Arts, July 1828, by Joseph Du Commun,

> *In the Harmony Gazette, November 21, 1827, there is a "Nut for the philosophers," picked, it is said from the National Gazette. I have endeavored to crack it, and I now present you with the kernel, leaving to your taste to determine whether it is palatable.*
>
> *The questions proposed are two in number, 1st, Why the fresh water issuing from the depth of two hundred and twenty feet, by boring in solid rock near the city of New Brunswick, rises from eight to fourteen feet above the surface of the Raritan river? and 2d, Why the quantity of water corresponds exactly and continually with the rising and falling of the tide?*
>
> *If we take an inverted glass siphon ACB and pour water into it, the two sides will be filled in part, and the water will rise in each side to the same height, say a and b.*



Note the "inverted." While Du Commun's overall argument may be faulted, the adjective, as we will note in Chapter 46, is correctly employed.

> *If instead of water, we introduce mercury in the branch A and rain water in the branch B, one inch of mercury at m will support above thirteen inches of water in the branch B.*
>
> *And lastly, if in the branch A we have a fluid denser than common water, as salt water for instance, the column of fresh water will be supported in the branch B, at the height b, by a column of the salt water inferior to it in height, in the inverse ratio of their densities, say to the height c only.*
>
> *But now, cannot the branch B, of our siphon represent the subterranean stream winding through the crevices of the rocks, until it reaches, at some depth or other, the great oceanic reservoir, and cannot the column of salt water in the branch A represent, in like manner, the height and pressure of the salt water of the ocean?*
>
> *If so, it explains why the fresh water, in boring by the sea shore, is raised and flows above the level of the sea water; thus, one of the two given questions seems to be solved.*

The answer to the second may be deduced from the same principle.

Let us suppose that a hole has been opened in the branch B, a little below lb the level of the water at ebb; the water will then flow with a velocity that may be represented by l, but at high tide the water might be supported at the height h, if the opening in the tube did not permit it to flow out, and it then must flow with the same velocity as if pressed under a column of fluid of that elevation. The quantity of water so running may be as 3, 4, 5, &c. according to the height of the tide; and finally, it must continually and exactly follow its oscillations.

To these considerations several might be added, for example: Knowing the proportional densities of the fresh water and the sea water, and the difference of the two levels, to determine at what depth the subterranean stream empties itself in the ocean. If we calculate the particular case here given, we shall find, the density of fresh water being represented by 1000, that of sea water by 1029 (Dr. Murray,) the difference of the levels being fifteen feet, we shall find, I say that the depth at which they join underground must be five hundred feet.

Thence it follows, that if the junction of the two different kinds of water should take place at five thousand feet, or one mile, below the surface, the fresh water should rise at one hundred and fifty feet; if at fifty thousand feet, or ten miles, as one thousand five hundred feet, &c. This I think may account for the springs on high ground, and even at the top of insulated mountains.

Though diagram is hydrostatically correct; its hydrodynamics are not. Once the U-tube equilibrates, fresh (i.e., less dense) water ceases to enter.

Were the ocean the cause of springflow, it stands to reason that tidal effects would be noted. From "Wonderful Underground Streams," Salt Lake Herald, August 22, 1897,

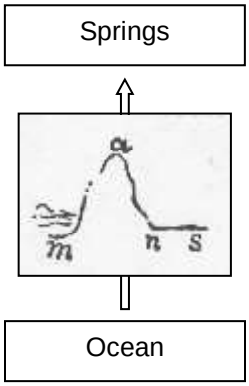
A remarkable new theory concerning the nature of parts of the earth's interior has just been promulgated by Professor F.H. King agricultural physicist of the University of Wisconsin. It is to the effect that the subsurface of the human footstool is interpenetrated by water incessantly in motion that there is a vast network of underground rivers, brooks, streams, pools and rivulets constantly flowing in various directions, some shallow, some deep, some near the surface some far below the outer crust, all of them having a definite tidal motion and all subject to lunar influence.

It is not stated whether there is any intimate connection between these underground streams and the great streams and bodies of water which exist on the surface except that they are both governed by lunar influence and that the natural process of percolation may indirectly connect them with each other... It is a contention of Professor King that the underground waters embrace a worldwide zone. They are not, therefore, confined to the United States alone but undermine the surfaces of Europe, Asia, Africa and Australia as well. Professor King is working to perfect a map of the underground streams of the world and as soon as he has finished we shall doubtless know more of what the interior of the earth is like.

To the right, "Recording Oscillations of Underground Streams with a Chronograph."

The promised map and chronographic measurements are yet to be published.

Siphoning



Da Vinci liked the idea of siphoned underground waters. It's his artwork in the graphic.

> *The water of the ocean cannot make its way from the bases to the tops of the mountains which bound it, but only so much rises as the dryness of the mountain attracts. And if, on the contrary, the rain, which penetrates from the summit of the mountain to the base, which is the boundary of the sea, descends and softens the slope opposite to the said mountain and constantly draws the water, like a siphon which pours through its longest side, it must be this which draws up the water of the sea.*

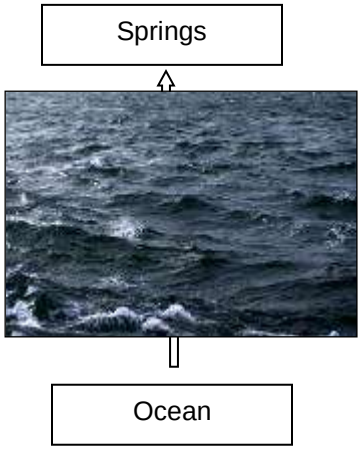
"Which pours through its longest side" indicates that da Vinci understood the principle.

> *Thus if s-n were the surface of the sea, and the rain descends from the top of the mountain a to n on one side, and on the other sides it descends from a to m, without a doubt this would occur after the manner of distilling through felt, or as happens through the tubes called siphons.*

“Distilling through felt” would seem to refer to capillary action, a mechanism discussed shortly, but da Vinci was one to cover all bases.

Much more has been speculated regarding siphoned springflow, but for that we'll wait until Chapter 46. Needless to say, of course, is that it doesn't trump gravity.

Sloshing

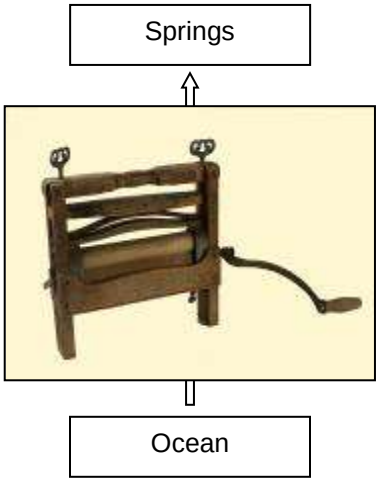


Of Kircher's several -- and sometimes conflicting -- geologic explanations for springflow, one involves seawater drawn into the earth's interior at the North Pole and expressed at the South Pole. (We've a map of the route in Chapter 16, The Maelstrom, and will thrill to tales of adventurous descents into such passages in Chapters 17-26) Subterranean sloshing causes the tides which in turn surge seawater through hidden channels to upland springs. High winds hasten the process

Kircher wasn't alone in the idea of sloshing seas. The working title for Galileo Galilei's Dialogue Concerning the Two Chief World Systems (1632) was Dialogue on the Tides in which he attributed tidal action to water sloshing due to the Earth's movement around the sun.

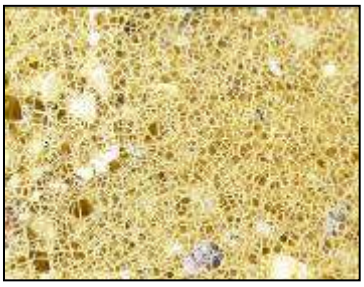
Galileo's interest was of, course, far above the earth sciences, but where an observation related to the latter might bolster the case for heliocentrism, Galileo found hydrology to be a useful science..

The Earth's Compressibility



Terrestrial pressure squeezing upward might explain underground rivers, but Da Vinci, to his credit, saw a problem.

> *If you should say that the earth's action is like that of a sponge which when part of it is placed in water sucks up the water so that it passes up to the top of the sponge, it cannot then pour away any part of itself down from this top, unless it is squeezed by something else, whereas with the summits of the mountains one sees it is just the opposite, for there the water always flows away of its own accord without being squeezed by anything.*



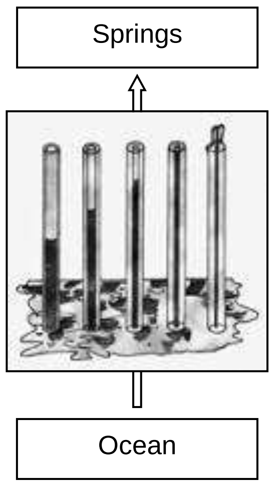
Because his works were read extensively, Jerome Cardan (1501-1576) was influential during the latter 1500s. Although Cardan plagiarized da Vinci, he seems to have preferred Aristotle regarding the origin of springs. The earth, like a sponge, is full of water always being squeezed free. As the proportion of land greatly exceeded that of water, water remains on the surface only because there is not enough room for it within.

Again we have a subterranean machine defying principles of elementary physics -- whatever pressure might squeeze a sponge would keep it squeezed -- a fact recognized by Georg Henning Behrens in The Natural History of Hartz Forest, being a Succinct Account of the Caverns, Lakes, Springs, Rivers, ... in the Said Forest (1703).

> [Some say] *that the Earth sucks up the Water like a Sponge: but if that were true it should also swell like a Sponge; which is against Experience...*
>
> *For a Sponge affords no moisture till 'tis squeez'd.*


HERCYNIA CURIOSA,
Curiöser
Hartz-Wald/
Sonderbahre
Beschreibung und Verzeichnis
Hölen/ Seen/ Brunnen/ Bergen/
Merckwürdigen Sachen
Medicinischen/ Physicalischen und Historischen
Anmerckungen
Liebhabern solcher Curiositäten
D. GEORG HENNING BEHRENS,
1703.

Capillary Action



Water's attraction to earth is known by all who garden. Perhaps rivers flow underground because the earth sucks it onward.

William Derham's (1657-1735) Physico-Theology (1713) declared that water rises from the level of the sea to the tops of mountains by capillary action. We'll see more of Derham in Chapter 13, Hydrotheology/Theohydrology, a chapter inspired by his work's title.

La Spectacle de la Nature (1732) by Noël-Antoine Pluche (1688-1761) was a work of eight volumes. From it,


LE SPECTACLE
DE
LA NATURE.
TOME HUITIÈME,
Contenant ce qui regarde
L'HOMME EN SOCIÉTÉ
AVEC DIEU.
SECONDE PARTIE.
A FRANCFORT, aux Frais,
M. DCC. LII

> *The seawater deposits its salt on the sands below, and that it rises little by little, distilling through the sands, and the pores of the earth, which have such a power of attraction as it is not easily accounted for, and that not only sand, but other earthly bodies have the power of attracting water, I am well assured of from an observation which occurred to me but this vary day. When I threw a lump of sugar into a small dish of coffee, I found that the water immediately ascended through the sugar and lay upon the surface of it. Yesterday I observed likewise that some water which had been poured at the bottom of a heap of sand ascended to the middle of it. And this case, as I take it, is exactly the same with respect to the sea and the mountains.*

A problem with the sugar-cube analogy is that landscapes are not made of sugar. The table below indicates typical heights of capillary rise in soils.

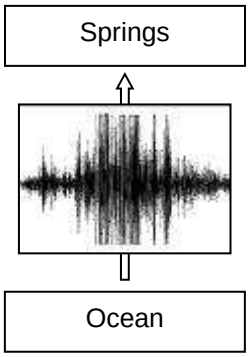
	Capillary Rise (m)
Fine Gravel	0.002
Very Coarse Sand	0.006
Coarse Sand	0.013
Medium Sand	0.025
Fine Sand	0.043
Silt	0.105
Fine Silt	0.200

Relative to the height of mountains, capillary rise is negligible.

A more fundamental mechanical problem lies in the fact that capillary action will not expel fluid from a conduit. If it could, we'd have a perpetual motion machine, albeit a small one. Pluche didn't check if the water ran out the top of his sugar cube and down the side.

An underground river cannot be driven by the pull of the soil.

Earthquakes



We can look to Thales (Chapter 2) for associations between earthquakes and springflow, but we'll again pick up the subject in the late 1400s. Da Vinci's evidence included,

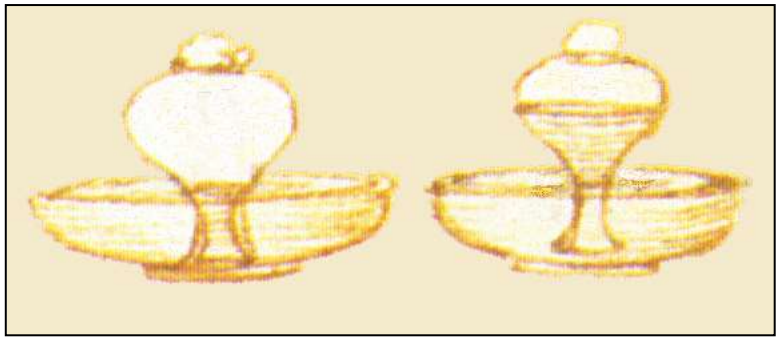
> *That there are springs which suddenly break forth in earthquakes or other convulsions and suddenly fail; and this happened in a mountain in Savoy where certain forests sank in and left a very deep gap, and about four miles from here the earth opened itself like a gulf in the mountain, and threw out a sudden and immense flood of water which scoured the whole of a little valley of the tilled soil, vineyards and houses, and did the greatest mischief, wherever it overflowed.*

Unlike many of da Vinci's hydrologic claims, he would have had personal knowledge of the Alpine Savoy. No subterranean reservoir, there or anywhere, has ever been rent open by an earthquake, however. Were such reservoirs to exist and were tremors to rupture them, we'd still be pressed to explain springs that don't diminish over the long period.

Pneumatics

The atmosphere was also thought to motivate underground rivers, the role variously taken to come from the suction of wind, a vacuum produced by the outflow of springs, pressure on the land surface and/or pressure from enclosed cavities.

Da Vinci considered Heron of Alexandria's experiment in which a burning coal is placed in an inverted vessel inserted below a water surface. Water rises within the vessel.



Da Vinci correctly attributed the phenomenon to the rarification of air within the receptacle -- as opposed to the direct action of the heat -- and was thus willing to reject the hypothesis in which the heat of the sun draws the water to the heights of mountains.

> *And if you should say as has been said that the sun sucks up and draws the waters from the roots of the mountains to their summits, then as the heat draws the moisture to itself the heat which is more powerful would draw to itself a greater amount of water than the less powerful. In summer therefore during the fiery heats the springs of the waters would have to rise higher*

into the summits of the mountains than they do in winter; but we see it is the contrary seeing that in summer the rivers lack a great part of their waters.

Because rain clouds often appear in conjunction with wind gusts, da Vinci believed that a vacuum is formed by the condensation. Actually, it's the aerodynamic drag of falling droplets that draws air downward. Variation of atmospheric pressure indeed explains the paths of frontal rainstorms, but the same can't be said for the flow of liquid water.

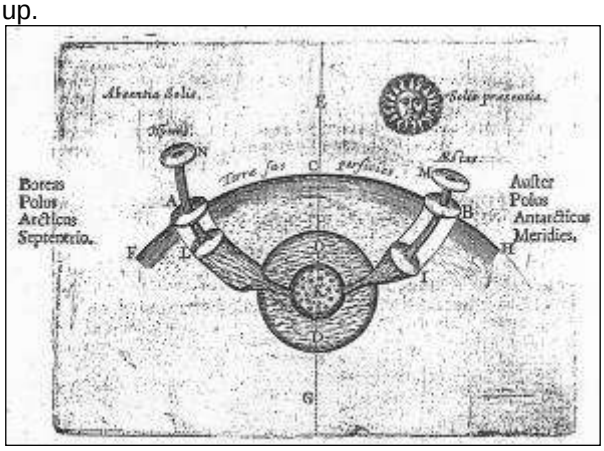
Gregor Reisch (1467-1525) was an intellectual of the Humanist era. His chief work was the Margarita Philosophica (1504), an encyclopedia of knowledge for youthful students, the World Book of his day.

Following is his explanation of the role of pressure, or more specifically, negative pressure.

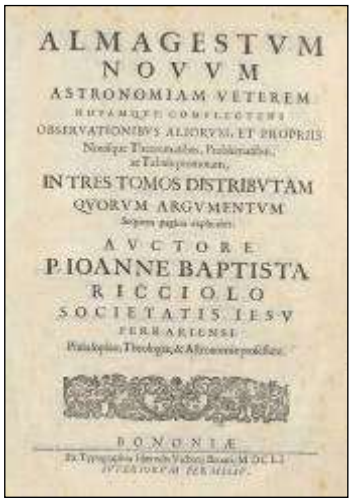
Within the earth as we have shown there are many open spaces and passages, into which (since there can be no such thing as a vacuum) vapors are drawn up from the earth and condensed into drops of water which unite to from rills, which running down to lower levels issue into the open air as springs.

Reisch then went on to assert that the condensation results in a new vacuum which in turn draws up more vapor. In short, the water sucks itself up.

The plungers in the illustration from Fludd's Philosophia Mosaica (1638) suggest a pneumatic causation for subterranean flow, though in this case it seems to be at global scale.



A variant on the vapor-bootstrap theory was put forward by Giovanni Battista in Almagestum Novum (1651). Moisture rises within the earth as natural vapor from seawater that has seeped into the ground. Condensed by the cold of winter or at night, a vacuum ensues and seawater is drawn up to fill it. Rainfall could not provide an adequate supply for springs, as it penetrates no more than 4 or 5 meters into the earth; and the Bible records that springs were in existence before the first rainfall.


ALMAGESTVM
NOVVM
ASTRONOMIAM VETEREM
OBSERVATIONIBVS ALIORVM, ET PROPRIIS
IN TRES TOMOS DISTRIBVTAM
QVORVM ARGVMENTVM
AVCTORE
P. IOANNE BAPTISTA
RICCIOLO
SOCIETATIS IESV
FERRARIENSI
BONONIÆ

Kircher, never at a loss for explanations, also looked to air pressure. From his Mundus Subterraneus (1665),

> *The sea, by pressure of air and wind or movement of the tide pushes the waters through subterranean passages to the highest water chambers of the mountains.*

Readers of "The Artesian Well," Western Rural and American Stockman, February 22, 1894, were misinformed that some artesian wells are due to subterranean gasses.

> *The philosophy of the flow of water from artesian wells is generally known. No matter how deep in the earth the well may have been sunk to strike a subterranean vein or pool of water, one of two causes must operate to force a flow of water to the surface. One of these causes* [the sole correct one, we now know]*, and the most common, is the existence of a fountain or source of supply situated at a higher altitude than the point of discharge at the surface of the ground where the well is situated, and generally a long distance away. The other cause, as a whole or in part, is the expansive force of air and gases, which operating under the column of water to be forced to the surface, supplies the power needed to do the work which the gravity pressure from a distance and higher fountain head has failed to do.*

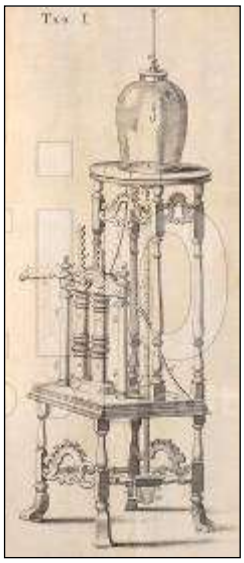
We'll again meet the Rev. William Derham in Chapter 13, regarding the theology of the hydrologic cycle, but here we can inspect his physical understanding.

In Physico-Theology, or A Demonstration of the Being and Attributes of God (1713), Derham cites a spring in his own parish which flows undiminished even when all ponds and adjoining brooks in the country have been dry for months. The spring never increases in the rainy seasons, except for a few hours after a violent storm. If the spring, he judges, originates from rain or vapors, there would be change corresponding to such causes.

> *That springs have their origin from the sea, and not from rains and vapors, among many other strong reasons, I conclude from the perennity of diverse springs, which always afford the same quantity of water. Of this sort there are many to be found everywhere. But I shall, for an instance, single out one in the Parish of Upminster, where I live, as being very proper for my purpose, and one that I have had' better opportunities of making remarks upon above twenty years. This in the greatest droughts is little, if at all, diminished, that I could perceive by my eye, although the ponds all over the country, and an adjoining brook have been dry for many months together; as particularly in dry summer months of the year 1705. And in the wettest seasons, such as the summer and other months were, preceding the violent storm in November 1703. I say in such wet seasons I have not observed any increment of its Stream, excepting only for violent rains falling therein, of raining down from the higher land into it; which discoloreth the waters oftentimes, and makes an increase of only a day's or sometimes but a*

few hours continuance. But now, if this spring had its origin from rain and vapors, there would be an increase and decrease of the one, as there should happen to be of the other. As actually it is in such temporary springs as have undoubtedly their source from rain and vapors.

As to the manner how the waters are raised up into the mountains and higher lands, an easy and natural representation may be made of it by putting a little heap of sand, ashes, or a little loaf of bread, etc., in a basin of water where the sand will represent the dry land, or an island, and the basin of water the sea about it. And as the water in the basin riseth to, or near the top of the heap in it, so doth the waters of the sea, lakes, etc. rise in the hills. Which case I take to be the same with the ascent of liquids in capillary tubes, or between contiguous planes, or in a tube filled with ashes: Of which the industrious and complete artificer in air-pumps, Mr. Hauksbee, hath given us some, not contemptible experiments, in his Phys. Mecb. Exp.



To the right, an air pump used to evacuate a glass container, from Physico-Mechanical Experiments on Various Subjects (1709) by Francis Hauksbee.

Derham eventually moves to his conclusion, albeit one not supported by his arguments.

Among the many causes assigned for this ascent of liquors, there are two that bid the fairest for it, viz. the pressure of the atmosphere, and the Newtonian attraction. That it is not the former, appears from the experiments succeeding, as well, or better in vacuo, than in the open air, the ascent being rather swifter in vacuo. This then being not the cause, I shall suppose the other is; but for the proof thereof, I shall refer to some of our late English authors, especially some very late experiments made before our most famous Royal Society, which will be so well improved by some of that illustrious body, as to go near to put the matter out of doubt.

The dutiful reader, however, is left in grave doubt about what has been asserted.

Nathaniel S. Shaler's discussion of artesian wells in Outlines of the Earth's History, A Popular Study in Physiography (1898) was a bit more complex.

It may be well to note the fact that the greater part of the so-called artesian wells, or borings which deliver water to a height above the surface, are not true artesian sources, in that they do not send up the water by the action of gravitation, but under the influence of gaseous pressure... In all cases this water contains a certain amount of gases derived from the decomposition of various substances, but principally from the alteration of iron pyrite, which affords sulphuretted hydrogen. Thus the water is forced to the surface with considerable energy, and the well is often named artesian, though it flows by gas pressure on the principle of the soda-water fountain.

Thomas Milner's The Gallery of Nature, A Pictorial and Descriptive Tour Through Creation, Illustration of the Wonders of Astronomy, Physical Geography, and Geology (1882) provides some pneumatic speculation.

Weeding Well, in the Peak of Derbyshire, otherwise called the Ebbing and Flowing ... lies in a field by the road-side in the neighborhood of Castleton Dale, surrounded with mud and weeds. The motion of the water depends upon the quantity of rain during the season, and is by no means regular, as it has ceased to flow for several weeks during a drought; but, in very wet weather, it will flow and ebb more than once in an hour. The time which it continues to flow varies; but it is sometimes four or five minutes, the water appearing at first slightly agitated, and then issuing forth from nine small apertures with a gurgling sound. After remaining stationary, it then ebbs to its ordinary level... No theory has yet been proposed to account for the peculiarity of these springs which is perfectly satisfactory; but probably the interposition of columns of gas conveying pressure, somewhat on the principle of Hero's fountain, acts an important part, as well as the common hypothesis of an interior cavity of water discharging itself by a siphon-formed channel.

A pneumatic engine for underground rivers requires a disparity in air pressure to push or suck water uphill. And indeed the atmospheric pressure at the foot of a hill is greater than that at the top, but the difference in energy (what would propel the fluid) is nil because the pressure drop is balanced by the elevation gain.

And 25 years later, the pneumatic theory with two options: one due to atmospheric pressure differential and the other to vapor entrainment. From "Blowing Springs and Wells of Georgia, with an Explanation of the Phenomena," Science, February 8, 1907, by S.W. McCallie,

Grant Blowing Spring

The phenomenon can readily be detected by holding a smoldering match or lighted paper near the opening from which the water flows. The motion of the air is to be seen in its full force at an opening in the bluff above... At this opening, which leads down to the stream supplying the spring, there is, at times, a strong current of air passing inward or outward, depending on the atmospheric conditions hereafter to be discussed.

Boston Well

The Boston deep well belongs to the second class of blowing wells, namely, wells in which the direction of the air current is in one direction only.

The main water supply at present is said to come from a subterranean stream in the limestone at 120 feet... Shortly after the completion of the well, Mr. J.Z. Brantley, the mayor of the town, discovered that there was a continuous draught of air passing down the casing, and by placing his ear near the mouth of the well he was able to detect a sound like running water. This indraught, Mr. Brantley reports, was quite strong and continued as long as the well was left open.

The Lester Well

Mr. Miller, in describing this well, says that at a depth of 154 feet he struck a stream of water running so swiftly that he could not pass a two-pound iron plumb bob attached to a fishing line through it. He reports blowing crevices in the well at 87, 124 and 144 feet. When the well was being bored the air from each of these cavities is said to have passed in in the forenoon and out in the afternoon; but after the completion of the well to the swift moving subterranean stream, the air ceased to pass outward, but was sucked in with a strong steady pull, drawing the flame and smoke of a torch down the casing when held 6 inches above its opening.

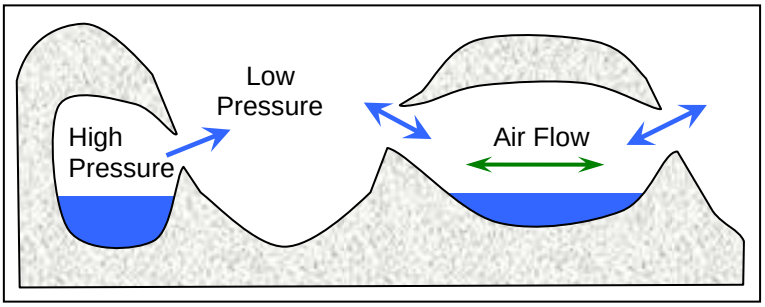
Causes of Blowing Springs and Wells.

The two classes of blowing springs and wells above described appear to be due to two entirely different causes. Those of the first class, of which the Grant Blowing Spring is a good type, seem to be due entirely to the difference of atmospheric pressure of the air on the outside and on the inside of the cave.

It's the pneumatic subterranean engine, the earth's interior air pressure blowing out the water.

In the second class of wells and springs, the constantly outgoing or the constantly ingoing current is entirely independent of atmospheric conditions. The currents, whether outward or inward, act with equal energy during high or low barometer and always move in the same direction. The Boston and the Lester deep wells are excellent examples of wells and springs of this class. The phenomenon which they exhibit seems to be due entirely to the friction of the air on a rapidly moving current of water. This phenomenon is beautifully illustrated in Richard's water air-blast, to be found in many well-equipped chemical laboratories. In the Boston well, and also in the Lester well, appear almost exactly the same conditions met with in Richard's water air blast. The well itself forms the inlet for the air, and the rapidly flowing stream in the subterranean channel below completes the conditions necessary for an ingoing air blast... It naturally follows that it must escape at some other point as an outgoing current, thus giving rise to continuously blowing caves or springs. As underground streams frequently pass from one bed of rock to another in their subterranean course, they, no doubt, often form waterfalls which possess all the essential conditions necessary for producing an air blast, thus giving rise to continuously blowing caves and springs.

The two classes of blowing wells and springs



McCallie provided additional explanation in A Preliminary Report on the Underground Waters of Georgia (1908).

It will be seen by the description of the Quitman deep well that not all deep wells penetrating subterranean channels with swift flowing streams are blowing or sucking wells. This may be accounted for by the channel being only partially filled with water, and the air being able to circulate freely within. The essential condition of continuous suction in wells is that the air once dragged into the underground stream by the friction of the water cannot again reach the point of intake.

The current of air above noted at the entrance of the cavers at Forest Falls is also due to the friction of the air and water, but as the air is free to escape into a subterranean chamber and the accompanying air could not escape by the way of its entrance it would give rise to a strong blast. As underground streams frequently pass from one bed of rock to another in their subterranean course, they no doubt often form waterfalls which possess all of the essential conditions necessary for producing air an blast and thus give rise to continuously flowing caves or springs,

McCallie's pneumatic theory wasn't confined to scientific publication, as evidenced in the Bend [Oregon] Bulletin, March 30, 1906

> *Drafts over deep wells are usually due to changes of temperature or barometric pressure, air being forced in as the pressure rises and drawn out when the barometer is falling. But in tow wells in the Vicksburg Jackson limestone of southern Georgia have shown the strange phenomenon of a continuous in-draft. This has been investigated by S.W. McCallie, who has found a rapid subterranean stream at a depth of about 120 feet, and it is supposed that the air is sucked in by friction and carried along until the water rises as a large spring.*

McCallie's logic is circular, of course, the water dragging the air and the air powering the water, but then again, understandings that seem logical to us may well be dismantled in the century to come.

Richard's apparatus made use of the injector principal to supply relatively small volumes of compressed air at low pressure. A small jet of water projected through a tube of gradually increasing diameter sweeps a larger volume of air into a receiver where the two are separated. Efficiency is increased by a projecting step in the injector tube, or by giving the tube the form or an undulating curve, deflecting the jet to completely fill the passage.

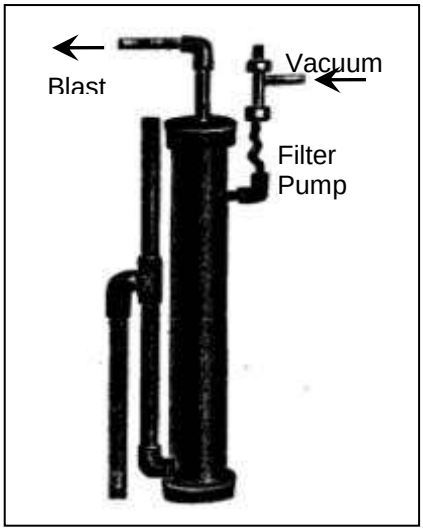
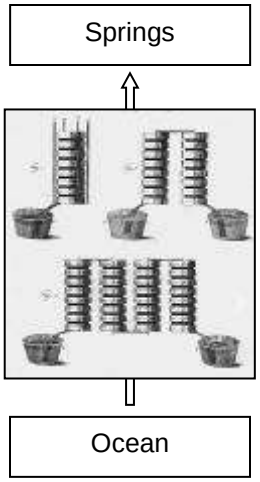


Illustration from Laboratory Supplies and Chemicals for Chemists and Bacteriologists (1919), A. Daigger & Company

Although we now know that air pressure does not drive spring flow, we can appreciate that it once seemed possible. Caves breathe in and out as high and low pressure weather systems move over a cave's entrance. Air exchange at speeds as high as 130 kilometers/hour have been measured.

Electromagnetism



We'll pursue the modern understanding of geomagnetism in Chapter 48, but here we can note what's been widely understood for centuries, that our globe has magnetic properties.

A relationship -- or lack thereof, we may come to conclude -- between underground rivers and electromagnetism might be manifested in one of three manners.

As an electromagnetic field emitted by subterranean waters revealing the water's presence, a hypothesis we'll consider in Chapter 49, Finding the Underground Waters.

As an electromagnetic field emitted by subterranean waters altering our terrestrial environment, allegations we'll weigh in Chapter 96, The Paranormal.

As an electromagnetic engine for the propulsion of subterranean water. With discovery of a relationship between magnetism and electricity -- what we now know to be an electromagnetic field -- it is not surprising that early investigators hoped that this new science might resolve geophysical perplexities, how water seemed to rise to mountain tops, for example.

De Magnete (1600) by William Gilbert (1544-1603). In the first work to describe the earth's magnetic field, oceanic tides stem from magnetic interaction between earth and moon.

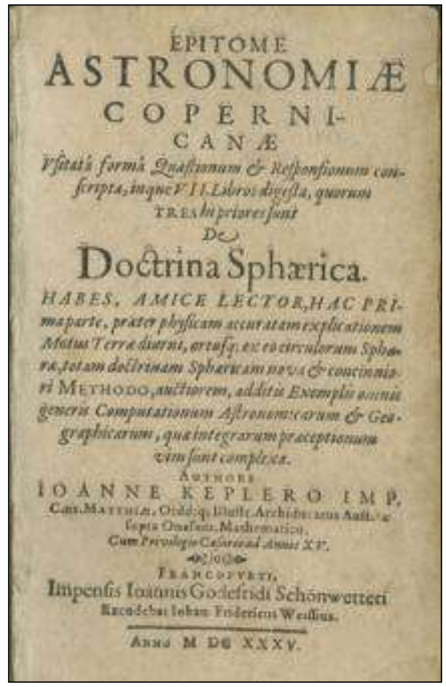
"Magnétisme et hydromantie" from Kircher's Magnes Sive de Arte Magnetica Opus Tripartitum (1643) which considered the magnetism of the earth and heavenly bodies, the tides and the metaphorical position of God, "the central magnet of the universe."

Presented in the Epitome of Copernican Astronomy (1618-1621), the natural philosophy of Johannes Kepler (1571-1630) -- whom we noted in Chapter 8 for his chemical speculations -- added a solar magnet to Gilbert's electrical universe.

> *The conclusion is therefore plausible: because the Earth moves the Moon by its species, and is a magnetic body; and because the sun moves the planets in a similar manner by the species which it emits, therefore the Sun, too, is a magnetic body.*

Kepler was in fact close to the modern idea of gravity.

> *If the moon and earth were not retained in their respective orbits by an animal force or by some equivalent force, the earth would climb toward the moon and the moon would descend toward the earth until these two heavenly bodies were joined. If the earth ceased attracting the waters covering it, the sea waves would all rise and flow toward the body of the moon.*



EPITOME
ASTRONOMIÆ
COPERNI-
CANÆ
Usitatâ formâ Quæstionum & Responsionum conscripta, inque VII. Libros digesta, quorum TRES hi priores sunt
De
Doctrina Sphærica.
HABES, AMICE LECTOR, HAC PRIma parte, præter physicam accuratam explicationem Motus Terræ diurni, ortusq; ex eo circulorum Sphæræ, totam doctrinam Sphæricam nova & concinniori METHODO, auctiorem, additis Exemplis omnis generis Computationum Astronomicarum & Geographicarum, quæ integrarum præceptionum vim sunt complexa.
AUTHORE
IOANNE KEPLERO IMP.
Cæs. Matthiæ, Ordd; q. Illustr. Archiducatus Austr. [illegible]
[illegible] Mathematico.
Cum Privilegio Cæsareo ad Annos XV.
FRANCOFURTI,
Impensis Ioannis Godefridi Schönwetteri
Excudebat Iohan. Fridericus Weissius.
ANNO M DC XXXV.

While earth science soon abandoned a magnetically-driven hydrologic cycle, the possibility of magnetically-assisted water flow is yet discussed.

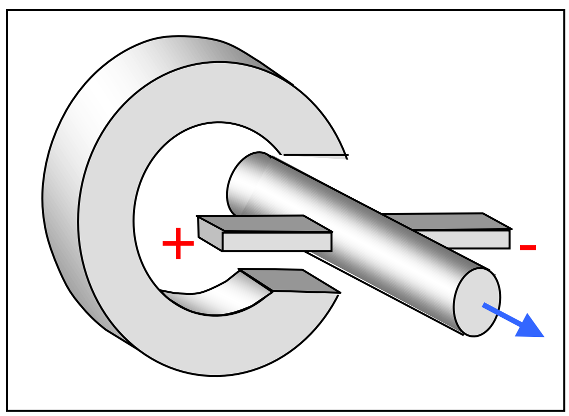
Laplace's Law describes the interaction between a magnetic field and an electric current when they are applied at right angles to each other and to a conductor of electricity. When an electrical current is passed through the conductor, an electromagnetic force known as a Lorentz force pushes the conductor in a direction perpendicular to the conductor and the magnetic field. The magnitude of the force is proportional to the magnetic field strength and the current density.

We will consider four schemes for an electromagnetic engine suitable for elevating a fluid.

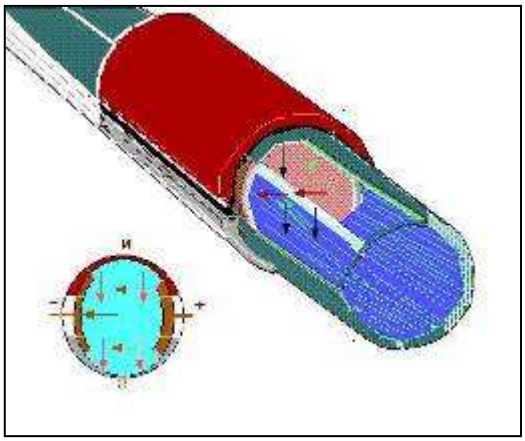
Method 1. Liquid Metal Pump

An electromagnetic pump moves liquid metal through a pipe between the poles of an electromagnet by passing a current through the liquid metal. To the tight is the conceptual design: a C-shaped permanent magnet, a pipe carrying molten metal as the conductor, and a direct current applied by an external source such as a battery.

Such a device can propel liquid metals, but not water?



Method 2. Water Pump



The Encyclopedia of Free Energy, a perpetual-motion reference, hypothesizes a like-comprised electromagnetic pump in which "there is no moving core except the motion of the liquid salty water," failing to recognize that the "liquid salty water" must be magnetized, a quality not within water's capacity because its dipolarity is electrical, not magnetic.

Water's polarity is due to the higher nuclear charge of oxygen displacing the shared bonding electrons towards the nucleus, leaving the oxygen with a partial negative charge and the hydrogen with a partial positive charge.

For a molecule to become magnetized, it must not only contain an unpaired electron, but also must group with like-aligned molecule into local domains that amplify the effect and retain their orientation over time. The effect is known as "ferromagnetism," the most well-known example, of course, being metallic iron.

To the Encyclopedia of Free Energy's credit, there is the disclaimer attached to its plans involving PVC pipe and a windshield wiper motor: "Please remember this only an Experimental Idea."

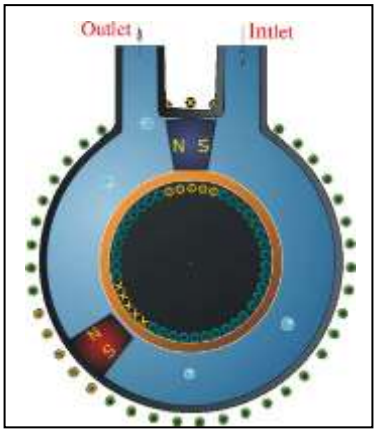
Electrical dipolarity gives water the ability dissolve, at least in small part, most geospheric inorganic solids, making water the "universal solvent," a quality of consequence in Chapter 40, Karstology.

Method 3. Levitation

Being electrically dipolar, a stream of water can be directed by an electromagnetic field, the static electricity a hair comb providing an easy experiment.

A water molecule can in fact be levitated by an electromagnetic field roughly 300 times that of the earth's, doable with electromagnets, but not with permanent magnets. No one has pulled water up a well tube or even above a lab table.

Method 4. Reciprocating Pump



Another, and very different, electromagnetic pump concept employs two rotating magnets in an annular channel, simultaneous energized with opposing polarity by of a pair of solenoids. One magnet works as a pump while the other is between the inlet and the outlet ports, acting as a valve. With each cycle, the magnets reverse their function. Tests have yielded a flow rate of 13.7 milliliters/minute at 200 rpm at a pressure of 785 Pascals, something less than 1 percent of atmospheric pressure.

This pump is thus just a mechanical pump in which magnetic switches control the component function.

Method 1 can work, but not for water.
Method 2 does not work.
Method 3 can work, but not at hydrologic scale.
Method 4 is a novel rotational pump utilizing electrical, rather than mechanical, switches.

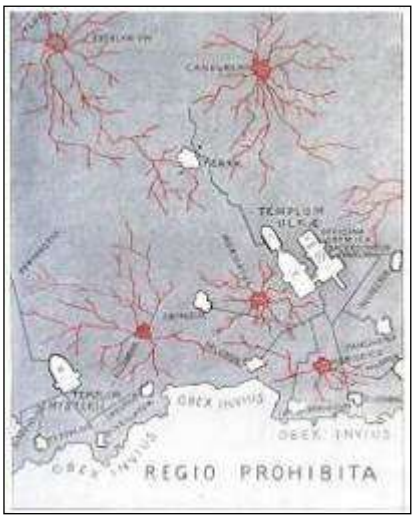
While the concept of an electromagnetic engine for subterranean streamflow resonates with some aspects of modern geoscience and technology, it's a proposition that again and again fails upon further consideration.

In 1940, M. King Hubbert's The Theory of Ground Water Motion demonstrated that Darcy's equation for groundwater (Chapter 45) is analogous to Ohm's law for electric current. By no means, however, does this imply that subsurface water is driven by electricity, but rather that the mathematical form of the underlying equations are the same. Because things act the same is not to say that they are the same.

We'll turn to literary fiction in chapters ahead, but the setting of John Mastin's The Immortal Light, a Scientific Romance (1907), an underground world in which electrical charge is the driver of nature, provides a fitting departure for our consideration of electromagnetism as a hydrologic energizer.

The air seemed to come along with several swiftly-flowing underground streams which roared and swelled in cataracts of foam... All this part was palisaded round, and well for us it was so protected, as the effect of the seething mass of foam-covered water had a curious, hypnotic effect on us, as it ran eddying in countless circles, all running to the outlet.

Some distance farther on it was even more inviting, for the cotton wool became detached into little pillows which twisted and twirled in a most fascinating manner. These passed on so slowly that we could easily keep pace with them as we walked along the bank, and then, suddenly they shot like lightning over the mass of smooth, oily-looking water, and in a second, were split up again into a dust of foam.



Underground river map

Our intrepid explorers, not evolved for their battery-like environment, must be wary of becoming short circuits.

"How do you account for the fact that this water is not magnetic?" asked Belt, after putting in his hands and feeling no shock. "Water is such an excellent conductor that it should carry the current from the other side of the wall. See, it flows from the inside."

"So it would," replied Norris, "if it came here through an archway, or grating j but it seems to soak through the wall like water through carbon in a filter, thus the wall perhaps also insulates the water and makes it safe."

This seemed to be the only explanation possible.

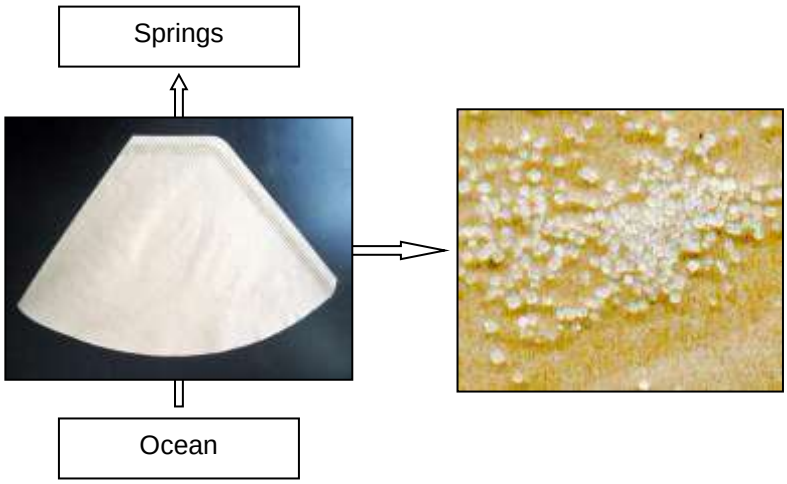
Conclusion

This and the previous two chapters suggest a myriad of engines thought possible to elevate subterranean rivers. Da Vinci hypothesized many such mechanisms, Kircher provided striking graphics and any number of early scientists proposed theoretical bases for such hydrologic pathways. As we will pursue in chapters to come, such speculation even today enlivens popular fantasy.

CHAPTER 11
STRAINING THE SALT

As to the source of the sea's salinity, the early philosophers were accord -- the sea is the "sweat of the earth." In this, they were correct.

As to the freshness of streamflow, the thinkers were likewise in agreement -- the earth filters away the salt. It this, they were wrong.



Why is the Sea Salty?

The Greeks of Chapter 2 were familiar with two processes thought to remove salt from water.

Evaporation, solar or by fire, could be seen to leave salt crystals behind.

Filtration through a cloth or fine-grained media could likewise be seen to leave residue. That the residue was coarse particulates, not salt grains, wasn't taken to be significant.

We know today that dissolved salts are filterable only by energy-consumptive reverse osmosis, a technology of recent decades and requiring human operation. While we're no more intelligent than the Greeks, we've the advantage of textbooks in physical chemistry.

Anaximander (611-547 BC) believed that all the earth was initially surrounded with moisture which dried into seas, which too, would ultimately expire.

To explain freshwater springs, Heraclitus (540-475 BC) cited distillation and filtration in the atmospheric and subterrestrial routes, respectively.

Anaxagoras (500-428 BC) attributed the sea's salinity to what the water gathers as it runs over the earth, akin to how water strained through ashes becoming salty. The sea is the accumulation of such runoff. To this point, the Greek is entirely correct, but now his thinking becomes muddled. Assuming only a subterranean hydrologic cycle, the sea's salinity is augmented by its underground descent in which it garners a portion of the matrix through which it passes. Evaporation concentrates the substrate, expelling the supernatant.

Empedocles (490-430 BC), a founder of the cosmogenic theory of the four classical elements, left us a poetic definition of seawater as "the sweat of the earth." It says it all.

Democritus (460-370 BC) held that the salinity of the sea is due to the same cause as the accumulation of salt on the land, like seeking like. As the water flees via secret channels to lakes and rivers, the sea will become smaller and smaller and finally dry up.

Aristotle (384-322 BC) drew upon them all.

> *At first the Earth was surrounded by moisture. Then the sun began to dry it up, part of it evaporated, and is the cause of winds while the remainder formed the seas. So the seas are being dried up. Others say that the sea is a kind of sweat exuded by the earth when the sun heats it, and that this explains its saltness, for all sweat is salt. Others say that the saltness is due to the earth. Just as water strained through ashes becomes salt, so the sea owes its saltness to the mixture of earth with similar properties.*
>
> *The fresh water, then, is evaporated, the salt water left. The process is analogous to the digestion of liquid food. The place occupied by the sea is the natural place of water, and fresh water evaporates more easily and quickly when it reaches and is dispersed in the sea. The sea is not salt either because it is a residue left by evaporation or because of an admixture of earth; nor is it any explanation to call it the sweat of the earth.*

Concluding "nor is it any explanation to call it the sweat of the earth" seems odd from a biologically-inclined philosopher, but to Aristotle's credit, his was the first theory of salt circulation not reliant on subsurface filtration.

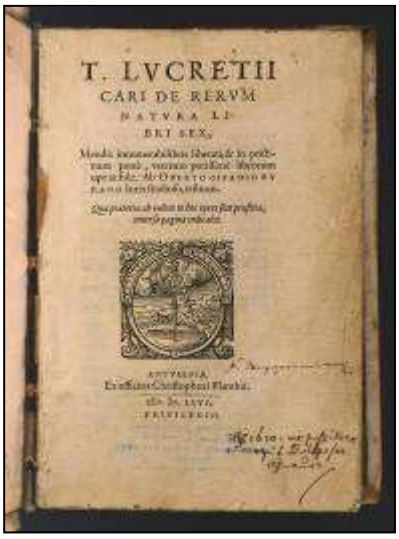
Seneca (3 BC-65 AD) agreed with the early Greeks that marine substances separate. Re-quoting from Chapter 3,

> *The sea water returns by a secret path, and is filtered in its passage back. Being dashed about as it passes through the endless, winding channels in the ground, it loses its salinity, and, purged of its bitterness in such a variety of ground as it passes through, it eventually changes into pure, fresh water.*

Unlike his predecessors, however, Seneca was on the lookout for evidence. "The endless, winding channels in the ground" he believed to be proven by calcareous tuff.

The poet Lucretius Caro (99-55 BC) adopted Aristotelian explanations in De Rerum Natura. Mt. Etna, Lucretius suggested, is hollow. As for the source of springs,

> *The sun drinks some, to quench his natural heat;*
> *And some the winds brush of.*
> *Some passes through the earth, diffused all over,*
> *And leaves its salt behind in every pore;*
> *For all returns through narrow channels freed*
> *And joins where ere fountain shows her head*
> *And thence fine streams in fair meadows play.*



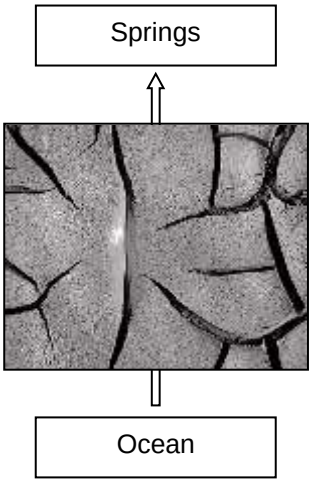
“The clouds imbibe much seawater,” as some translations render the leading words. The power of wind drives together an abundance of clouds and presses the water out.

"And leaves its salt behind in every pore" was an insightful consequence for a Roman poet, but one not to be carried to logical conclusion until much later.

Less astutely, Lucretius noted,

> *Since the earth has a porous body, and it is joined together with the sea, girdling its shores all around, it is necessary that as the flow of water comes from the land into the sea, so also it should ooze into the land from the salt sea; for the pungency is strained off, and the substance of the water oozes back, and all meets in a moving mass of sweet along the path which was once been cut for it in its liquid course.*

The science is Roman -- to put it positively -- but as "ooze into the land" is poetic, we'll grant a schematic of squeezed mud.



Fifteen centuries later, even Athanasius Kircher (1602-1680), whom we met in Chapter 8, never shy with answers, was perplexed by the oceans. According to Bishop Richard Watson's Chemical Essays (1781-1787),

> *Father Kircher, after having consulted three and thirty authors upon the subject, could not help remarking, that the fluctuations of the ocean itself were scarcely more various then opinions of men concerning the origin of its saline impregnation.*

But Why, Then, are Springs Not?

We need only consult Aristotle.

As fresh water is lighter than saltwater, the former properly seeks its natural place above the latter by rising, though the philosopher himself wouldn't have defined "lightness" in terms of physical measurement. That dissolved salt doesn't settle within the liquid, leaving a fresh upper stratum, was pragmatically recognized by the Greeks, but Aristotle and his followers wouldn't have conditioned the voracity of philosophical truth on fallible physical verification. Fresh seeking fresh and salt seeking salt, the philosopher would have determined.

The practicality of subterranean salt separation aside, any desalination scheme poses a consequent question. What becomes of the residue?

In the short run, we might expect the formation of salt beds, a geological formation familiar to the ancients. In the long run, however, there's only so much subterranean space to store the byproduct.

In his Notebook entry "Refutation of the Pliny's Theory of the Saltness of the Sea," da Vinci (1452-1519) ponders Pliny. We'll break da Vinci's thoughts into proposition and refutation.

Pliny says that the water of the sea is salt because the heat of the sun dries up the moisture and drinks it up; and this gives to the wide stretching sea the savor of salt.	*But this cannot be admitted, because if the saltness of the sea were caused by the heat of the sun, there can be no doubt that lakes, pools and marshes would be so much the more salt, as their waters have less motion and are of less depth; but experience shows us, on the contrary, that these lakes have their waters quite free from salt.*
Again it is stated by Pliny that this saltness might originate, because all the sweet and subtle portions which the heat attracts easily being taken away, the more bitter and coarser part will remain, and thus the water on the surface is fresher than at the bottom.	*But this is contradicted by the same reason given above.*
Again, it has been said that the saltness of the sea is the sweat of the earth.	*To this it may be answered that all the springs of water which penetrate through the earth, would then be salt.*
But the conclusion is, that the saltness of the sea must proceed from the many springs of water which, as they penetrate into the earth, find mines of salt and these they dissolve in part, and carry with them to the ocean and the other seas, whence the clouds, the begetters of rivers, never carry it up	*And the sea would be saltier in our times than ever it was at any time.*
And if the adversary were to say that in infinite time the sea would dry up or congeal into salt,	*To this I answer that this salt is restored to the earth by the setting free of that part of the earth which rises out of the sea with the salt it has acquired, and the rivers return it to the earth under the sea.*

We tend to know da Vinci for his intuition, not his formal logic, but here he lays bare the consequential fallacy of two millennia of natural philosophy. The earth beneath us has not over the eons become an accumulation of salt.

Geological action lifts up the salty sea bed and rivers, both above and below ground, return it to the sea. But as was his journaling propensity, da Vinci rarely halted when he was ahead.

> *The ocean does not penetrate under the earth, and this we learn from the many and various springs of fresh water which, in many parts of the ocean make their way up from the bottom to the surface. The same thing is farther proved by wells dug beyond the distance of a mile from the said ocean, which fill with fresh water; and this happens because the fresh water is lighter than salt water and consequently more penetrating.*
>
> *That fresh water penetrates more against salt water, than salt water against fresh is proved by a thin cloth dry and old, hanging with the two opposite ends equally low in the two different waters, the surfaces of which are at an equal level; and it will then be seen how much higher the fresh water will rise in this piece of linen than the salt; by so much is the fresh lighter than the salt.*

Fresh water does indeed float above saline water (a Ghyben-Herzberg lens to hydrogeologists), but it's due to a difference in density, not as a result of being "more penetrating." The fresh water's not lifted; it's seepage from above.

Da Vinci's reference to linen would seem to imply capillarity, but in that respect, fresh and saltwater are indistinguishable.

"The ocean does not penetrate under the earth" substantially contradicts da Vinci's writings of Chapters 7 and 8 in support of underground rivers. While da Vinci's critique of Pliny is sound, his own thoughts meandered.

Da Vinci's contempory, Felix Faber (1441-1502) drew attention to the connection between water sinking in mountain dolines and springs in the valleys below. From Faber's Historiae Suevorum (1489),

> *Therefore Nature has ready in the earth certain hollows in which the waters collect and... from whence they flow further through veins to the place where they have to flow out. These are especially noticeable in the Swabian AIps, where one sees many cup-shaped pits in the ground, into which the rain and the snow water penetrate and sink into underground lakes from whence it gushes forth again*.

At the same time, however, he thought some springs also fed with desalinated sea water.

> *Incapable of bearing the severity of the sea, it* [spring water] *comes concealed in the veins of the earth and penetrates in inexplorable routes into the narrowest crevices of the earth and rock, so that it leaves behind it the bitter skin with which it was clad in the sea, behind on the sand, the rocks and the earth. And thus it eventually comes again to the place, from whence it started, and emerges sweet, clear and drinkable out of the earth, to flow again according to the word of the Preacher* [i.e., Ecclesiastes].

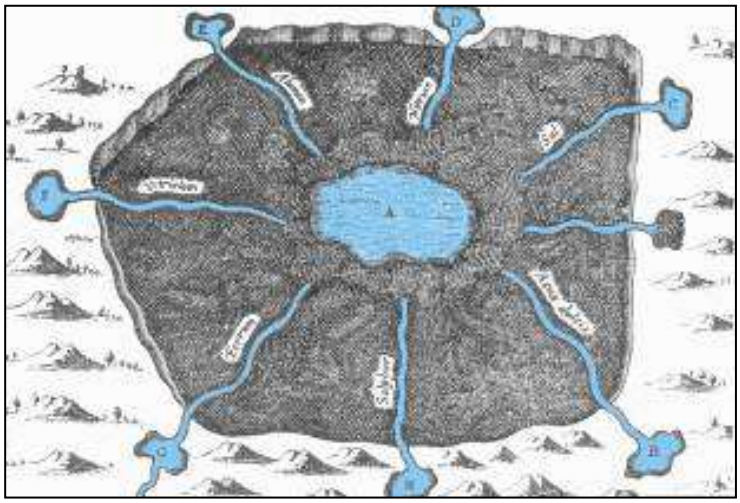
Meteorologicum (1627) by S.L. Fromondus dealt with springs, rivers, the sea and earthquakes. Seawater is evaporated by the earth's central fire, the salt coming off with "the steam and only being separated from it as it filters up through the earth."

Descartes expressed similar views in his Philosophidae Principia (1644), but being more widely read, hence had greater influence. The earth's heat causes steam to rise continuously from large seawater-filled cavities beneath the mountains, passing through crevices so minute that when the steam condenses against the cooler rocks, the condensate cannot return by the same route and therefore seeks larger fissures leading springs on the earth's surface. The salt left behind explains the deposits of rock salt.

Mathematician Jacques Pelletier (1517-1582) supposed that springs must be of marine origin, as many of them contain salt. While saline springs do exist, they're in fact uncommon, and thus here we have a logical determination based on false premise.

According to Kircher, the earth contains subterranean conduits from deposits of Ferrum, Sulphur, Aqua dulcis, Sal, Nitrum, Alumen and Vitriolum, all but the last easily cognated. “Vitriolum” is glass.

Pelletier overestimated the extent of saline springs and Kircher was far too fond of subterranean rivers, but the two scientists were on the chemical track. Mineral content indeed reveals the nature of a spring's source.



"Must Clog and Obstruct"

But let us return to Lucretius' earlier deduction that any ocean-derived subsurface stream that emerges as fresh water "leaves its salt behind in every pore."

Charles Hutton, whom we'll again encounter in Chapter 12, Superterranean Metrics, raised an irrefutable challenge in A Mathematical and Philosophical Dictionary, Containing an Explanation of the Terms, and an Account of the Several Subjects (1795).

> *And though the sand and earth through which the water ascends may acquire some saline particles from it, they are nevertheless incapable of rendering it so fresh as the water of our fountains is generally found to be. Not to add, that in process of time the saline particles of which the water is deprived, either by subterranean distillation or filtration, must clog and obstruct those canals and alembics.*

Natural desalination can't persist if the salt is left to smother the mechanism. Were underground rivers to work this way, the earth beneath our feet would by now be packed with white crystals.

Had the likes of Pelletier and Kircher pondered the implications of "clog and obstruct," their belief underground rivers might have been less certain. But as often the case through history, models rooted in culture are slow to fade.

Thomas Milner (Chapter 10) illustrated that even another century was not suffice for the demise of an illogical concept.

> *It is possibly the case, indeed, that the ocean filtering through pores of the earth the salt particles being lost in the passage may give rise to many springs; but as the preceding cause is amply sufficient to explain their formation, we need not recur to any other.*

As with all the candidate mechanisms of Chapter 8-8.2, salinity comes up short as the engine for underground streamflow.

Naturalists must have come to wonder why their otherwise-so-productive scientific method again and again failed to discover the mechanism for desalinating underground rivers. Perhaps -- we can imagine them at this point lowering their voices as to not invite the scorn of their colleagues -- the cause is absent because such rivers are not in existence.

We'll return to the subject of salt in Chapter 72, Minewaters.

CHAPTER 12
SUPERTERRANEAN METRICS

With Aristotle's help, Greek mythology sustained popular belief in underground rivers for millennia. Christianity then assumed the conceptual stewardship of underground rivers as the will of God. With Renaissance probing for sensible reason came a spectrum of candidate causalities for subsurface streams. Does the water rise because of a fiery earth? Tidal action? Chapters 8-10 provided more explanations than perhaps we can remember.

While scholasticism had moved beyond Plato to embrace observation, the Renaissance, per se, provided few tools by which to test the best explanations. Da Vinci wrote prolifically and drew exquisitely, but didn't bother with measurement.

Until the era of Isaac Newton (1642-1727), five erroneous hydrological propositions were yet favored by most natural philosophers.

Mechanisms such as wind, capillary action wave or action can draw large quantities of water from the earth's interior.
Sea water can lose its salt by infiltrating through soil.
Rainfall is insufficient to account for all water discharged by rivers.
Rainfall cannot infiltrate into the ground in large quantities.
The earth contains a large network of caverns and rivers.

But combining Platonic credence in mathematics with an Aristotelian influx of physical evidence, hydrology was about to change.

The discernment process began to advance when chemist Robert Boyle (1627-1691) established the standard of experimental inquiry that's still with us: tests must be conducted under controlled conditions and observations must be replicable.

As illustrated by the three paintings below, metrics became valued.

God as Architect, from the Bible Moralisée, Codex Vindobonensis (c. 1250)

William Blake, God as an Architect (1794)

William Blake, Newton (1795)

In the leftmost piece, a product of the Middle Ages, God is measuring his creation, the units perhaps being metrics of holiness. In the next painting, 500 years later, God again reaches

downward, but this time to measure the tangible. In the third, fueling the science vs. religion controversies to come, God is replaced by Newton.

Newton's Principia (1687) was elegant as it pertained to celestial workings, but provided little but a few conceptual pointers regarding much of what occurs below. The path of Mars made more mathematical sense than did the level of the Thames.

A 1692 issue of The Gentleman's Journal listed ten different explanations of the oceanic tides, complaining that competing ideas caused "the learned ... [to be] much puzzled about... the Flux and Reflux of the Sea."

The task of quantifying subsurface flow was indeed the most challenging part of the hydrologic cycle. Rainfall could be measured with a pan. Streamflow would be estimated by measuring a cross-section and timing a floating object. But no one could reach into the earth with a pan, a ruler, a clock, or for that matter, any instrument of measurement.

As we remarked in concluding Chapter 2, we'd like someone underground to take a look, but if we can't send someone with a lantern, perhaps we can measure what's occurring on the earth's surface and deduce the rest.

This chapter explores how measurement disproved the hydrologic necessity of underground rivers.

We'll begin by looking three Frenchmen,

Bernard Palissy,
Pierre Perrault,
Edmé Mariotte,

and then cross the channel to note the contributions of three Englishmen,

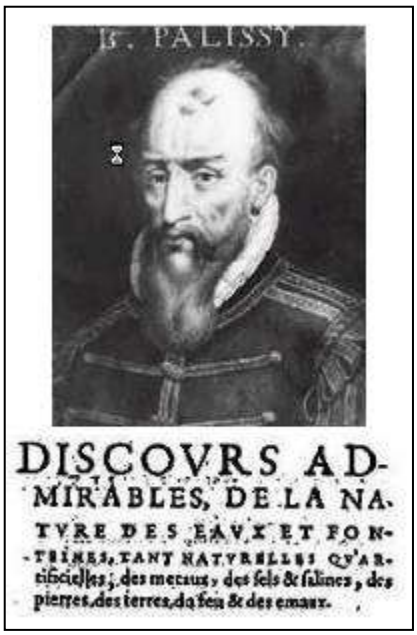
Edmond Halley,
Charles Hutton,
John Dalton.

Three Frenchmen

French Huguenot Bernard Palissy (1509-1590) began his career making stained glass windows and after 16 years of experimentation, perfected an enameled pottery which brought him and his heirs great fortune. An 1880 Palissy factory gravy dish is shown to the left.

Among the first of his nation to embrace Protestantism, had it not been for his patron the High Constable of Saintes, Palissy would have been executed.

But Palissy was more than a successful potter and free thinker. He was a natural philosopher, his theories generally based upon personal observation. Because Palissy was familiar with Vitruvius (Chapter 3), it's likely that the Frenchman lifted ideas from the Roman, but even so, Palissy's substantiation was by contemporary observation carried out with contemporary logic,



In his Discours Admirables de la Nature des Eaux Etfonteines (1580, but not translated to English until 1876) Palissy makes use of two voices: Theory, the one who imagines, and Practice, the writer's alter ego, the one who looks.

Theory challenges:

> *Looking back upon the whole body of doctrine taught by the old Potter in the last years of his life, where have you found all this written? Or tell me in what school you have been?*

And Practice responds:

> *I have no other book than the heavens and the earth, which are known of all men, and given to all men to be known and read. Having read in the same I have reflected on terrestrial matters.*

Practice unsuccessfully seeks water from a village spring:

> *When for a long time I had closely considered the cause of the source of natural fountains and the places where they might proceed, at length I became plainly assured that they could proceed from or be engendered by nothing but the rains.*

Theory finds fault:

> *After having heard your opinion, I am compelled to say that you are a great fool. Do you think me so ignorant that I should put more faith in what you say than in so large a number of philosophers who tell us that all waters come from the sea and return thither? There are none even to the old men who do not hold this language, and from time on we have all believed it. It is a great presumption in you to wish to make us believe a doctrine altogether new, as if you were the cleverest philosopher.*

Practice:

> *If I were not well assured in my opinion, you would put me to great shame, but I am not alarmed at your abuse or your fine language, for I am quite certain that I shall win against you and against all those who are of your opinion, though they may be Aristotle and the best philosophers that ever lived, for I am quite assured that my opinion is trustworthy.*

Theory:

> *Verily I find out now that you are a great liar, and if it were true that seawater could be so raised up into the air and fall afterwards upon the earth, it would be salt rain, so there you are caught by your own argument.*

Practice contends that rivers and springs have no source other than rainfall, for which he is called a “great dolt” by Theory for contradicting the most excellent philosophers.

Practice refutes that streams must originate either from seawater or from air converted into water. The concept of gravity weighs against the seawater theory, as sea level would have to exceed the mountain tops.

> *I tell you, as a general and certain rule, that waters never rise higher than the sources from which they proceed.*

Spring waters would be saline and would dry up during low tide. Some rivers do dry up, of course, but,

> *If the sea were to feed by its nipples all the springs of the universe, they would never dry up during the months of July, August and September, at which time an infinite number of wells dry up.*

And as maximum tidal levels are associated with the full moons of March and July, wells and rivers should not go dry during those months.

Even if the sea were as high as the mountains,

> *Its waters would not reach the high parts of these mountains where the springs originate. This is because the earth is, in many places, full of holes, cracks and abysses a through which water that came from the sea would flow back to the plain from the first holes, sources or abysses it could find.*

Practice concedes that water could form in caverns by the condensation of vapor, but in inadequate amount to sustain rivers. Rather,

> *Rain water that falls in the winter goes up in summer, to come again in winter... And when the winds push these vapors the waters fall on all parts of the land, and when it pleases God that these clouds (which are nothing more than a mass of water) should dissolve, these vapors are turned to into rain that falls on the ground.*

Moreover,

> [Soils] *retain water from the rain as would a bronze vessel. And the said water falling on these mountains flows downwards through the soil and cracks and continues until it finds a uniform and hard bed of stone or solid rock; and when it comes to rest on such a base and finds a canal or other opening, it emerges as springs, or as streams and rivers, depending on the size of the openings.*

Practice has qualitatively described porous-media groundwater flow as we today understand it.

Significant to our pursuit of underground rivers, while Theory clings to idealized subterranean channels, Practice demands a mechanism consistent with how water is observed to seep.

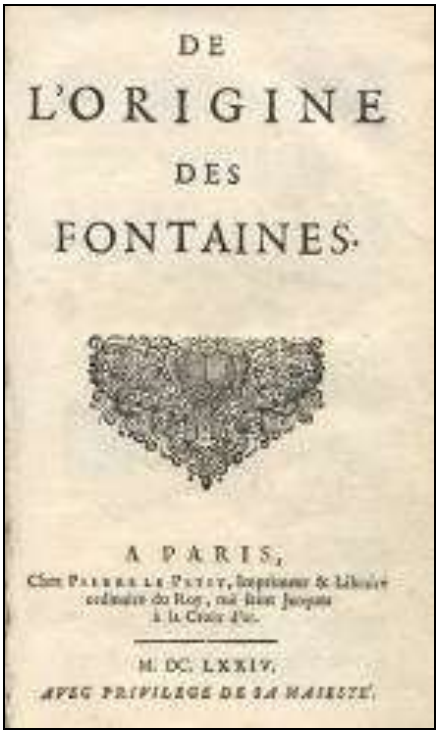
As Palissy concluded (in his own voice),

> *When I had long and closely examined the source of the springs of natural fountains, and the place whence they could come, I finally understood that they could not come from or be produced by anything but rains.*

Pierre Perrault (1608-1680), Receiver General of Finances in Paris, studied the River Seine near Burgundy, measuring the average annual rainfall over a small portion of the upper basin for comparison to the annual discharge from that catchment.

The portrait to the right is of Perrault, but as we'll shortly note, we can't be certain that we have the correct sibling.

Perrault's De l'Origine des Fontaines (1674) reported that rainfall was six times the amount that flowed out of the watershed, thus proving that precipitation was more than enough to supply the water in the Seine and,



DE

L'ORIGINE

DES

FONTAINES.

A PARIS,

M. DC. LXXIV.

AVEC PRIVILEGE DE SA MAJESTÉ.

Frontispiece, "De L'origine des Fontaines"

> *To cause this River to flow for one year, from its source to the place designated, and which must serve also to supply all of the losses, such as the feeding of trees, plants, grasses, evaporation…*
>
> *If then this water suffices for one river, it will suffice for all the other rivers of the world in proportion.*

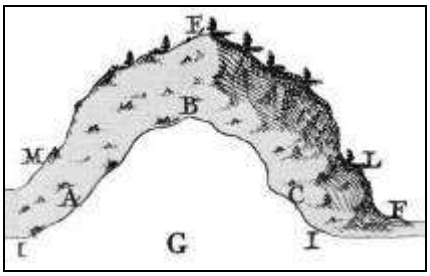
Perrault demonstrated by measurement that capillary rise of water was less than 1 meter in sand and could not create a body of free water above the water table. The revolutionary aspect of Perrault's finding of a 6:1 rainfall/runoff ratio was that the value substantially exceeds unity. Palissy had suggested that rainfall was sufficient to supply the total streamflow, but it took 94 years for Perrault to attach a number.

Pierre's brother Claude (1613-1688) was a physician, but became the architect of the Louvre and translated of the ten books of Vitruvius (Chapter 3).

We'll catch up with brother, Charles (1628-1703), in Chapter 18, Underground Rivers in Continental Fiction for his contribution to the study of underground streams in Tales of Mother Goose (1697).

Edmé Mariotte (1620-1684) refuted the yet-popular assumption of springs derived from condensation in subterranean caverns, as precipitation could not penetrate more than a few meters into the earth.

Mariotte's Traité du Mouvement des Eaux et des Autres Corps Fluides (1686),



> *For if ABC is a vault in the mountain DEF; it is evident, that if the vapor should become water in the concave of the surface ABC, that water would fall perpendicularly towards HGI, and not towards T or M, and consequently would never make a spring. Besides, it is denied that there are many such hollow places in mountains, and it can't be made appear that there are such. If we say there is earth on the side of, and beneath ABC, it will be answered, that the vapor will gush out at the sides towards A and C, and that very little will become water; and because it appears that there is almost always clay where there are springs, it is very likely that those supposed distilled waters can't pass through, and consequently that springs can't be produced by that means.*

More simply: We won't find subterranean reservoirs behind springs.

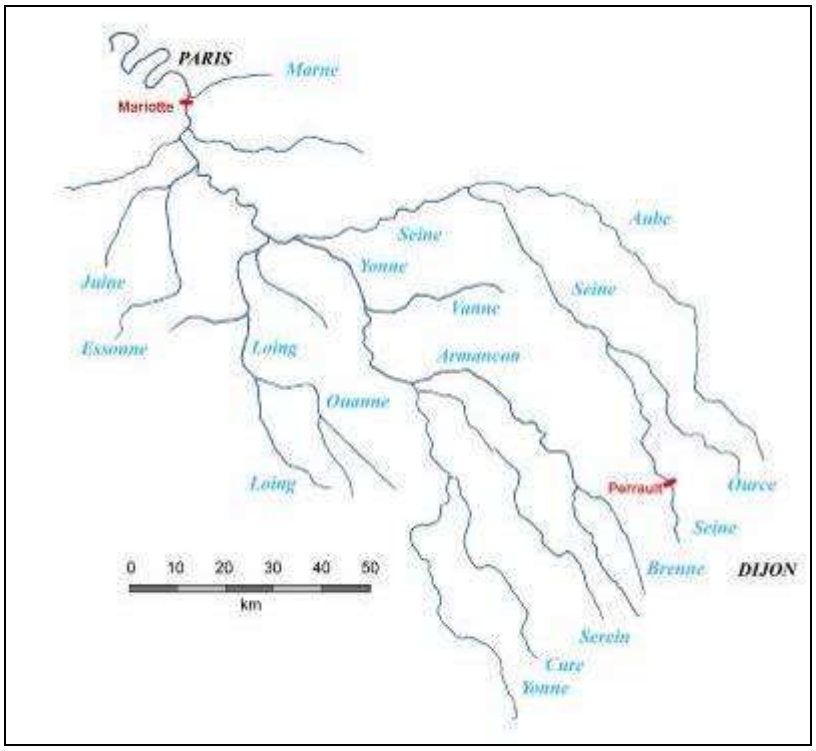
To establish that the source of groundwater must be precipitation, Mariotte compared seepage into the cellar of the Paris Observatory to the rainfall above, noting that more water came into the basement after heavy rains.

> [Rainfall} *filtered through the soil until it met with impervious layers in then interior, through which it was unable to pass; it therefore continued its course along them in an oblique direction until it found egress and came out as springs.*

Scientifically better educated that Perrault, Mariotte sought to confirm Perrault's result using a much larger catchment, that of the Seine at Paris.

> *It is thus evident that when a third of the rain waters have evaporated, a third will keep the soil moist in the large plains, and a third will still be sufficient to feed springs and rivers.*

As Perrault's and Mariotte's studies were close in both time and location, it is informative to compare their findings.



The table below summarizes their respective results.

Investigator	Perrault	Mariotte
Publication	De L'origine des Fontaines (1674)	Traité du Mouvement des Eaux et des Autres Corps Fluides (1685)
Basin	Seine above Aignay-le-Duc	Seine above Paris
Area (square km)	121	60,356
Duration of Study	3 years	3 years
Average Precipitation (mm)	520	400
Annual Precipitation (cubic m)	60,750,000	24,142,400,000
Annual runoff (cubic m)	10,000,000	3,553,056,000
Precipitation/Runoff	6.0:1	6.8:1

An historical fact, Claude Perrault was the architect of Versailles and Mariotte, the well-driller. The history of scientific hydrology is indeed one of crossed paths.

Water Tank, Versailles

Current estimates of the precipitation/runoff ratio are summarized below by continents.

	Precipitation (mm)	Evapo-transpiration (mm)	Runoff (mm)	Precipitation/ Runoff
Africa	690	550	140	4.9:1
Asia	720	430	290	2.5:1
Australia	740	510	230	3.2:1
Europe	730	410	320	2.3:1
North America	670	380	290	2.3:1
South America	1650	1060	590	2.8:1

Perrault's and Mariotte's fundamental breakthrough wasn't the precise precipitation/runoff ratio; it was that its value significantly exceeds 1.0. The perception that rivers bear more water than the upstream rainfall was at last disproven.

As well-builder for the Palace of Versailles, Mariotte put his findings to practice. In the world's first application of hydrologic modeling, Mariotte calculated that 100 square kilometers should supply the palace's water need. The channels, however, couldn't transmit the flow and so fared the first application of hydrologic design.

Three Englishmen

English astronomer Edmond Halley (1656-1742), son of an industrial soap-maker, is best remembered for the comet honoring his name, but his most influential contribution to science was that of translating the works of his friend Isaac Newton from Latin to English.

Noting the likeness of comets observed in 1531, 1607 and 1682, Halley concluded that all three were in fact the same object and correctly predicted its 1758 return. Halley's contribution to the science of hydrology stemmed from the condensation on his optical equipment on clear day, 730 meters above the Mediterranean, making the astronomer to be among the first to appreciate the magnitude of atmospheric water.

Halley filled a 20-centimeter pan half-full with salt water and heated it to the temperature of a summer day. In two hours, 0.5 ounces were evaporated. Estimating the surface of the Mediterranean to be 1.9 million square kilometers -- actually, it's 2.5 -- Halley calculated daily evaporation to be 5.3 billion metric tons. (Lest the value seem unduly large, it corresponds to slightly less than 3 millimeters/day. Modern meteorological records averaged over a full year indicate about half that.)

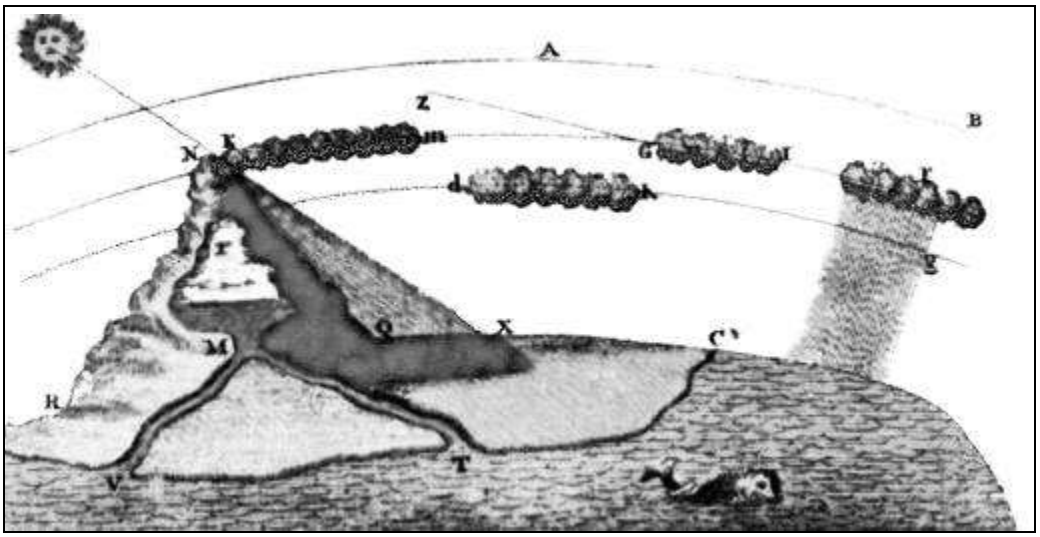
By extrapolating from the estimated flow of the Thames, Halley concluded that evaporation from the Mediterranean exceeds its river inflow and again extrapolated that there is sufficient evaporation from the world's oceans to supply all the rivers and springs.

To bring his numbers into balance, he reported to the Royal Society that some of the vapor from the sea swept against the high mountain tops "gleets down" into caverns from where it flows back to the sea. Mountains thus act as "external alembics," distilling fresh water for the benefit of man "like so many veins in the microcosm."

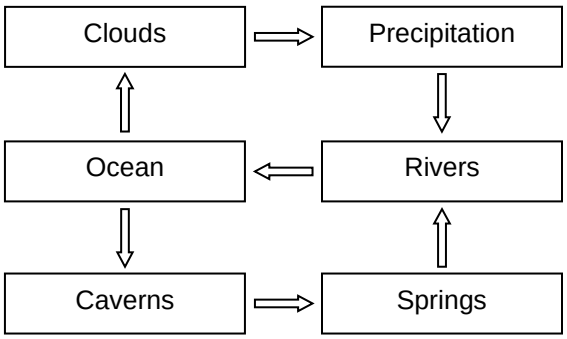
"An Account of the Circulation of the Watery Vapors of the Sea, and of the Causes of Springs," Philosophical Transactions of the Royal Society (1686) explains how springs continue to flow during periods when there was no rain.

> *Those Vapors therefore that are raised copiously in the Sea, and by the Winds are carried over the low Land in those Ridges of Mountains, are there compelled by the stream of the Air to mount up with it to the tops of the Mountains, where the Water presently precipitates, gleeting down by the Crannies of the stone; and part of the Vapor entering into the Caverns of the Hills, the Water thereof gathers as in an Alembick into the Basons of stone it finds, which being once filled, all the overplus of Water that comes thither runs over by the lowest place, and breaking out of the sides of the Hills, forms single Springs.*
>
> *I doubt not but this Hypothesis is more reasonable than that of those who derive all Springs... from a Filtration of Percolation of the Sea-waters through certain imaginary Tubes or Passages within the Earth, wherein they lose their saltness.--*

His An Estimation of the Quantity of Vapor Raised out of the Sea, and the Cause of Springs (1687) illustrates the caverns and rivers.



Below is Halley's hydrologic model showing the caverns-springs-rivers route.



We will return to Halley's condensation hypothesis as it relates to caves in Chapter 40, but before then, we'll meet the astronomer looking further downwards in Chapter 15, Hollow Earth Geophysics.

Charles Hutton (1737-1823) was an encyclopedist, striving to sort the burgeoning set of scientific findings into an objective framework. Following are several entries from his A Mathematical and Philosophical Dictionary, Containing an Explanation of the Terms, and an Account of the Several Subjects (1795).

As to what would become to be today's common understanding of the hydrologic cycle,

> *The most general and probable opinion among philosophers, on the formation of Springs, is, that they are owing to rain. The rain-water penetrates the earth till such time as it meets a clayey soil, or stratum; which proving a bottom sufficiently solid to sustain and stop its descent, it glides along it that way to which the earth declines, till, meeting with a place or aperture on the surface, through which it may escape, it forms a Spring, and perhaps the head of a stream or brook.*

Regarding Perrault's 6:1 rainfall/runoff ratio,

> *Now, that the rain is sufficient for this effect, appears from hence, that upon calculating the quantity of rain and snow which falls yearly on the tract of ground that is to furnish, for instance, the water of the Seine, it is found that this river does not take up above one sixth part of it.*

Hutton understood enough basic hydraulics to envision the upper slopes of a nearby mountain feeding a geologic stratum that curves below nearby valleys to rise elsewhere.

> *And if we sometimes see Springs on high grounds, and even on the tops of mountains, they must come from other remoter places, considerably higher, along beds of clay, or clayey ground, as in their natural channels. So that if there happen to be a valley between a mountain on whose top is a Spring, and the mountain which is to furnish it with water, the Spring must be considered as water conducted from a reservoir of a certain height, through a subterraneous channel, to make a jet of an almost equal height.*

Hutton, however, perpetuated Halley's subterranean cavern theory.

> *The tops of mountains usually abound with cavities and subterraneous caverns, formed by nature to serve as reservoirs; and their pointed summits, which seem to pierce the clouds, stop those vapors which float in the atmosphere; which being thus condensed, they precipitate in water, and by their gravity and fluidity easily penetrate through beds of sand and the lighter*

> *earth, till they become stopped in their descent by the denser strata, such as beds of clay, stone, &c, where they form a basin or cavern, and working a passage horizontally, or a little declining, they issue out at the sides of the mountains.*

Refuting those who hold to underground rivers from the sea,

> *Some naturalists therefore have recourse to the sea, and derive the origin of Springs immediately from thence. But how the sea-water should be raised up to the surface of the earth, and even to the tops of the mountains, is a difficulty, in the solution of which they cannot agree.*

Regarding Halley's condensation caves,

> *Others... set aside the alembics, and think it enough that there be large subterranean reservoirs of water at the height of the sea, from whence the warmth of the bottom of the earth, &c, may raise vapors which pervade not only the intervals and fissures of the strata, but the bodies of the strata themselves, and at length arrive near the surface; where, being condensed by the cold, they glide along on the first bed of clay they meet with, till they issue forth by some aperture in the ground.*

In support of Perrault's rainfall-alone explanation,

> *The water that is supposed to ascend from the depths of the sea, or from subterranean canals proceeding from it, through the porous parts of the earth, as it rises in capillary tubes, ascends to no great height, and in much too small a quantity to furnish springs with water, as Perrault has sufficiently shewn.*

As they share the same surname, perhaps here we should mention the Rev. John Hutton, who wrote on the subject a century later. The latter Hutton's A Tour to the Caves, in the Environs of Ingle Borough and Settle, in the West-Riding of Yorkshire (1880, 1881) noted two underground streams crossing without mixing.

> *The springs were entirely dependent on the rains.*
>
> *Though we met with many streams below the earth; yet we could easily find they originally descended from its surface, and not from any distillations against the sides of the caves.*

Much had indeed be learned between Hutton I and Hutton II.

Over his lifetime, John Dalton (1760-1844) made over 200,000 meteorological observations, the basis of his Experiments and Observations to Determine Whether the Quantity of Rain and Dew is Equal to the Quantity of Water Carried off by the Rivers and Raised by Evaporation, with an Enquiry into the Origin of Springs (1802).

After correction for missing areas, Dalton estimated the mean rainfall and snowfall (water equivalent) for England and Wales to be 79 centimeters. He added 13 centimeters for annual dewfall. To estimate the total river outflow, he divided the country into catchments and from the flow of the Thames and the relative sizes of the watersheds, obtained 33 centimeters.

Dalton monitored the long-term water balance of a soil-filled container to estimate 76 centimeters for the annual evapotranspiration loss.

```
   79  centimeters of rain and snow
+  13  centimeters of dew
   92  centimeters of inflow

   33  centimeters of streamflow
+  76  centimeters of evaporation
  109  centimeters of outflow
```

Dalton attributed the discrepancy to overestimated evaporation and non-representativeness locations.

> *Upon the whole then I think that we can finally conclude that the rain and dew of this country are equivalent to the quantity of water carried off by evaporation and by the rivers. And as nature acts upon general laws, we ought to infer, that it must be the case in every other country until the contrary is proved.*

Dalton's finding is a prime example of Ockham's Razor, Chapter 10. When choosing between conflicting, but incompatible, explanations, the simper of the explanations is more likely to be the better. Dalton's finding calls upon but four quantifiable hydrologic estimates, no unseen routes or mechanisms and no unique physical relationships.

We should not close this chapter secure that science has triumphed, however. Skepticism is too much a part of human nature. Nearly a century later, the German geologist Otto Volger (1822-1897) in The Scientific Solution to the Water Issue with Respect to the Supply of Cities (1877) categorically denied any relation between rainfall and groundwater. Volger also maintained that concern for groundwater contamination was a fear of phantoms which would impose unnecessary costs on public water wells.

We began this chapter with a list of fallacious hydrological propositions commonly held until the time of Newton.

Mechanisms such as wind, capillary action or wave action can draw large quantities of water from the earth's interior.
Sea water can lose its salt by infiltrating through soil.
Rainfall is insufficient to account for all water discharged by rivers.
Rainfall cannot infiltrate into the ground in large quantities.

Rudimentary measurements disprove all four.

An ocean-to-mountain underground river becomes unnecessary when rainfall exceeds streamflow. It seems, therefore -- if we allow ourselves a bit of reflection -- that Chapters 8-10 was spent looking for engines that need not exist.

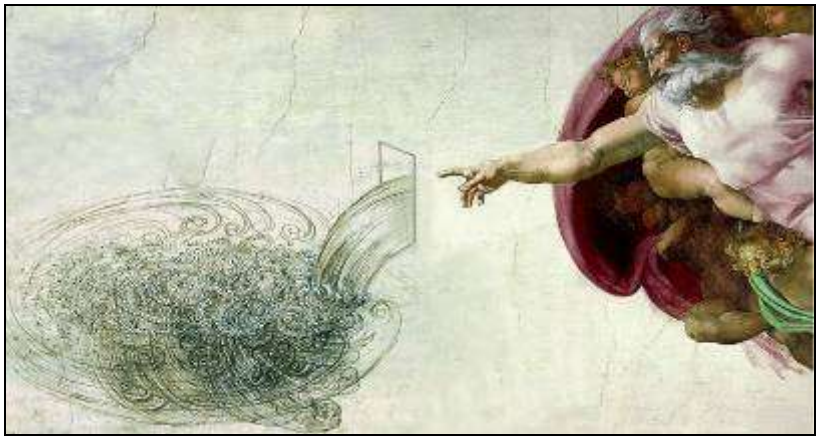
The fifth perception, however -- that the earth contains a large network of caverns and rivers -- yet eluded testing.

Eliminating hydrologic necessity for underground rivers does not dispel the possibility of their existence.

Did quantifying the hydrologic cycle remove underground rivers from theological interest?

Not at all. As we will see in the next chapter, it confirmed Christianity.

CHAPTER 13
HYDROTHEOLOGY/THEOHYDROLOGY



"Idroteologia/Teoidrologia"(1504), Leonardo da Vinci and Michelangelo

The above collaboration is penultimate proof of unity of hydrology and theology. Or at least it will be proof, once the work's authenticity is verified. The hand of each master cannot be denied and it is speculated that the two met in Florence.

"Natural theology" refers not to a theology particular to the physical world, but rather to the epistemological distinction between what may be known through revelation and what may be known through by human sensibility and reason.

The theological challenge in da Vinci's and Michelangelo's time was that of reconciling biblical cosmology with new-found Humanism, a challenge that morphed over the subsequent two centuries into that of that of validating Biblical inerrancy in an increasingly-quantifiable terrestrial sphere.

The three phases in theology's adjustment to human experience:

Dismissal of unsettling evidence. We saw this in Chapter 4, The Cross.

Floundering dogma. Christendom was intellectually challenged by Renaissance thought, the subject of Chapter 7.

Reconciliation with ascertained fact. Seventeenth-century theologians sought attributes of God in the heavens (astronomy), the inhabitants (biology), and the earth (geology). The chapter at hand relates how a church that not long before had insisted on the existence of underground rivers came to espouse hydrologic science that dispelled the need for such waters.

Perhaps more than any chapter in our journey, this one revolves on intellectual conflict. Respected voices were weighing in from all perspectives. The advocates for science would eventually dominate the advocates for revelation, but not without determined effort.

Era of the Scientific Revolution (1550-1700)

As the Scientific Revolution called for a mechanical, not magical, Creation, the Hand of God was perceived as that of a master mechanic. The vast complexity of an intricately-interlocking, precisely-tuned physical world stands as our signpost to the Creator's infinite design.

This wasn't new thought at the time. According to Aquinas, the existence of God can be proven in five ways, the first four being arguments from motion, efficient causes, possibility and necessity and gradation of being.

Aquinas's fifth way is argument from design. Observe that animate natural bodies lacking intelligence work toward some goal, and do so not by chance. As an arrow reaches its target because it is so directed by an archer, so that which lacks intelligence achieves its goal by being directed by another intelligence. Therefore some intelligent being must exist by whom all natural things are directed to their end. This being may be called God.

God as the archer wasn't a productive analogy to those in the forefront of in the Scientific Revolution, but such shortcoming didn't necessarily hinder the era's energetic cross-country ramblers and specimen collectors from pronouncing that proof of God was manifest in their footpaths.

Perception of Divine Providence, in fact, enabled the fledgling Scientific Revolution to thrive under the religious dogma that it would later come to expel from scholarly inquiry.

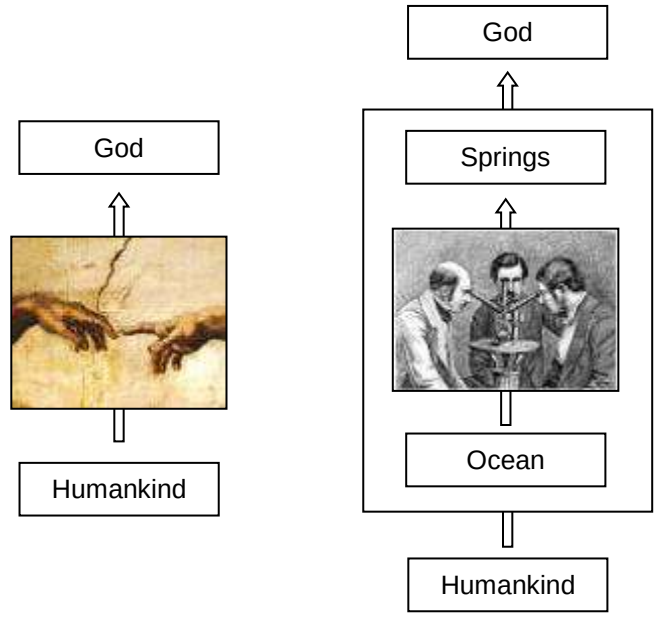
When Isaac Newton was but a lad, "physico-theology," a strain of natural theology that interpreted regularity and functionality as proof of God's guarantee of a stable, anthropocentric world, came into being.

And what might better prove God's grace than His establishment of natural and perpetual replenishment of that which sustains human kind/?

The hydrologic cycle fit the bill.

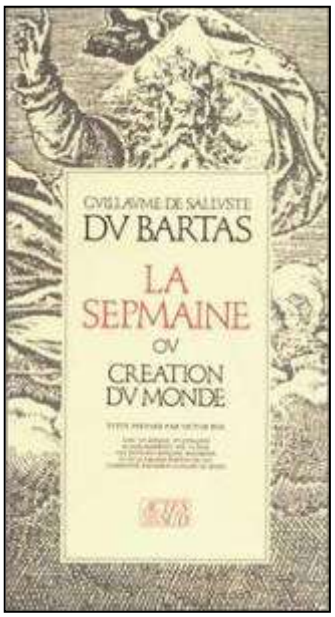
Biblical assurance in one hand and instruments of hydrologic measurement in the other, the Christian apologist could sally forward.

But thou hast ordered all things in measure, and number, and weight. -- Wisdom 11:21



Revealed Theology Natural Theology

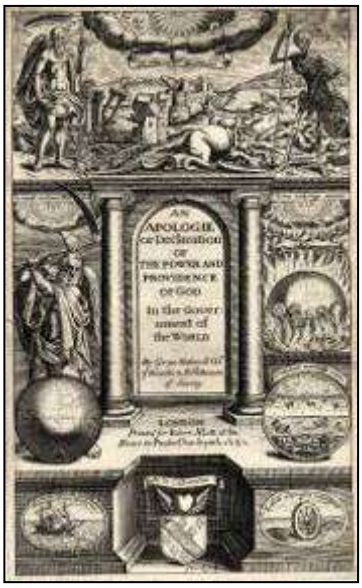
La Sepmaine, ou, Creation du Monde (1578) by Guillaume de Salluste du Bartas, a Huguenot, was an influential account of Creation in which the hydrologic cycle exemplifies how its closure provides for man.



One while, he sees how the ample Sea doth take
The Liquid homage of each other Lake;
And how again the Heav'ns exhale, form it,
Abundant vapors (for our benefit).
And yet it swells not for those tribute streams,
Nor yet it shrinks not for those boiling beams.

John Donne's Christmas Day sermon, 1624, put it succinctly,

One of the most convenient hieroglyphics of God is a circle ... and a circle is endless; His sun and moon and stars move circularly.



An Apologie (1627) by English clergyman George Hakewill asserted that, "The power and providence of God in the government of the world" and censured, "the common error touching nature's perpetual and universal decay."

The "weighty authority" of Solomon, "the wisest man that ever lived," spoke for "the circulation of all things as it were in a ring... running round of all things." Both the wind and the water move in circuits.

Whereupon he infers the thing that hath been, it is that that shall be, and that which is done, is that which shall be done, and there is no new thing under the sun.

Specific to the theohydrology of underground rivers, we turn to another member of the clergy, John Swan, author of Speculum Mundi (1635), or

> *A glass representing the face of the world: showing both that it did begin, and must also end: the whole of which may be fitly called an hexameron or discourse of the clauses, continuance, and qualities of things in nature, occasioned as matter pertinent to the work done in the six days of the world's creation.*

The frontispiece, rife with esoteric symbolism, is shown to the right.

Swan's encyclopedic arrangement of science according to the days of Creation embodies the conflict between science and scripture, superstition and belief.

The air is now "corrupted" and the "fruits of the earth of a feeble nourishment." The Flood wrought damage through the action of "the salt waters of the great deep," and also by way of "vapors or... exhalations."

Swan's answers to six self-addressed hydrological questions.

How the waters were gathered together?

> *For the efficient cause of the sea was the only word of God.*

How it can be said that they were gathered to one place; seeing there be many seas, lakes, rivers, and fountains that are far asunder?

> *Every part of the water is joined unto the whole as it were with arms and legs, and veins diversely dilated and stretched out.*

Whether they be higher than the earth?

> *Suppose that certain springs arise out of the highest mountains, must the sea therefore needs be higher than those mountains? Surely I think not. For albeit I be not of Aristotle's mind, nor of their opinions who do not derive the rivers from the seas, nor make subscription onto them who give a sucking and an attractive power to the veins of the earth; yet I find it as a thing possible, although that part of the sea which lieth opposite to the heads of the fountain, or to a place where the water first breaketh out, be lower than the ground, that the said water may neverless easily ascend, and not break forth until it finds a place convenient. Now this ascent is caused by the sea, which, seeing it is a vast body, is very ponderous and heavy, and cannot be thrust back by the waters at the head of the fountain opposite to it, but rather it doth potently and strenuously crowd on the said water through the hollow ports and passages of the earth, until at the last is springeth forth.*

It's the weight-of-the-sea engine, a proposed subterranean engine we reviewed in Chapter 10.

Whether there be more water than earth?

> *When God commanded the waters to be gathered, he gathered them into the seventh part of the earth, and dried up the six other parts.*

Whether the earth can be founded upon the waters?

> *The Psalmist seemeth of affirm it.*

Why the seas be salt, and the rivers fresh?

> *If therefore Aristotle's aerial vapors have anything to do in this generation, it is as much as nothing.*
>
> *This freshness, notwithstanding their salt origin, may be ascribed to percolation and straining through the narrow spongy passages of the earth, which makes them leave behind (as an exacted toll) the color, thickness, and saltness.*

We're familiar with Chapter 11's salt-straining earth.

What causeth an ebbing and flowing in the sea, rather than in rivers?

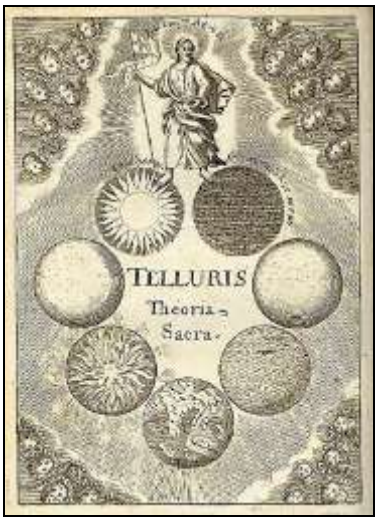
> *It is a great secret of nature, and gives us therefore principal occasion to magnify the power of God, whose name only is excellent, and whose power above heaven and earth.*

As revealed theology, Speculum offered little not already centuries old. As natural theology, it relied on science already disproven. We'll give Swan credit, however, for trying to bridge the gap.

Neo-Platonist and royal chaplain to William III, Thomas Burnet sought to explain,

> *The origin of the earth, and all of the general changes which it hath already undergone or is to undergo till the consummation of all things.*

Burnet's Telluris Theoria Sacra (1684) tells how the earth was fluid chaos until the heavier parts sunk to form a fiery core, leaving a thin earthen crust upon a watery abyss. The earth was of perfect mathematical form, smooth and beautiful, "like an egg," with neither seas nor islands nor valleys nor rocks, "with not a wrinkle, scar, or fracture."



All Creation was equally perfect. There were no alternating seasons, storms or rivers. It rained only at the poles from where the water filtered into the soil and flowed underground to the inhabited tropics.

But sin led to the breaking up of the "foundations of the great deep" and the fertile superficial layer was dried by the sun and began to crack until the colder waters below burst upward, causing mountains, abysses and islands. Had there been a sea before the deluge, sinners would have learned to build ships and could have saved themselves.

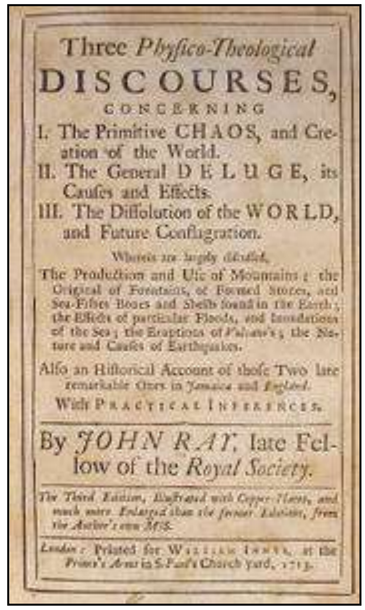
When the earth's crust collapsed, air was trapped under the rubble, but with time, the air escaped and was replaced by waters connected by underground passages. To visualization such,

> *We must take off the cover of all subterraneous places and deep caverns, to see the inside of the earth; and lay bare the roots of mountains, to look into those holes and vaults that are*

under them, fill'd sometimes with fire, sometimes with water, and sometimes with thick air and vapors.

It is Genesis retold per the science of the day.

When God created heaven and earth, He also created underground rivers. If they don't service us as well as they used to, it's because of our sin.

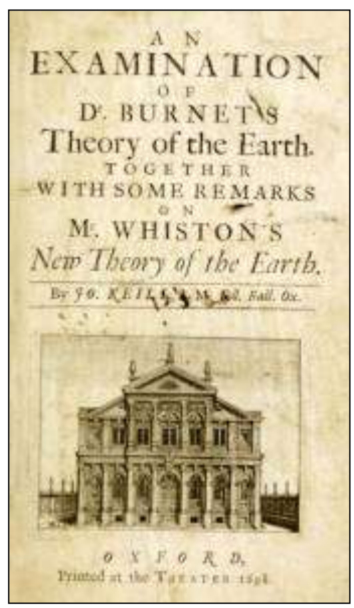

Three Physico-Theological
DISCOURSES,
CONCERNING
I. The Primitive CHAOS, and Creation of the World.
II. The General DELUGE, its Causes and Effects.
III. The Dissolution of the WORLD, and Future Conflagration.
Wherein are largely discussed,
The Production and Use of Mountains; the Original of Fountains, of Formed Stones, and Sea-Fishes Bones and Shells found in the Earth; the Effects of particular Floods, and Inundations of the Sea; the Eruptions of Vulcano's; the Nature and Causes of Earthquakes.
Also an Historical Account of those Two late remarkable Ones in Jamaica and England.
With PRACTICAL INFERENCES.
By JOHN RAY, late Fellow of the Royal Society.
The Third Edition, Illustrated with Copper-Plates, and much more Enlarged than the former Editions, from the Author's own MSS.
London: Printed for WILLIAM INNYS, at the Prince's Arms in S. Paul's Church-yard, 1713.

John Ray, a devout Anglican, was a forerunner of Linnaeus in biologic taxonomy. The son of a blacksmith, Ray became professor of Greek at age 20 and later a professor of mathematics. <u>The Wisdom of God Manifested in the Works of Creation</u> (1691) was followed by <u>Three Physico-Theological Discourses</u> (1693).

The sea, what infinite variety of fishes doth it nourish! How doth it exactly compose itself to a level, of equal supercies, and in the earth make one spherical roundness? How doth is constantly observe its ebbs and flows, and still retain its saltiness, so convenient for the maintenance of its Inhabitants, serving also the uses of man for navigation, and the convenience of carriage?

Ray refuted Burnet's view of mountains as blemishes on the earth's surface. Among other benefits to humanity, mountains provide boundaries, produce springs and rivers and contain caves providing refuge for Christians.

To Ray, the hydrologic cycle is a unifying concept that incorporates a remarkable range of facts. In light of his own observations and the findings of Perrault and Mariotte (Chapter 12), Ray supported the pluvial theory by correlating the relative size of watersheds to the magnitudes of their respective waterways.


AN
EXAMINATION
OF
D^r. BURNET's
Theory of the Earth.
TOGETHER
WITH SOME REMARKS
ON
M^r. WHISTON'S
New Theory of the Earth.
OXFORD,
Printed at the THEATER 1698

Burnet's Deluge theory involved waters upwelling and returning into the Abyss, a sequence of conceptual nature, but when numerically pursued in John Keill's <u>An Examination of Dr. Burnet's Theory of the Earth, Together with Some Remarks on Mr. Whiston's New Theory of the Earth</u> (1698), one that failed to add up.

And as for rivers, I believe it is evident, that they are furnished by a superior circulation of vapors drawn from the sea by the heat of the sun, which by calculation are abundantly sufficient for such a supply. For it is certain that nature never provides two distinct ways to produce the same effect, when one will serve.

It's Ockham's Razor from Chapter 10.

As for Whiston's New Theory of the Earth (to which we gave mention in Chapter 7), Keill's thoughts converge from two directions, the first arguing against the Kircherian hydrophylacia (Chapter 9, Thermodynamic Engines) to which Whiston subscribed.

> *But the increase and decrease of rivers, according to wet and dry seasons of the year, do sufficiently show their origination from a superior circulation of rains and vapors. For if they were furnished by vapors exhaled from the Abyss through subterraneous pipes and channels, I see no reason why this subterraneous fire, which always acts equally, should not always equally produce the same effect in dry weather that it does in wet.*

In short, the earth's fire wouldn't burn in seasons.

Keill's second objection is less cerebral; he inquired regarding evidence.

> *I know the maintainers of this opinion... allege that there are springs and fountains on the tops of mountains which cannot easily be maintained by a superior circulation of vapors, but I beg those gentlemen's pardon, for I can give no credit to any such observations, for I am well assured that there are none of those springs in some places where it is said they are. And particularly that learned and diligent observer of Nature Mr. Edward Lloyd, the Keeper of the* [Oxford] *Museum Ashmolean, assured me, that throughout all his travels over Wales, he could observe no such thing as a running spring on the top of a mountain. On these considerations, I think it is not in the least probable that rivers and springs proceed from vapor that is raised by a subterraneous heat through the fissures of the mountains*

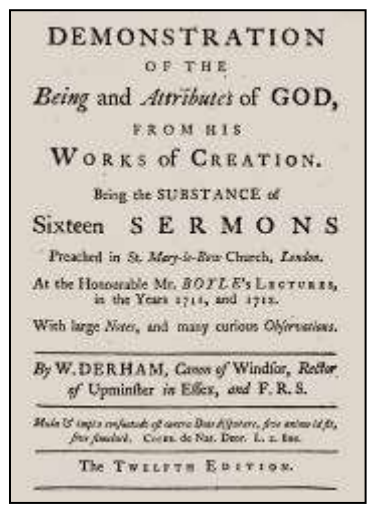
To the best of Keill's knowledge, no one had ever seen a spring issuing from a mountain top.

Post 1700

The authors in the remaining portion of the chapter, dutiful servants of God all, were expounding into an increasingly secularized auditorium.

We were introduced to Anglican clergyman, William Derham's scientific inquisitiveness -- if not insight -- in Chapter 10, Geophysical, Pneumatic and Electromagnetic Engines.

Derham found proof of God's existence in Physico-Theology, or A Demonstration of the Being and Attributes of God (1713) in which all facets of physical geographic interactively give evidence of "the most indulgent Creator."


DEMONSTRATION
OF THE
Being and *Attributes* of GOD,
FROM HIS
WORKS of CREATION.
Being the SUBSTANCE of
Sixteen SERMONS
Preached in *St. Mary-le-Bow* Church, *London.*
At the Honourable Mr. *BOYLE*'s LECTURES, in the Years 1711, and 1712.
With large *Notes*, and many curious *Observations.*

By W. DERHAM, *Canon of* Windsor, *Rector of* Upminster *in* Essex, *and* F. R. S.

The TWELFTH EDITION.

The label "hydrotheology" was coined by Hamburg polymath Johann Albert Fabricius as title for his 1734 treatise.


HYDROTHEOLOGIE
Oder
Versuch,
durch aufmerksame Betrachtung
der Eigenschaften, reichen Austheilung
und Bewegung
Der Wasser,
die Menschen
zur Liebe und Bewunderung
Ihres Gütigsten, Weisesten,
Mächtigsten Schöpfers
zu ermuntern.
Ausgefertiget
von
JO. ALBERTO FABRICIO,
D. und Prof. Publ. des Gymnasii zu Hamburg.
Nebst einem Verzeichniß von alten und neuen
See- und Wasser-Rechten,
wie auch Materien und Schriften, die dahin gehören, unter XL. Titul gebracht.
Hamburg, bey Kühg und Richter, 1734.

> *An Attempt through Observing the Properties, Distribution and Movement of Water, to Encourage Human Beings to Love and Admire the Benevolence of the Powerful Creator,*
>
> *There is none which does not give us reasons to wonder at the magnitude of the works of the Lord… But nothing else might move us more in this way than the combined consideration of all the properties of water… and of its beneficial relation to the other creatures.*

Topics included

> *The wise and liberal dispensation of water in the world, the rivers, lakes, ponds, the water underground and the human exploitation thereof.*
>
> *The movement of water in the air, in the sea and in rivers and its use in cooking, boiling, distillation and perspiration.*
>
> *How the different physical properties of water combine in a senseful way in order to form a hydrological cycle...*
>
> *The benefit we draw from this evaporation of the waters, the uninterrupted circulation it maintains with the aim of nourishing the creatures, keeping them alive and rendering them fertile, offers us sensible proof of the wise power of the Creator.*

As to the depth of such reflections, Mikls Vassnyi puts it kindly in Anima Mundi, the Rise of the World Soul Theory in Modern German Philosophy (2011): Fabricius "belongs among the intellectually less demanding philosophers of the physico-theological tradition."

Fabricius was one to hedge his bets, however, concerning where to find proof of God. He was also the translator of Derham's Astrotheology (1728) and the author of Pyrotheologie (1732).

Friedrich Christian Lesser was a pastor with a prolific physico-theologic pen, his works including,

Lithotheologie (1735), "A Natural History and Spiritual Consideration of Stones." which included a section "Aerotheologie," by Fabricius.

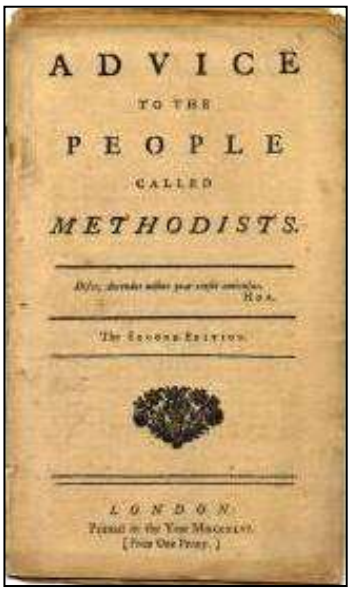
Insecto-Theologie (1738), and

Testaceotheologie (1756), having to do with shells.

Pharmacotheology was another spinoff, in which physician Friedrich Hoffmann used natural theology to justify the therapeutic use of herbs.

Astro- Pyro- , Litho-, Aero-, Insecto- and Pharmaco-. As a body of thought, hydrotheology enjoyed good company.

John Wesley, the evangelist known for his advocacy of Methodism, also applied his prodigious preaching skill to the subject of earth science. Based on the Almighty finding the earth and all created things "very good," Wesley declared in a 1750 sermon that no one can deny that "sin is the moral cause of earthquakes, whatever their natural cause may be."


ADVICE
TO THE
PEOPLE
CALLED
METHODISTS.
LONDON

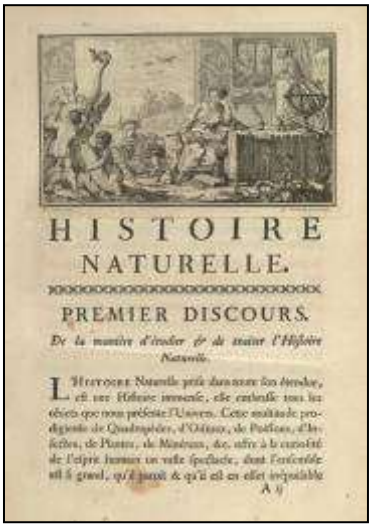
Regarding the provision of water on the land, Wesley's attributed the larger role to evaporation.

> *That the vapor rising from the sea, are more than sufficient to supply both the surface of the earth, and the rivers with water.*
>
> *That the mountains, by their particular structure, arrest the vapors that float in the atmosphere, and having collected them in their reservoirs, dismiss them again through their sides, either in perpetual or intermitting currents.*

But, cognizant of Ecclesiastes, Wesley's A Survey of the Wisdom or God in Creation *(*1763) added,

> *And yet we need not deny, that some springs may arise from the sea, or the great abyss, those in particular, which at all times afford the same quantity of water.*

Once again, the ancient tale.

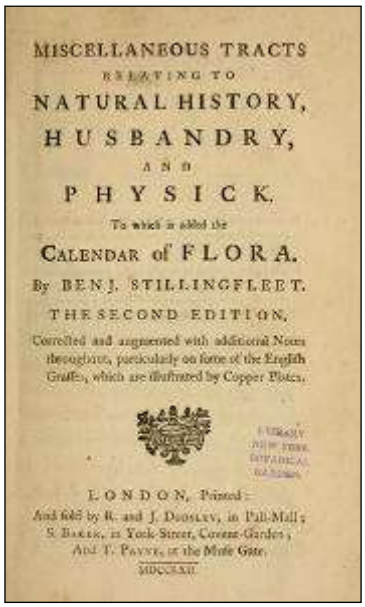

HISTOIRE
NATURELLE.
PREMIER DISCOURS.

George Louis Lecrec Buffon, a Catholic, translated Newton's Principia into French and directed what was to become Paris' Museum of Natural History. In Theorie de la Terre, the first volume of Histoire Naturelle (1749), Buffon assumed not a geo-central fire, but rather subterranean fire-hearths directly linked to volcanoes and earthquakes, the Kircher graphic of Chapter 9.

Buffon argued that the earth was impermeable at a depth beyond four feet where rainwater stagnates until flowing out as springs. "Each river is a large lake that stretches out far underground." is not far from sounding like an alluvial aquifer, but in this case, he appears to have meant a literal lake.

Nature's service to mankind is proof of God's wisdom. That underground rivers -- having never been actually observed -- did not technically qualify as "phenomena" wasn't of concern on Sunday.

Attributed to Swedish taxonomist Karl Linné (Linnaeus), but actually the thesis of his student, Isaac Biberg, "The Oeconomy of Nature" (1749) published in Miscellaneous Tracts Relating to Natural History, Husbandry, and Physick (1762) by Benjamin Stillingfleet, contains a picture of the hydrologic cycle.


MISCELLANEOUS TRACTS
RELATING TO
NATURAL HISTORY,
HUSBANDRY,
AND
PHYSICK.
To which is added the
CALENDAR of FLORA.
By BENJ. STILLINGFLEET.
THE SECOND EDITION,
Corrected and augmented with additional Notes throughout, particularly on some of the English Grasses, which are illustrated by Copper Plates.
LONDON, Printed:
And sold by R. and J. Dodsley, in Pall-Mall; S. Baker, in York-Street, Covent-Garden; And T. Payne, at the Mews Gate.
MDCCLXII.

The clouds collected from exhalations, chiefly from the sea, but likewise from other waters, and moist grounds, and condensed in the lower regions of the atmosphere, supply the earth with rain; but since they are attracted by the mountainous parts of the earth, it necessarily follows that those parts must have, as is fit, a larger share of water than the rest. Springs, which generally rush out at the foot of mountains, take their rise from this very rain water, and vapors condensed, that trickle through the holes, and interstices of loose bodies, and are received into caverns.

This afford a pure water purged by straining, which rarely dry up in summer, or freeze in winter, so that animals never want a wholesome and refreshing liquor.

The chief sources of rivers are fountains, and rills growing by gradual supplies into still larger and larger streams, till at last, after the conflux of a vast number of them, they find no stop, but falling into the sea with lessened rapidity, they there deposit the united stores they have gathered, along with foreign matter, and such earthy substances, as they soar off in their way. Thus the water returns in a circle, whence it first drew its origin that it may act over the same scene again.

As a scientist, Linnaeus had no intention of expounding upon the supremacy of Divine Providence, but those so inclined were more than pleased with Linnaeus' thesis of natural order.

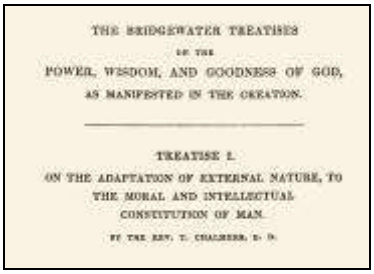
Hydrologic evidence of God's being was still touted into the mid-19th century, as evidenced in Thomas Dick's The Christian Philosopher, or the Connection of Science with Religion (1842).

The all-wise Creator has impressed upon its various masses a circulating motion... The rills pour their liquid stores into the rivers; the rivers roll their watery treasures into the ocean. By the solar heat, a portion of these oceanic waters is carried up into the atmosphere, till at last it descends in rain and dew, to supply the springs... so that there is a constant motion and circulation of the watery element, that it may serve as an agent for carrying forward the various processes of nature, and for ministering to the wants of man and beast.

The Bridgewater Treatises on the Power, Wisdom and Goodness of God as Manifested in the Creation (1834-40) derive from the bequest of the Rev. Francis Henry Egerton, eighth Earl of Bridgewater, who died in 1829, leaving £8,000 for the Royal Society of London to commission eminent scientists and philosophers to write, print, and publish 1,000 copies of a work

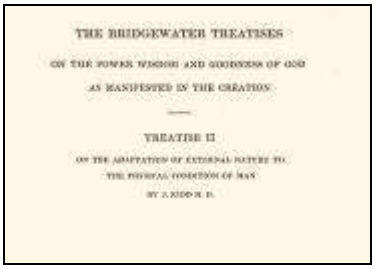
On the Power, Wisdom and Goodness of God as manifested in the Creation illustrating such work by all reasonable arguments as, for instance, the variety and formation of God's creatures, in the animal, vegetable and mineral kingdoms; the effect of digestion and thereby of conversion; the construction of the hand of man and an infinite variety of other arguments; as also by discoveries ancient and modern in arts, sciences, and the whole extent of modern literature

The Royal Society determined that the money should be assigned to eight authorities for as many distinct treatises.


THE BRIDGEWATER TREATISES
ON THE
POWER, WISDOM, AND GOODNESS OF GOD,
AS MANIFESTED IN THE CREATION.

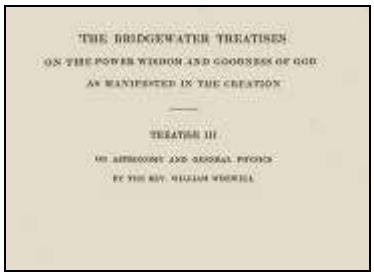
TREATISE I.
ON THE ADAPTATION OF EXTERNAL NATURE, TO
THE MORAL AND INTELLECTUAL
CONSTITUTION OF MAN.

I. On the Adaptation of External Nature to the Moral and Intellectual Constitution of Man (1833) by Thomas Chalmers


THE BRIDGEWATER TREATISES
ON THE POWER WISDOM AND GOODNESS OF GOD
AS MANIFESTED IN THE CREATION

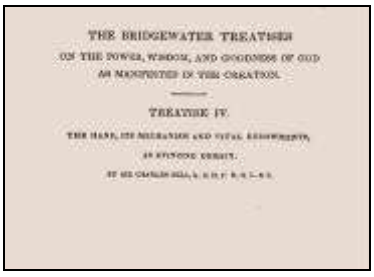
TREATISE II

II. On the Adaptation of External Nature to the Physical Condition of Man (1837) by J. Kidd


THE BRIDGEWATER TREATISES
ON THE POWER WISDOM AND GOODNESS OF GOD
AS MANIFESTED IN THE CREATION

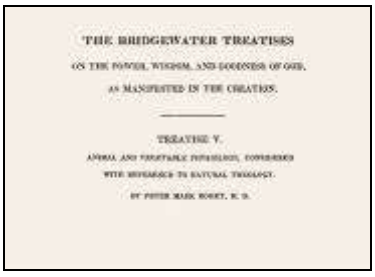
TREATISE III

III. Astronomy and General Physics 1839) by William Whewell


THE BRIDGEWATER TREATISES
ON THE POWER, WISDOM, AND GOODNESS OF GOD
AS MANIFESTED IN THE CREATION.

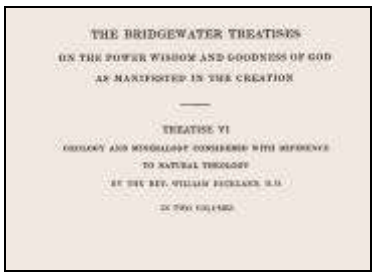
TREATISE IV.

IV. The Hand, its Mechanism and Vital Endowments as Evincing Design (1837) by Charles Bell


THE BRIDGEWATER TREATISES
ON THE POWER, WISDOM, AND GOODNESS OF GOD,
AS MANIFESTED IN THE CREATION.

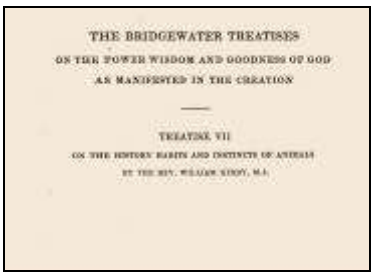
TREATISE V.

V. Animal and Vegetable Physiology Considered with Reference to Natural Theology (1840) by Peter Roget


THE BRIDGEWATER TREATISES
ON THE POWER WISDOM AND GOODNESS OF GOD
AS MANIFESTED IN THE CREATION

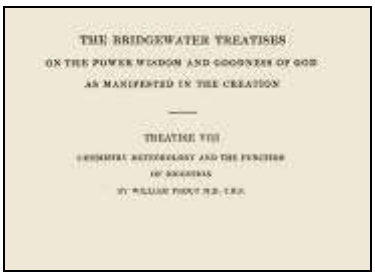
TREATISE VI

VI. Geology and Mineralogy Considered with Reference to Natural Theology (1837) by William Buckland


THE BRIDGEWATER TREATISES
ON THE POWER WISDOM AND GOODNESS OF GOD
AS MANIFESTED IN THE CREATION

TREATISE VII

VII. History, Habits and Instincts of Animals (1835) by William Kirby


THE BRIDGEWATER TREATISES
ON THE POWER WISDOM AND GOODNESS OF GOD
AS MANIFESTED IN THE CREATION

TREATISE VIII

VIII. Chemistry, Meteorology, and the Function of Digestion (1834) by William Prout

The treatises were unequal merit, but even the best haven't withstood the test to time, partly because of scientific advancement, but more due to the authors' wholesale abandonment of objectivity.

We'll quote from just two, one ill-conceived and the other, fairly even-handed, given the work's commission.

From History, Habits, and Instincts of Animals,

> *The word of God, in many places, speaks of an abyss of waters under the earth, as distinct from the ocean though in communication with it, and also as contributing to form springs and rivers.*

> *Scientific men, in the present day, appear disposed to question this; the Geologist, though he may regard the granitic strata as forming the base, as it were, of the crust of the earth, seems rather to view it as containing a focus of heat, than a magazine of infinite waters; from whence are partly derived the springs and rivers that water the earth's surface, and ultimately make good to the ocean its whole loss by evaporation.*
>
> *"Springs," says the author above quoted* [Conrad Malte-Brun, coauthor of Geographie Mathematique (1803-12)] *"are so many little reservoirs, which receive their waters from the neighboring ground, through small lateral channels." He allows, however, that the origin of springs cannot be referred to one exclusive cause, and associates with that just mentioned, the precipitation of atmospheric vapors attracted by high lands, the dissolving of ice, the filtering of sea-waters, and the explosion of subterraneous vapors. He makes no direct mention of a storehouse of waters in the bosom of the earth as in any case the source of springs and rivers, but allows that*
>
> > *"The phenomena of capillary tubes may obtain in its interior. The sea-waters, deprived of their salt and bitter elements, may ascend through the imperceptible pores of several rocks, from which, being disengaged by the heat, they will form those subterraneous vapors to which many springs owe their origin."*
>
> *A very slight alteration of this passage would make it harmonize with the Scripture account of the matter...*

By the time of this writing, subterranean vapors -- and we're just flagging one assertion -- had been eliminated from the hydrologic cycle and were not a fact to rephrase as Holy Word.

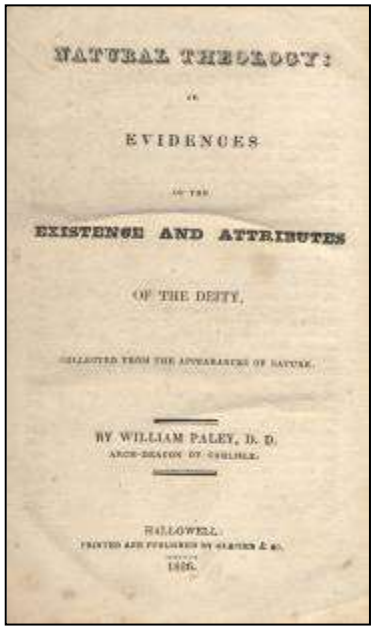
Astronomy and General Physics more successfully stayed with science. The author understood the hydrologic cycle as a quantitative process, and while resorting to "blood of the veins" wording (an ancient theory we covered in the latter part of Chapter 8), he did so as analogy, not justification.

> *Another office of water which it discharges by means of its relations to heat is that of supplying our springs. There can be no doubt that the old hypotheses which represent springs as drawing their supplies from large subterranean reservoirs of water, or from the sea by a process of subterraneous filtration, are erroneous and untenable. The quantity of evaporation from water and from wet ground is found to be amply sufficient to supply the requisite drain. Mr. Dalton calculated that the quantity of rain which falls in England is thirty-six inches a year.*
>
> *Of this he reckoned that thirteen inches flow off to the sea by the rivers, and that the remaining twenty- three inches are raised again from the ground by evaporation. The thirteen inches of water are of course supplied by evaporation from the sea, and are carried back to the land through the atmosphere. Vapor is perpetually rising from the ocean, and is condensed in the hills and high lands, and through their pores and crevices descends, till it is deflected, collected, and conducted out to the bay, by some stratum or channel which is watertight.*
>
> *The condensation which takes place in the higher parts of the country may easily be recognized in the mists and rains which are the frequent occupants of such regions. The coldness of the atmosphere and other causes precipitate the moisture in clouds and showers, and in the former as well as in the latter shape, it is condensed and absorbed by the cool ground. Thus a perpetual and compound circulation of the waters is kept up..., the water ascending perpetually by a thousand currents through the air, and descending by the gradually converging branches of the rivers, till it is again returned into the great reservoir of the ocean.*

As the work needed to spiritually agree with the late of Earl of Bridgewater, however, it goes on to celebrate the evidence of higher guidance.

> *It is maintained by machinery very different, indeed, from that of the human system, but apparently as well, and, therefore, we may say as clearly, as that, adapted to its purposes.*

While Archbishop William Paley offered no particular insight regarding underground waters, we mustn't skip his Natural Theology, or Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature (1802) in which he introduced the famous metaphor of the watchmaker.


NATURAL THEOLOGY:

OR

EVIDENCES

OF THE

EXISTENCE AND ATTRIBUTES

OF THE DEITY,

COLLECTED FROM THE APPEARANCES OF NATURE.

BY WILLIAM PALEY, D. D.

HALLOWELL.

1806.

> *When we come to inspect the watch, we perceive... that its several parts are framed and put together for a purpose, e.g., that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day; that if the different parts had been differently shaped from what they are, or placed after any other manner or in any other order than that in which they are placed, either no motion at all would have been carried on in the machine, or none which would have answered the use that is now served by it... the inference we think is inevitable, that the watch must have had a maker -- that there must have existed, at some time and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer, who comprehended its construction and designed its use.*

If God has taken such care in winding the machine of nature, how much more must He care for us wretched sinners!

Paley's watchmaker analogy faded in the subsequent centuries until John Archibald Wheeler, colleague of Albert Einstein and coiner the term "black hole," re-popularized the thesis in his forward to The Anthropic Cosmological Principle (1986), by John Barrow and Frank Tipler. What's come to be known as "Intelligent Design" argues that a "life-giving factor lies at the center of the whole machinery and design of the world."

Alliance between God and the hydrologic cycle has proven itself to be a persistent assertion.

CHAPTER 14
FOUNTAINS OF THE NILE

> *Seeing the nature and origin of this hidden source deserves to be as much enquired into as that of the Nile did formerly, let us pass through these subterraneous waters with the sails of our reason.*
>
> Bernardino Ramazzini, De Fontium Mutinensium (1691)

> *The Nile does not receive a single visible affluent; nevertheless, it must necessarily be replenished by several underground tributaries, for its liquid mass is much more considerable in Egypt than in Nubia.*
>
> Elisee Reclus, The Earth: A Descriptive History of the Phenomena of the Life of the Globe (1871)

We've worked our way through a few thousand years of changing perception regarding underground rivers. This chapter will be structured somewhat differently, holding itself to one particular question, the mystery of the Nile. We'll revisit thinkers and explorers from previous chapters and acquaint ourselves with others.

Where does the River Nile begin? There have been many explanations.

The first involves the whims of gods of the underworld, how nature has often been first conceived.

The second is through the eyes of the Jews. The Nile is the River Gihon, said to emerge from the Paradise.

Then follows the correct explanation, though steeped in controversy until remarkably recently. The greater Nile begins as the White Nile from as lakes of Uganda. While the hydrology is essentially on the surface, subterranean aspects have long been perceived.

The next asserts the Blue Nile of modern Ethiopia to be the source, a theory that persisted remarkably long. As with the White Nile, Blue Nile streamflow generally falls within the domain of surface hydrology, but expectation of "fountains" biased early perception.

The fifth looks to the west for a trans-African waterway, perhaps having a subterranean component where desert intervenes.

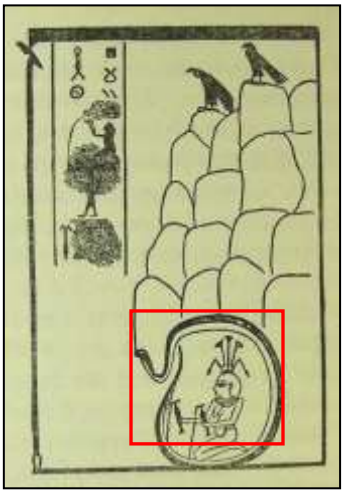
The final thoughts span a spectrum of far-flung conduits mentioned by imaginative geographers.

We'll focus on suppositions involving subterranean waters.

Egyptian Gods

It is not believed that the prehistoric civilization of the Nile delta ventured above the river's first great cataract, but they would have heard of the remarkable countercurrents in which a boatman could drift 100 kilometers further upstream. From such tales came belief that two Niles rose at the cataract, one flowing north, the other, south.

Mythology conceived the Nile as a great circle, an invisible southward subterranean river surfacing at two caverns in the cataract, from where it flows northward.



To the right, after a relief showing the Nile god Hapi, surrounded by a protective serpent, pouring the Nile waters from two bases hidden beneath the rocks. A vulture and a hawk perch on a rocky overhang.

A hieroglyphic inscription still on a rock near the first cataract,

> *The wonderful island Elephantine. On it was built the first city that was ever known in the world, and out of it rises the Sun. Within the island is a great cavern, which is in two parts, each shaped like the breast of a woman, and inside this cavern is the source of the Nile.*

The two branches of the Nile were also said to rise into the upper world as fountains springing from vases held by the underworld god Osiris, tale yet recounted a millennia later in "Noah and his Family," The Monist, April 1919, by W. Max Muller and M. Milman,

> *Osiris, the Lord of Eternity, who once floated about in his miraculous chest and now sits on his throne at the source of the Nile and of all waters.*

In another version, the king goes at death to dwell in the refrigerium at the first cataract, where he is purified by Khnum and Satis (pictured to the right), gods of Elephantine, who each hold a vase from which spring the two Niles.

Whether the bearers are Hopi, Osiris, Khnum or Satis, there are generally two vases issuing into the upper world.

Astrology also provided a framework for mythology. The Egyptians associated the river's flooding at Memphis with the brightest star in the night sky, Sirius, the Star of Isis. As from 3000 to 1000 BC, the rising of this star at sunrise coincided with the flood season, the star was thought to draw up the waters/

The Roman poet Lucan ((39-65) summarized the astrological explanation in Pharsalia.

> *Some there are who think that there are channels in the earth and vast inlets in the hollow structure. This way through secret courses does the water glide from the interior, attracted to the mid region of the earth from the arctic colds, when Phoebus* [Apollo] *presses upon Meroe* [Kush] *and the scorched earth thither draws the waters. Both Ganges and Padus* [Po] *are drawn through the secret regions of the world. Then is Nile, discharging all the rivers from one source, unable to give them vent at a single mouth.*

As the role of the pyramids in such mysteries is known to a select few, we'll include an update on that aspect in Chapter 63, Cargo Conveyance.

With the honing of philosophical thought, however, attribution of physical nature to supernatural vagrancies became intellectually less satisfying.

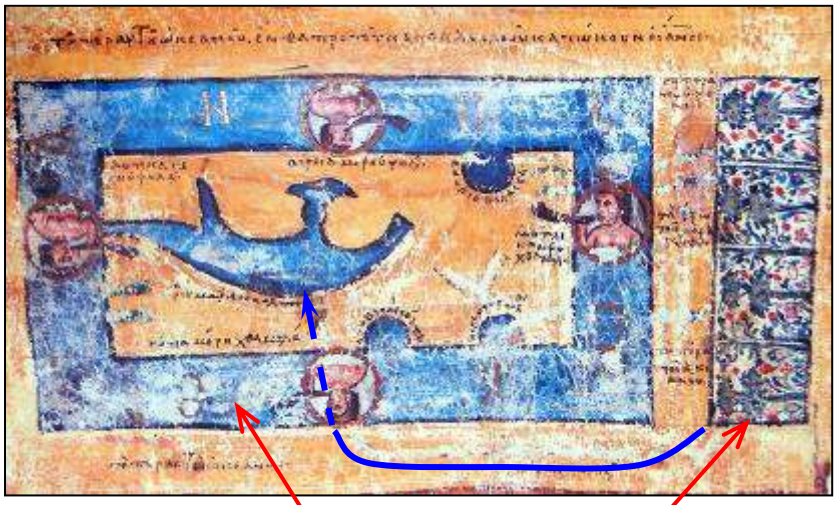
Judeo-Christian Lore

As we noted in Chapter 4, Genesis 2 speaks of the Edenic River Gihon. Ezekiel, Isaiah, Joshua and Jeremiah mention the Nile by name, but nowhere do scriptures equate the two. Hebrew association of the Nile with the Gihon, however, was noted by Flavius Josephus in The Antiquities of the Jews (c. 93 AD).

> *Gihon runs through Egypt, and denotes what arises from the east, which the Greeks call Nile.*

Early Christians accepted lore of a primal underground Gihon, as evidenced by Cosmas (Chapter 4) who believed the world to be shaped like a tabernacle with a central landmass is surrounded by an un-navigable Oceanus which, in turn, is surrounded the Paradise of Adam.

From the eastern portion Paradise flow the four sacred rivers under Oceanus to the present world.



Gautier de Metz's L'Image du Monde (c. 1246), a work based on Imago Mundi by Honorius of Autun (d. 1151) surfaced the Nile headwaters in distant Asia, then bringing the river westward.

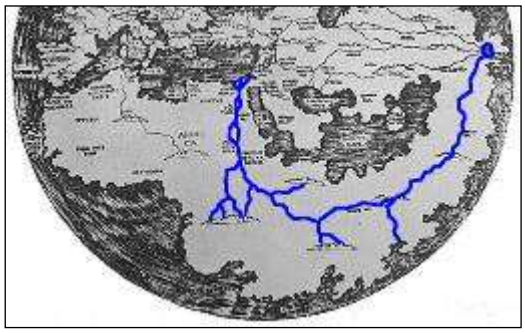
> *The second of the four floods is named Gihon or Nylus, which entreth into the earth by a pool, and runneth under the earth.*

Metz embellishes, however, as Genesis makes no mention of "under the earth,"

> *And the name of the second river is Gihon: the same is it that compasseth the whole land of Ethiopia.*

"Ethiopia," we should note, was generally applied by the Greeks to designate the south of Africa, the region inhabited by Blacks.

To the right, an anonymous 15th-century map showing the Nile rising in distant Asia, then flowing to Africa. The three other Rivers of Life can be seen likewise directed to the ancient world.



From A New Commentary on Genesis (1888) by Franz Delitzsch,

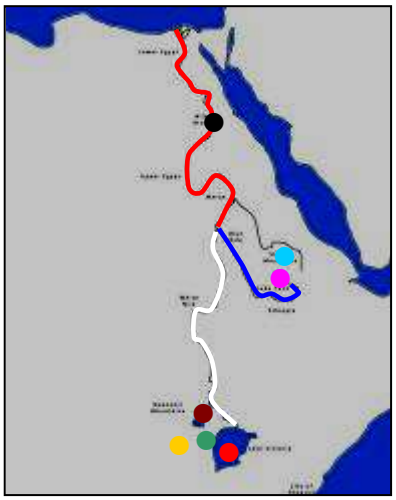
> *The Nile was regarded as the Araxes, flowing* [from Paradise] *on subterraneously and reappearing in Egypt... According to the ancient view, the Nile comes from Asia into Africa, the Persian Gulf and the Red Sea being considered inland seas. Inspiration does not in things natural raise its subject above the state of contemporary information.*

As we will shortly see, however, as mapping dispensed with such a land bridge, the source of the mighty river must be closer to home.

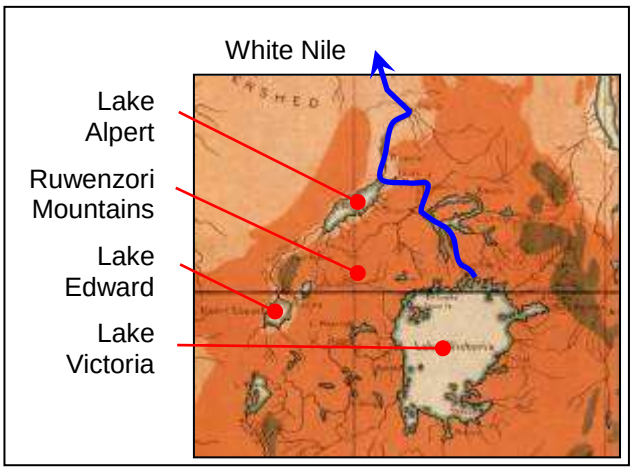
The White Nile

- First Cataract
- Lake Victoria
- Lake Albert
- Lake Edward
- Ruwenzori Mountains, "Mountains of the Moon"
- Lake Tana
- Simien Mountains
- Nile
- Blue Nile
- White Nile

The White Nile flows from Lake Victoria in modern Uganda and then courses through Lake Albert on its northward journey.



"The Mountains of the Moon,"
Illustrated London News, February 1 1890



First identified by Stanley in the 1880s, the snow-capped Ruwenzoris are Ptolemy's "Mountains of the Moon," one of the most enduring apocryphal elements in the history of cartography.

A lake nearly as large as Lake Victoria once covered the basin's marshy plain further north. In ages past it may still have been vast enough to suggest to Egyptians a sea opening to the Indian Ocean. The mountains, vaguely visible from its banks, would have been the Ruwenzoris.

The Nile's origin was of great interest to Herodotus (c. 484-425 BC). From his Histories,

> *With regard to the sources of the Nile, I have found no one among all those with whom I have conversed, whether Egyptians, Libyans, or Greeks, who professed to have any knowledge, except a single person. He was the scribe who kept the register of the sacred treasures of Minerva in the city of Sais, and he did not seem to me to be in earnest when he said that he knew them perfectly well. His story was as follows:*
>
> > *"Between Syene, a city of the Thebais, and Elephantine, there are two hills with sharp conical tops; the name of the one is Crophi, of the other, Mophi. Midway between them are the fountains of the Nile, fountains which it is impossible to fathom. Half the water runs northward into Egypt, half to the south towards Ethiopia."*
>
> *The fountains were known to be unfathomable, he declared, because Psammetichus, an Egyptian king, had made trial of them. He had caused a rope to be made, many thousand fathoms in length, and had sounded the fountain with it, but could find no bottom.*

Herodotus' "τοῦ Νείλου πηγέων" translates more appropriately as "sources of the Nile," not an artesian feature. "Fountains" however, are what later Europeans came to envision.

Herodotus noted that the ancients also believed that the Nile derives from two great mountains in southern Ethiopia having eternal springs which lessen in winter by the attraction of the sun. Unlike mythological explanations, this one has physical basis. The Father of History spurned this belief, however, based upon his observation that in traveling towards the equator, the climate becomes hotter. How could snow fall in such a place?

Ephorus (c. 400-330 BC) thought that there were deep springs in the Nile's bed which gushed forth with great force in summer.

The Romans were curious regarding the Nile's source, per the words of Lucan.

> *Cesar's desire to know our Nilus' spring*
> *Possessed the Egyptian, Persian, Grecian king.*
>
> *No age but strived to future time to teach*
> *This skill: none yet his hidden nature reach.*

Philip's great son, Memphis' most honored king,
Sent to earth's utmost bounds, to find Nile's spring,

The first recorded expedition up the White Nile was undertaken by two Roman centurions, but they failed to penetrate the great swamps.

Pausanias (110-180) informs us in Description of Greece,

> *Those Greeks or Egyptians who have gone up into Ethiopia beyond Syene as far as the Ethiopian city of Meroe all say that the Nile enters a lake, and passes through it as though it were dry land, and that after this it flows through lower Ethiopia into Egypt.*

Pliny (23-79) loosely quotes from Plato's Timaeus (c. 360 BC),

> *The source of the river is known by the name of Phiala, and that the stream buries itself in channels underground, where it sends forth vapors generated by the heat among the steaming rocks amid which it conceals itself; but that, during the days of the inundation, in consequence of the sun approaching nearer to the earth, the waters are drawn forth by the influence of his heat, and on being thus exposed to the air, overflow; after which, in order that it may not be utterly dried up, the stream hides itself once more.*

"The stream buries itself in channels underground" implies downward direction, however, at variance with Timaeus, viz,

> *The Nile, who is our never-failing savior, delivers and preserves us. Whereas in this land, neither then nor at any other time, does the water come down from above on the fields, having always a tendency to come up from below; for which reason the traditions preserved here are the most ancient.*

As Pliny, not Plato, would become the geographic authority for centuries thereafter, the former's "buries itself" would become entrenched in European thought.

Marinus of Tyre recorded that the Greek trader Diogenes traveled from today's Tanzanian coast for 25 days in about 50 AD, encountering two great lakes and a snowy range of mountains.

Influenced by Marinus, Claudius Ptolemy's second-century Geographia showed the "Mountains of the Moon." Although Ptolemy's original maps are lost, mediaeval copies came to be the unchallenged representation through the 16th century, their identifying characteristic being side-by-side headwater lakes, and to the south, Mountains. Below are several renditions.

c. 1320

1482

1489

c. 1535

1554

1578

We repeat Kircher's Mundus Subterraneus (1665) graphic of the African hydrophylacium.

The principal hydrophylacium of Africa, located in the Mountains of the Moon, lakes and rivers flowing strong at the newly discovered origin of the Nile.

The truth, however, is less dramatic.

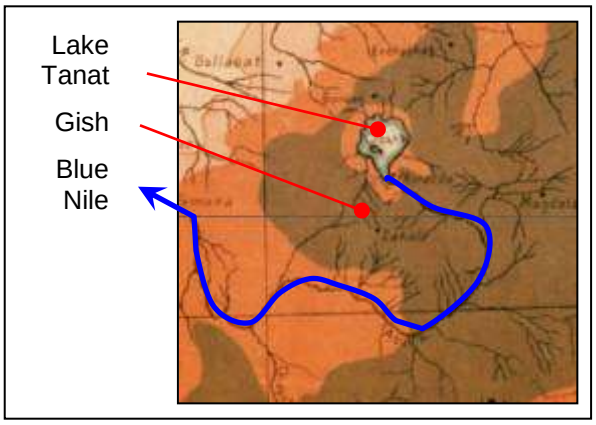
The Nile's longest pathway bubbles from Rwanda's Nyungwe Forest and flows from there to Lake Victoria

Tradition, however, maintains that the river arises from upwellings along the lake's bank.

The Blue Nile

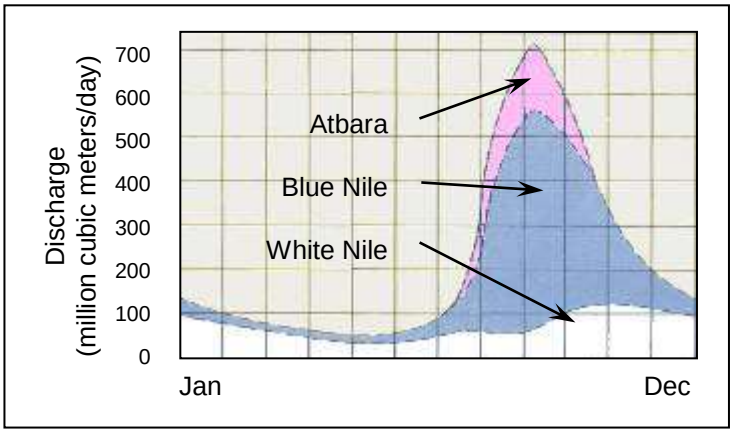
The Blue Nile flows from Ethiopia's Lake Tana, and joins the White at Khartoum

Mt. Gish lies within the Blue Nile's clockwise loop, 110 kilometers below Late Tana.



The hydrograph indicates the contribution of the Nile's three major tributaries, the Ethiopian River Atbara being below the confluence of the Blue and White.

As the Blue Nile constitutes the majority of the flood peak, it is understandable that Egyptians took it to be the defining tributary.



The 12th-century Beatus world map showing the White and Blue Niles crossing. Our journey is awash with "subterranean rivers." Chapter 76 deals with "submarine rivers." Here we have a "subriverine river."

A Short Relation of the River Nile, of Its Source and Current (1669) by Jeronimo Lobo, who passed through East Africa in 1629, describes what the author took to be the Nile's headwaters

> *In this territory of Toncua is the known head and source of the River Nile, by the natives called Abani (i.e.) the Father of Waters... The head rises in the most pleasant recess of the territory, having two springs, called Eyes, each about the bigness of a coach wheel, distant twenty paces.… These two springs rise in a little field covered over with green and thick wood... This plain is on the top of a high mountain, overlooking many spacious valleys and from this height insensibly descends... At little more than three days journey from the Head, the river is large, deep enough for vessels to sail in.*

In looking for twin Ptolemaic waterbodies in the hills, Lobo found them, albeit smaller than anticipated. He wouldn't be the first to be confused.

Kircher's Mundus Subterraneus includes an account from the journal of Pedro Paez, who likewise visited the site.

> *On the 21st of April, in the year 1618...I discovered first two round fountains, each about four palms in diameter, and saw, with the greatest delight, what neither Cyrus king of the Persians, nor Cambyses, nor Alexander the Great, nor the famous Julius Caesar, could ever discover. The two openings of these fountains have no issue in the plain on the top of the mountain, but flow from the root of it. The second fountain lies about a stone-cast west from the first: the inhabitants say that this whole mountain is full of water, and add, that the whole plain about the fountain is floating and unsteady, a certain mark that there is water concealed under it; for which reason, the water does not overflow at the fountain, but forces itself with great violence out at the foot of the mountain.*

Kircher's forte, for better or worse, was that of stitching together, leading him to issue Paez' "fountains) from Ptolemy's Mountains of the Moon

In 1690, Vincenzo Coronelli was the first to identify the significance of Lake Tana and the clockwise unfolding of the Blue Nile.

"The source of the Nile, known as Ouembroma, Eyes of the Nile."

To the right, Nicolas de Fer's 1705 map showing "les yeux du Nil" (the eyes of the Nile) based on Paez.

To the left, "Source of the Nile," Description de l' Univers (1719) by Alain Mallet.

Exploring the region of Lake Tana in 1770, James Bruce came upon the Springs of Gish, inauspicious headwaters of the River Abay -- locally the "Felege Ghion," identifying with the Gihon of Exodus -- which flows into the lake.

From Bruce's Travels to Discover the Source of the Nile (1790),

> *The fountains of the Nile are three... All the three may be observed to spring, but so imperceptibly that it can scarcely be discerned by great attention, and it is false what is said by some that they spring with a noise out of the ground, rising above it.*

The three fountains are portrayed on the volume's cover.

The false claim in Latin,

> *It had not happened that another had seen the source*.

"Mr. Bruce at the Fountains of the Nile" (1802)

Bruce's Map 1790

Bruce's description of the sub-lacustrine pathway,

> *In April... the Nile... forces itself through the stagnant lake without mixing with it. In the beginning of May, hundreds off streams pour themselves... into the Lake Tana, which had become low by intense evaporation, but now begins to fill insensibly, and contributes a large quantity of water to the Nile, before it falls down the cataract.*

This brings to mind an earlier quote from Pausanias, "The Nile enters a lake, and passes through it as though it were dry land."

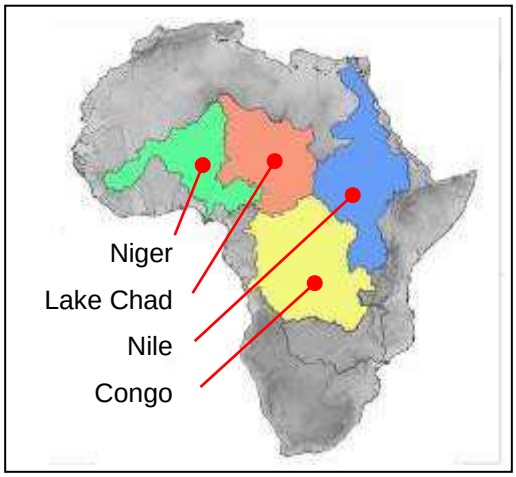
The inhabitants say that this whole mountain is full of water, and add, that the whole plain about the fountain is floating and unsteady, a certain mark that there is water concealed under it; for which reason, the water does not overflow at the fountain, but forces itself with great violence out at the foot of the mountain.

One must wonder if this was what the inhabitants actually said, as the hollow-hill seems strikingly similar to what Bruce would have read from Kircher.

The West African Connection

Between the Nile and Niger basins, the intervening Chad Basin is terminal, meaning that its waters infiltrate or evapotranspirate.

Before the 19th century, speculation ran rampant regarding which river mouth connected to fabled reaches deep within the foreboding continent. While the Nile's south-to-north gradient was long known, there was scant agreement regarding the paths of the immense waterways to the west. Perhaps waters within what we know today to be the Niger, Chad and Congo basins were portions of a trans-African waterway.



A tale told to Herodotus,

Five young men were chosen to explore the deserts of Libya. They reached a district full of wild beasts, and continuing their route towards the west for a considerable time, through very sandy country, they reached a plain where there were trees. Having approached them, they ate some of the fruits of these trees, and while they were so engaged, a body of men, whose stature was beneath the middle size, fell upon them and carried them off by force. They conducted them through many districts, and having traversed these, they arrived at a city, all of the inhabitants of which were black and of the same size as those who had conducted them thither. A great river, in which there were crocodiles, ran through this city from west to east. With regard to this river, Etearchus conjectured that it was the Nile, and this seems reasonable, for the Nile comes from Libya and intersects it through the middle.

The river which Etearchus took to be the Nile was likely the Niger, the two rivers likewise equated in Arabica by King Juba II of Numidia (c. 51 BC-23 AD), a work well known in Rome.

Herodotus didn't personally believe that the crocodile-infested river was the Nile, however, as he also notes,

It is certain that the Nile comes from the west, but nothing certain can be ascertained of what is beyond the country of the Automoles [subjects of the Ethiopian king], four months journey by land and water from Elephantine.]

A trans-African Nile river was now in the books. And even better, within a saga of young adventures taken captive by dwarfs to a crocodilian land. It's a tale worth retelling, and as we'll come to appreciate, re-told fancy often trumps dreary fact.

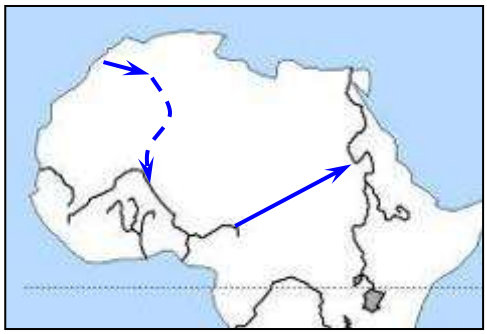
The 1907 Atlas of Ancient and Classical Geography's rendition of how Herodotus would have envisioned Africa.

Mela described a River Nuchul "on the far side of the desert in Ethiopia" in De Situ Orbis Libri III (c. 43), conjecturing that it may flow as a trans-African waterway

> *While all others direct their course toward the ocean, this one flows towards the east, and the center of the continent, and whither it goes is quite uncertain.*

Pliny drew upon Juba's Arabica and interviewed Suetonius Paulinus who had crossed the Western Atlas and desert, arriving at a great river which Pliny deemed to be the Nile, the water diving underground whenever a tract of sand presented itself and bursting upward in fertile land.

> *The sources of the Nile are unascertained, and, travelling as it does for an immense distance through deserts and burning sands, it is only known to us by common report.... It rises, so far indeed as King Juba was enabled to ascertain, in a mountain of Lower Mauritania, not far from the ocean; immediately after which it forms a lake of standing water, which bears the name of Nilides. Pouring forth from this lake, the river disdains to flow through arid and sandy deserts, and for a distance of several days' journey conceals itself; after which it bursts forth at another lake of greater magnitude in the country of the Massaesy.*
>
> *It then buries itself once again in the sands of the desert, and remains concealed for a distance of twenty days' journey, till it has reached the confines of Ethiopia. Here, when it has once more become sensible of the presence of man, it again emerges, at the same source, in all probability, to which writers have given the name of Niger, or Black.*
>
> *After this, forming the boundary-line between Africa and Ethiopia, its banks... it travels through the middle of Ethiopia, under the name of Astapus* [the Atbara, the Nile's most northern tributary]*, a word which signifies, in the language of the nations who dwell in those regions, "water issuing from the shades below."*



The Land of Shades was said to be located at the border of our world and home to dwarfs, monsters and spirits. Beyond this lay a sea sprinkled with mysterious islands and enchanted archipelagoes inhabited by serpents with human voices, sometimes friendly and sometimes cruel to the shipwrecked. He who ventured forth from the islands could never return. The parallels to Greek sagas are inescapable.

Nearly two millennia after Herodotus, John Mandeville's Travels (c. 1360) would describe the subterranean desert route.

> *Nile of Gyon. It rises out of the earth a little way from Mount Atlant* [Atlas]. *Not far from there it sinks down again into the earth and runs underground until it comes to the shore of the Red Sea, and there it rises again out of the earth and runs all round Ethiopia, and so through Egypt until it comes to Alexandria.*

As continued Northern African exploration revealed nothing of this western Nile, however, its perceived location drifted southward, jungle impenetrable to man (Europeans, that is), but freely penetrable to water. Logical need for the flow to dive beneath the surface went away.

Left, The map after Beatus (1060) showing a great inland lake, most likely Victoria, and to its left, a latitudinal river terminated by lakes at either end, a representation of a waterway that would persist in maps for centuries.

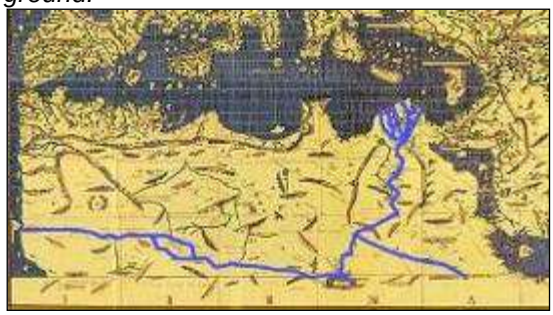
Right, A 1644 map including an Atlas-to-Nile tributary based upon Pliny**.**

As we observed regarding the River Styx, a river's name can migrate further than the channel meanders, and this adds another uncertainty, as with time, more than one river would be called the Nile. Berber explorer Ibn Batuta, for example, called middle course of the Niger "the Nile of the Negroes." in 1330.

Belief in a subterranean tributary to the Nile flowed persisted into the 16th century. A Report of the Kingdom of Congo (1591) by Felipe Pigafetta discusses observations of Duarte Lopes from 1578 to 1587.

> *Some in those countries think that the Nile issuing from the first lake flows underground and then reappears. Others deny this, but Lopez asserts as a reliable fact that the Nile does not flow underground, but running through desert and lonely valleys without inhabitants, and having no settled channel, is therefore said to flow underground.*

Al Idrisi (1099-1165), who lived in Sicily, proposed in Opus Geographicum that the fountains of the Mountain of the Moon form two lakes, which feed another large lake. From this lake issues two rivers - the Nile of Egypt flowing north, and that of the Negroes flowing west.



Al-Idrisi's Tabula Rogeriana (1154)

The early Egyptians believed that the Nile communicated by means of the Atbara River with the Red Sea near Suakin in modern Sudan. As exploration marched southward, however, the elusive connection moved with the frontier, and by the middle of the second millennium, the supposed juncture was far to the south.

Kircher held that Africa's great rivers issued from a common southern lake. The map is from his Oedipus Aegyptiacus (1653).

Heinrich Scherer's 1703 map showing a western river exiting Lake Victoria.

The Nile flowing from two vessels, one held by a Nigerian, the other by an Egyptian.

Rufane Donkin revived the option in A Dissertation on the Course and Probable Termination of the Niger (1829), though his route veered toward the Mediterranean before reaching Egypt.

> *I have declared my opinion against the possibility of the absorption of such a flowing body of water as the one we are speaking of in a desert of siliceous sand, and I have shown that, covered up as it is, it cannot evaporate. But if it be neither absorbed nor evaporated, it must*

either force its way into evidence above ground in the form or a lake or an inland quicksand -- which we know it does not do -- or it must travel further on till it meets at some point with a level which checks it -- and that point I indicate the Gulf of Sidra [Libya].

I have no doubt but that, in very remote ages, the united Niger and Geir, that is the Nile of Bornou, did roll to the sea in all the magnificence of a mighty stream.

Above left, a 1584 map showing Lake Victoria connecting northward as the Nile and to the Atlantic through the Congo. To the right, the 1644 map also showing the westward waterway.

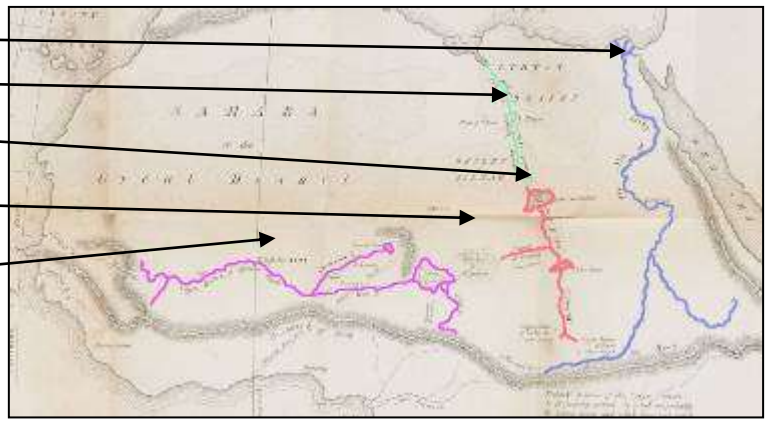
In An Account of the Empire of Morocco (1809), James Grey Jackson ties the Nile of the Negroes to the river of Egypt.

With regard to the water communication between Timbuktu and Cairo, there is no doubt but such a communication exists; it does not; however, facilitate the purposes of transport, the expense of a land carriage by means of camels being more moderate than that of water.

The source of the Nile of Timbuktu is at the foot of the western branch of the chain of the mountains called Jibbel Lumra, of Mountains of the Moon, where it forms a merja, or swamp, and on the western side of the same mountains is another lake or swamp which is the source of the Senegal River. Hence the established African opinion that the Senegal and Nile have the same source, though these two merjas are separated by the mountain.

Jackson passes along a story related "by a very intelligent man" a party of Africans canoeing in 1790 from Timbuktu to Cairo, a journey of 14 months. In places, "they could not proceed in the boat, which they transported over land, till they found the water flowing in sufficient body to float it." They had to portage around "considerable cataracts," cross "an immense lake whose opposite shore was not visible" and guard against crocodiles, detail that bolsters voracity.

Jackson's Map



David Livingston was repeatedly frustrated in his effort to confirm a western waterway. From his The Last Journals of David Livingstone in Central Africa from 1865 to His Death (1874),

> *It is all but certain that four full-grown gushing fountains rise on the watershed eight days south of Katanga, each of which at no great distance off becomes a large river; and two rivers thus formed flow north to Egypt, the other two to Inner Ethiopia.*

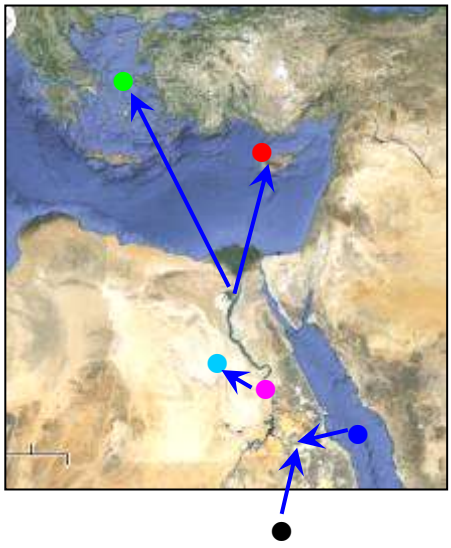
In summary, the hydro-history of the trans-African Nile.

Herodotus herd tell of it
Pliny deduced that a portion of it may flow underground.
Cartographers (though not Ptolemy) showed it to pass through Lake Victoria.
Explorers of the 19th century found nothing.

Is there yet more to this story?

Chapter 77, history more modern, is entitled "Sub-Saharan Streamflow..."

Theories More Remote



Bacchae, by Euripides (c. 480-406 BC), speaks of the Nile bringing fertile waters to Paphos.

> *Would that I might go to Cyprus, the island of Aphrodite, where the heart-charming Erotes govern mortals, and Paphos, which the seven-mouthed streams of the barbarian river* [the Nile] *fertilize without rain.*

Callimachus of Cyrene (d. 240 BC) suggested a connection between the Nile and the Inopus on the of isle of Delos in Hymn to Delos.

> *So didst thou speak, and she gladly ceased from her grievous wandering and sat by the stream of Inopus, which the earth sends forth in deepest flood at the season when the Nile comes down in full torrent from the Aethiopian steep.*

Mela's De Chorographia (c. 43) includes a systematic list of physical explanations of Nile flooding, but departs logical sorting for an idea more intriguing -- the river originates in a continent south of the known world and travels via sub-oceanic conduits to Ethiopian wellsprings. Dry-season floods pose no mystery because the antichthonian seasons are opposite.

> *If, however, there is a second world, and if there are Antichthones located directly opposite to us in the south, that first explanation will not have departed too far from the truth. The river, originating in those Antichthonian lands, emerges again in ours, after it has penetrated beneath Ocean in an unseen channel, and it therefore increases at the summer solstice because at that time it is winter where the river originates.*

We'll have more to say about submarine rivers in later chapters.

From "Herodotus II, 28 on the Sources of the Nile," Journal of Hellenic Studies 73 (1953), G.A. Wainwright,

> *Herodotus gives it as his opinion that there must have been whirlpools in the Cataract. Mr. Warner says that the place gets its name because there is supposed to be an underground channel communicating with the Great Oasis (Khargah) a hundred miles distant. Dr. Hurst adds to that, for he tells me that the story goes that a trader was wrecked in the whirlpool and lost all his belongings. A year later he was sitting beside a well in the Oases when suddenly there came up on the flow of water a wooden bowl which he recognized as his own which had gone down with his boat on the Nile.*

Strabo quotes a fragment of Prometheus by Aeschylus (525-456 BC) regarding the Red Sea.

> [Leaving] *the Erythraian* [Red] *Sea's sacred stream, red of floor, and the mere by Oceanus, the mere of the Ethiopia* [Blue Nile]*... that giveth nourishment unto all.*

Strabo's Geographia (3 BC-23 AD) also tells us,

> *Those who would have the river Inopus to be a branch of the Nile flowing to Delos, exaggerate this kind of marvel to the utmost... There is even a story that the Nile itself is the Euphrates, which disappears into a marsh, rises again beyond Ethiopia and becomes the Nile.*

Philostorgius (c. 368-425) wrote in Historia Ecclesiastica -- a work now lost, but quoted in the ninth century by Photius -- that the Tigris and the Euphrates flow underground to rise again to the surface. Nile crosses the Indian Ocean underground to the Red Sea and surfaces at the Mountains of the Moon where it divides into two streams which cascade to Egypt via Ethiopia. "As best we can conjecture," in the words of the author. "But who can have accurate knowledge?

Leonardo da Vinci merits re-quoting from Chapter 7, for his insight.

> *We may conclude that the water goes from the rivers to the sea, and from the sea to the rivers, thus constantly circulating and returning, and that all the sea and the rivers have passed through the mouth of the Nile an infinite number of times.*
>
> *And if you chose to say that* [Scythian, i.e., central Eurasian] *rivers... issue forth again at the sources of the Nile, this is false; because Scythia is lower than the sources of the Nile, and,*

besides, Scythia is only 400 miles from the Black Sea and the sources of the Nile are 3000 miles distant from the sea of Egypt into which its waters flow.

Summary

The source of the Nile is the watershed of Lake Victoria. As the area is not karstic, there's little geological likelihood for underground streamflow.

That, however, hasn't precluded hypotheses of subterranean nature.

Mythological underworld fountains rising at the Nile's first cataract.
Greek philosophers moving the fountains further upstream.
The Hebrews' Edenic Gihon, rising from Paradise.
Ptolemy's twin headwaters depicted by cartographers for centuries.
Pliny's western tributary, implicitly relegating the desert portion to beneath the surface.
Kircher's hydrophylacium.
Bruce's Blue Nile flowing under a dry lake.
A myriad of underground conduits said to connect to distant lands.

It's hard to keep a good river up.

CHAPTER 15
HOLLOW EARTH GEOPHYSICS

This chapter describes hollow earth geophysical hypotheses based scientific conjecture, as opposed to a pseudo-scientific hollow globe described in popular fiction.

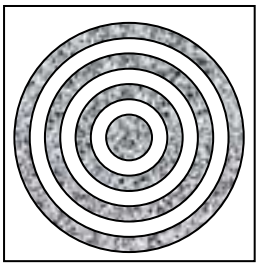
We'll first take our look at the geophysics of such worlds, and then be made partly to perhaps the greatest geophysical secret ever, the Polar Hole.

The Geophysics

We first met Edmund Halley (1656-1742) in Chapter 12 where his estimation of evaporation helped quantify the hydrologic cycle as we now know it. Halley was likewise interested in the earth's magnetic field, concluding "that the globe of the earth might be supposed to be one great magnet, having four magnetical poles or points of attraction" -- Philosophical Transactions of the Royal Society (1683).

> *No magnet I had ever seen or heard of had more than two opposite poles, whereas the earth had visibly four, and perhaps more...* [and] *these poles were not, at least all of them, fixt in the earth, but shifted from place to place…whereas it is not known or observed that the poles of a load stone ever shifted their place in the stone.*
>
> [The cause of geomagnetism must] *turn about the center of the globe, having its center of gravity fixt and immoveable in the same common center of the earth,* [but must be] *detached from the external parts.*
>
> *In order to explain the change of the variations, we have adventured to make the Earth hollow and to place another globe within it; and I doubt not but this will find opposers enough. I know 'twill be objected, that there is no Instance in nature of the like thing; that if there was such a middle globe it would not keep its place in the center, but be apt to deviate therefrom, and might possibly chock against the concave shell, to the ruin or at least endammaging thereof; that the water of the sea would perpetually leak through, unless we suppose the cavity full of water.*

The solution: a hollow earth of concentric shells, not unlike the yet-to-be-invented dynamo. The outer shell is 500 miles thick. Drawing upon his planetary knowledge, Halley determined that the two inner shells have diameters comparable to Mars and Venus and the solid inner core is the size of Mercury.

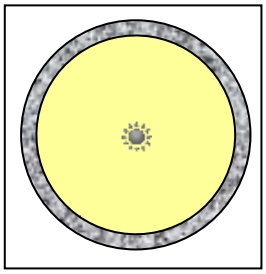


Bathed in perpetual light from a luminous gaseous atmosphere that filled the inner spaces, each sphere "might support life." Halley even entertained the possibility of "more ample creation" within the earth, which might include suns. Surely God would provide no less for his creatures. In the very year that Halley's essay was published, Robert Boyle initiated a lecture series dedicated to the scientific proof of Christianity. As Halley had recently been charged with "atheism" -- a term holding different connotations than it does today -- the nod to the Almighty may have been politically astute.

Halley at 80, holding a drawing of his hollow earth.

Swiss mathematician Leonard Euler (1707-1783) speculated about a hollow earth in 1767, proposing a thought experiment in which at the earth's center lies a glowing core which serves as a miniature sun for interior inhabitants.

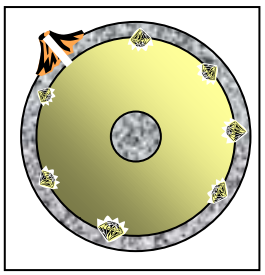
It's unlikely that Euler believed any such thing, but subsequent public perception often differs from individual initial intent.

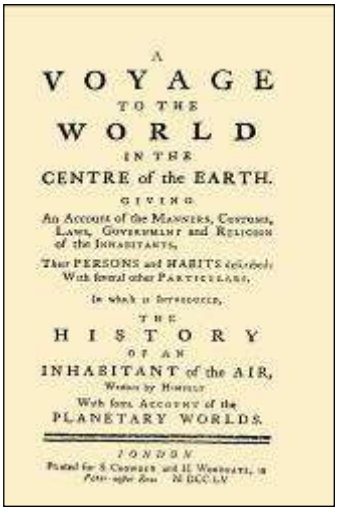


<u>A Voyage to the World in the Center of the Earth</u> (1755) by "Himself" is the account of an adventurer who enters the world within our own earth's interior by way of a tumble into Mt. Vesuvius, a volcano we visited in Chapter 9. Fortunately, the traveler lands upon a haystack.

The interior sphere is 100 miles in diameter and illuminated by jewels on the concave shell, 100 miles thick, of our own world. An opaque cloud circles hemispherical within the void blocking the radiance for half the time.

The system is held together by a type of magnetism.





A
VOYAGE
TO THE
WORLD
IN THE
CENTRE of the EARTH.
GIVING
An Account of the Manners, Customs, Laws, Government and Religion of the Inhabitants,
Their PERSONS and HABITS described:
With several other PARTICULARS,
In which is interspersed,
THE
HISTORY
OF AN
INHABITANT of the AIR,
Written by Himself.
With some Account of the
PLANETARY WORLDS.
LONDON

The utopian social values of the inner-world stand in stark contrast to those of the Whig party in England above -- the point of the book -- but as hydrologists, we'll remain neutral in political matters. We seek the water story.

While in free fall, the writer notes,

I then plainly defined seas, vast continents, mountains and islands.

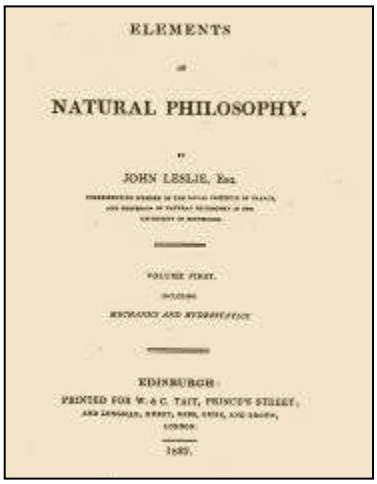
A hospitable inner-earthling later shows him a fish farm.

We followed him to a pond, and found a cistern near it, full of clear water, and several fish in it of different sorts, floundering and playing about. As the side of it was a barrel full of a sort of grain, of which he now and then threw a handful or two in to feed the fish he had caught.

"Himself" doesn't provide us much to go on, but it's clearly a hydrologic world akin to our own, the difference being that theirs is better managed.

John Leslie (1766-1832) wrote “The Philosophy of Arithmetic,” but is best known for his research on heat and is considered to be the first scientist to properly describe capillarity -- a geophysical mechanism we saw much abused in Chapter 10.

Every genius has his or her shortcomings, Leslie's being a theory of compressible bodies holding that density to be a function of both a substance's particular elastic properties and its distance from earth’s center. Material at the earth’s core would be thousands of times more massive than that allowed by Newtonian physics.


ELEMENTS

OF

NATURAL PHILOSOPHY.

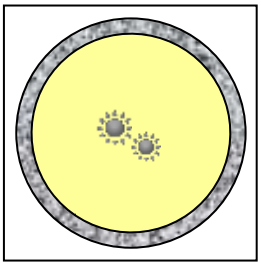
BY

JOHN LESLIE, Esq.

EDINBURGH:

PRINTED FOR W. & C. TAIT, PRINCE'S STREET;

1829.



To make the math work, Leslie proposed in Elements of Natural Philosophy (1829) that, “Our planet, must have a very widely cavernous structure,” and “we tread on a crust or shell whose thickness bears but a very small proportion to the diameter of its sphere." As nothing can be stationary, a single interior star couldn't be the source, but binary stars (which he named Pluto and Proserpine) resolved that problem.

Because an absolute vacuum was inconceivable, something must fill the intraplanetary void. It couldn't be air, because near the center, even air would be subject to,

Immense compression [that] *would totally derange the powers of elective attraction, and change the whole form and constitution of bodies.*

Rather,

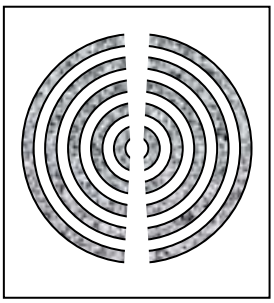
The vast subterranean cavity must be filled with some very diffusive medium, of astonishing elasticity or internal repulsion among its molecules.

This left only one possibility,

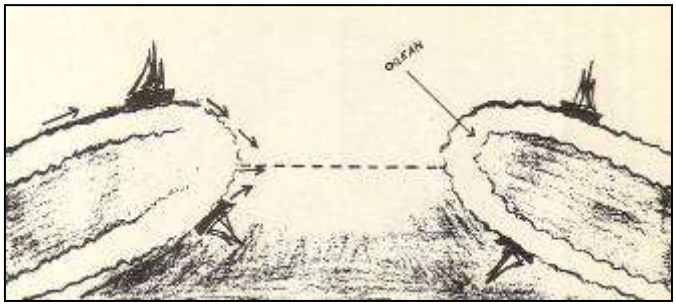
[The] *only fluid we know possessing that character is LIGHT itself.*

To illustrate Leslie's point, we've added the color yellow.

The American John Cleves Symmes, Jr. (1779-1829), an officer from the War of 1812, may have learned of Halley's theory by way of Cotton Mather's The Christian Philosopher (1721). To this, Symmes added entrances 6,600 and 10,000 kilometers in diameter at the two poles, suffice to allow the expulsion of Leslie's light and the inflow of air.



A confused gravity allows the dwellers to inhabit either side of each shell. A ship at the polar hole would simply sail around the rim and onto the shells inside ocean, masts now pointing toward the geo-center. Polar access, detailed by Max Fyfield, is shown to the right.



It's all about pressure,

> *…thus causing a universal pressure, which is weakened by the intervention of other bodies in proportion to the subtended angle of distance and dimension, necessarily causing the body to move toward the points of decreased pressure.*

In an 1818 circular sent "TO ALL THE WORLD," Symmes proposed,

> *I declare the earth is hollow, habitable within; containing a number of solid concentric spheres; one within the other, and that it is open at the pole twelve or sixteen degrees. I pledge my life in support of this truth, and am ready to explore the hollow if the world will support and aid me in the undertaking.*
>
> *I ask one hundred brave companions, well equipped, to start from Siberia in the fall season, with Reindeer and slays, on the ice of the frozen sea; I engage we find a warm and rich land, stocked with thrifty vegetables and animals if not men, on reaching one degree north-ward of latitude 62; we will return in the succeeding spring.*

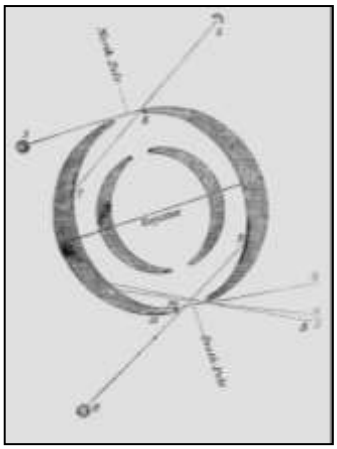
One might wonder about the vegetables, but Symmes was prepared. As flora would require additional light, there may exist non-polar openings in uninhabited parts of South America, northern Asia, Canada and Alaska, Iceland and Greenland.

Noting that other things in nature are likewise hollow -- bones, reeds and hair, for example -- and using spherical bowls of sand, magnets and iron filings to demonstrate his physics, Symmes carried his case to the public.

A Symmes' advocate proposed to the United States Congress an expedition to the earth's interior to open profitable trade with the natives. As Congress preferred to explore the West, not the Under, however, the proposal was defeated, 56 to 46.

By 1824, Symmes had abandoned the idea of multiple concentric spheres in favor of a single hollow shell. Late in life, Symmes sought to join a Russian polar expedition, but could not raise the passage to St. Petersburg.

Capt. Adam Seaborn's Symzonia, Voyage of Discovery (1820) is an account of how the author sailed over the rim of the world and into the interior where there appear two suns and two moons, refractions from the exterior. Seaborn's identity is unknown but most believe nom to have been Symmes himself. Others identify the author as Nathanial Ames who wrote other works, including one that may have served as the inspiration of Moby Dick.



A monument erected over Symmes' grave, a hollow earth model at its top, stands today in the center of Fourth Street Park, Hamilton, Ohio, just south of the business district.

Symmes died, but not his advocates, one being newspaper editor Jeremiah Reynolds, whose hollow-earth lectures were favorably received in Philadelphia, Baltimore, Boston and New York.

In 1828, Reynolds approached Navy Secretary Samuel Lewis Southard, who in turn convinced President John Quincy Adams to mount the "Great American Exploring Expedition" in search of, among such other things, a hole into the hollow earth. States-rights Democrats delayed the expedition until 1838, by which time Reynolds was pragmatically no longer promoting on the basis of subterranean secrets.

Though the venture surveyed nearly 300 islands and more than 1500 miles of Antarctic shoreline, the entrance was not encountered. The expedition, however, marked a turning point for American science, and the Smithsonian Institution was established to archive the thousands of superterranean specimens collected.

"HOUSE OF REPRESENTATIVES, *April 2d*, 1836.

"Mr. Pearce, of Rhode Island, from the Committee on Commerce, reported the following resolution:—

"*Resolved*, That the use of this Hall be granted to J. N. Reynolds, Esq., on Saturday evening next, for the purpose of delivering an address, on the subject of an Expedition, or Voyage of Discovery, to the South Sea and Pacific Ocean.

"The Resolution was agreed to."

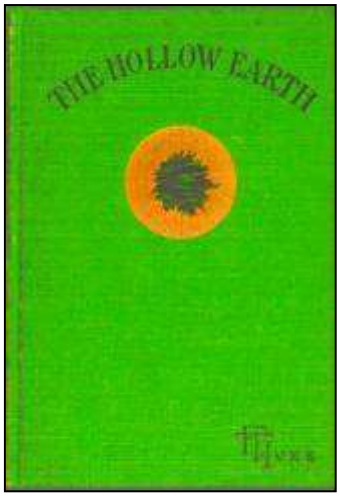
An awed Edgar Alen Poe reviewed the address in the January 1837 Southern Literary Messenger,

> *With mental powers of the highest order, his* [Reynolds'] *indomitable energy is precisely of that character which will not admit of defeat.*

Poe used some 700 words of the address in The Narrative of Arthur Gordon Pym, a work we'll review in Chapter 17, Underground Rivers in English Fiction.

In the October 1882 Harper's Magazine, a Mr. Howgate proposed an expedition to discover "Symmes' Hole." The team would acclimate to higher and higher latitudes, moving further north each year, watching for animals that wintered within the earth and emerged to bear young. The explorers were to follow the animals to where they re-entered.

Franklin Titus Ives, chairman of the Connecticut State Board of Mediation and Arbitration, was another proponent Symmes' theory. We'll quote a few passages from his The Hollow Earth (1904).



Arctic Elephants

> *It has often been a query from whence came the Arctic elephants, the remains of which are found so plentifully on the north shores of Siberia, some of which during the last century have been in such a state of preservation as that their flesh was eatable by bears and wolves.*
>
> *Why were they protected by a covering of hair if not originating in a colder climate than exists south of the Arctic Circle?*
>
> *Do they not still exist in the interior, or have they passed out with the great Auk, a former external resident?*

The Role of Centrifugal Force

> *Every lake is but a mammoth spring, or reservoir of numerous springs that feed into its base. The provision by nature of this inexhaustible reservoir of fresh water is beyond doubt the most essential of any other bounty bestowed upon every living thing on Earth's surface. The principle of centrifugal motion and power is here developed to its highest advantage.*
>
> *At this point it may be well to call attention to another feature in the river system. The water on the grindstone will give force to this suggestion. At a certain speed the water will tend to the outside of the stone; below speed required to do that, the tendency will be toward the center of the stone, or strictly toward the center of the Earth's motion.*
>
> *Now let us see what the river system says. Look on your maps and see about where the common divide occurs, which is seemingly not far from the 50th parallel, where centrifugal force is apparently not strong enough to carry the waters toward the Equator, and the principal waters flow toward Symmes's Hole.*

The Insufficiency of Rainfall

> *And while all this grand and complete arrangement supplies vegetation with its bathing and drinking, as said before, it has nothing to do with the living and lasting supply of our springs, lakes and rivers. They are fed from a never failing and almost unchanging source -- that is, by the immense supply taken in at the polar holes in a river over 4,000 miles wide at each end of the Earth's axis.*

Mountaintop Springs

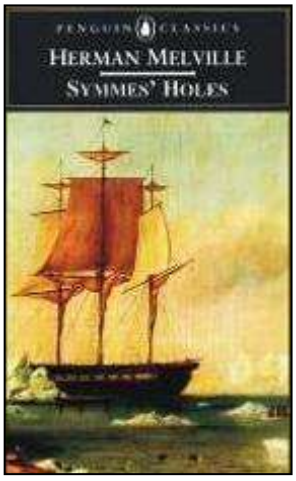
> *Within twenty rods of the top of Mount Washington, the highest peak in the New England States, flows out a copious spring of water. The whole mountain system is full of springs and lakes. The entire Adirondack region is in the same condition. It is safe to leave it to the reader who has ever been out of sight of the smoke of his own chimney to think of the abundance of instances where he has seen lakes and springs on the tops of high hills, where no shed water to any extent could reach them, and wonder how they came there.*

Artesian Wells on Plains

> *Here is a subject that is worthy the attention of settlers in our arid and apparently desert regions of country. We are told that the source of an artesian well is from fountains of water gathered and stored in higher lands that run through different strata of rocks till they reach the valleys, and when the boring reaches down to these strata the water naturally comes up toward the height of the fountain it started from. Would it not be a sensible inquiry to make as to where the supply came from to furnish the water in the higher lands? That the accepted theory of supply to artesian wells comes from some higher point is not correct can be demonstrated on the prairies, where no higher land is in sight.*

The Symmes legacy seems unbounded. The man wasn't the first to imagine polar holes, but he the popularized the possibility. In the century following his 1818 "TO ALL THE WORLD," scores of dime novels -- of which we've listed many -- followed one fictional hero or another into the polar entrance. Fortunately, most escaped.

Reynolds is also known for his May 1839 Knickerbocker Magazine piece, "Mocha Dick, or the White Whale of the Pacific" detailing the capture of a giant sperm whale infamous for attacking ships. The mammal was named after the Mocha Islands where it was sighted. "Dick" was a common male name. Herman Melville (1819-1891) plagiarized the theme in his 1851 novel.

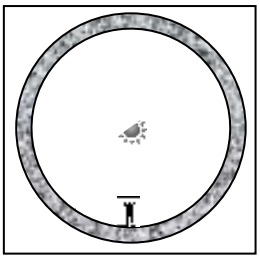


Melville, in turn, has been linked to hollow-earth lore by his manuscript Symmes' Holes (1876), a recent printing shown to the right. It may be a Penguin Classic, but unfortunately the work's a forgery.

Henry David Thoreau (1817-1872) cited Symmes in Walden (1854).

> *It is not worth the while to go round the world to count the cats in Zanzibar. Yet do this even till you can do better, and you may perhaps find some "*Symmes*' Hole" by which to get at the inside at last.*

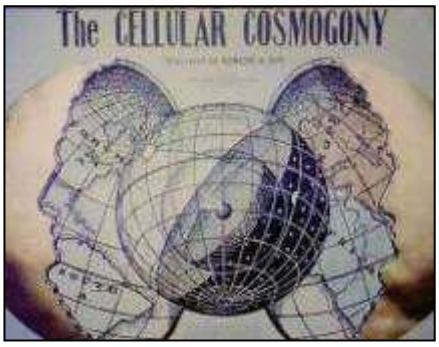
Cyrus Read Teed (1839 -1908), an “electro-alchemist” from Utica, New York, saw the "geocosmos" differently. According to Teed’s Cellular Cosmogony (1870), the earth is a hollow sphere and we dwell on the inner side. Our heads point toward the center where the sun, half dark and half light, rotates to create the appearance of sunset and sunrise. "Gravic rays" emanating from the sun hold us onto the crust. The universe that we "see in the sky" is cradled "in the hands of God."



The earth shell consists of 17 layers of which the outermost seven are metallic, the golden layer having the greatest radius. The next five layers are mineral and the remaining are geologic strata.

Within the earth shell are three atmosphere shells: air, hydrogen, and "aboron" which prevent us from seeing across.

In summary, "To know of the earth's concavity is to know God."



After an 1869 "illumination" in which it was revelation that he was the incarnation of Christ, Teed changed his name to Koresh, established “Koreshenity” and established a utopian commune Florida. Teed and followers organized the Koreshen Geodetic Survey and conducted an experiment to prove the earth’s concavity.

Using a “rectilliniator,” the believers spent five months in 1897 moving the device along four miles of beach to prove the earth’s concavity. The results were said to be as Teed predicted.

At the right is the opinion the Chicago Daily Tribune, March 31, 1895.

TEED'S QUEER IDEA OF THE WORLD.

He Thinks It a Hollow Sphere and That We All Live Inside It.

Dr. Cyrus R. Teed, he of "heaven" fame, and erstwhile organizer of angelic hosts, made a desperate, but probably an unsuccessful, effort to convince the people in a Hyde Park audience last night that they were on the inside rather than on the outside of this mundane sphere. Seventy-five people heard the address. The purpose of the address seemed to be to prove that "the earth is a hollow spere, the surface of which is concave, and the inhabitants live on the inside instead of the outside of this sphere." The address was started with a personal allusion, in which the doctor informed the audience of his personal greatness and qualifications for the work in hand. The doctor thought the argument that ships could sail around the earth applied to his scheme, too. Any spirit level, if long enough, would run into the ground, so the ground must run up hill. By other arguments he endeavored to prove that the sun was at least 4,000 miles away and at the center of the earth. Questions were propounded by those present who had less perception than the speaker, but they staggered him not. Everything difficult in the way of questions he had settled, and he let it go at that.

While Teed draws upon Symmes for hollow earth inspiration, there's a significant difference in perspective.

> According to Symmes, we're not within the hollow earth and thus can only speculate on the nature of that realm. Symmes proposed an American expedition of discovery.

According to Teed, we're already living in the hollow earth and need to explain what we observe about us.

Teed's "illumination" provided an explanation. Centrifugal force -- the inertial force that pushes objects outward from the center of a spinning circle -- accounts for what the unenlightened -- Newton and his crew -- mistakenly attribute to gravity.

On the bottom of the diagram to the right we have the world as explained by Newton.

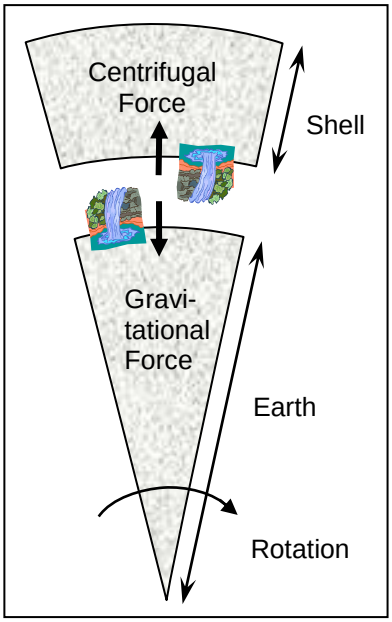
A segment of a solid rotating earth with a waterfall on its surface.

Gravitational force causing the water to fall downward. Gravitational force doesn't depend on the earth's rotation.

On the top we have Teed's explanation.

A segment of a spinning shell with an upside-down waterfall on its inner surface, "upside-down" on the page, that is, not to an inner-world citizen.

Centrifugal force pushing the waterfall outward.



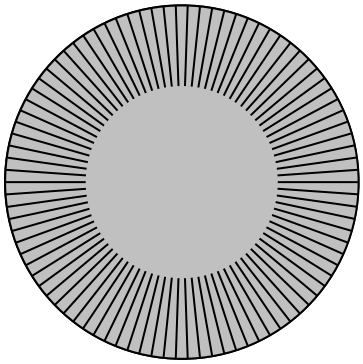
According to Teed, the waterfall we think to be directed by gravity is in fact responding to outward centrifugal force. It makes conceptual sense, perhaps, at least until we look at the math.

To begin, let's consider a non-rotating solid globe, Case 1 below, in which the only force operating is that of gravity,

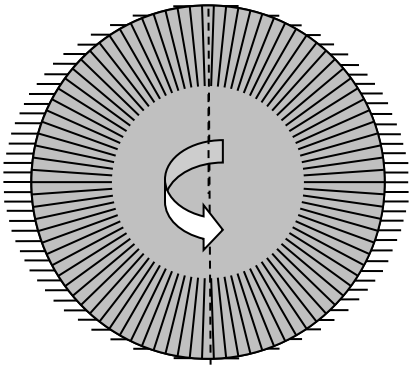
Gravitational force = $m\,g$

where m is an object's mass, and
g is gravitational acceleration, 9.81 meters/second^2 at the earth's surface.

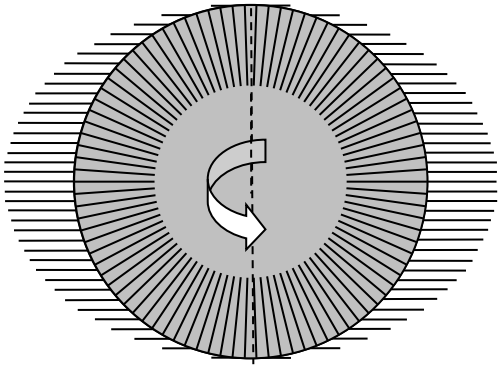
The radial lines represent gravitational pull toward the center of the globe. For a given object, the g's magnitude is the same everywhere on the surface.



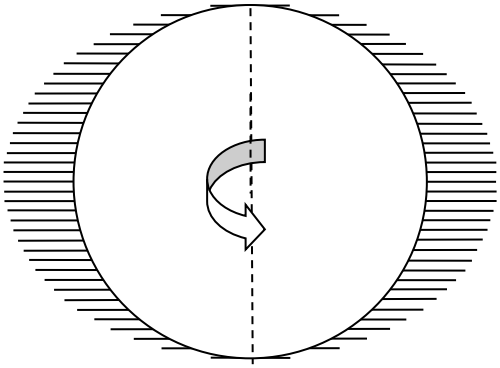
Case 1: Gravitation alone



Case 2: Gravitation plus 1 rotation/day centrifugal force



Case 3: Gravitation plus 17.1 rotation/day centrifugal force



Case 4: 17.1 rotation/day centrifugal force alone

Case 2 adds centrifugal force

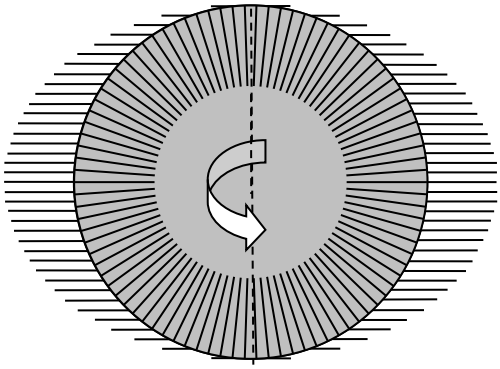
Centrifugal force = $m\ r\ \omega^2$

where r is the radius of rotation, 637 kilometers for an object at the Equator, and
ω is the angular velocity, 1/day for the earth.

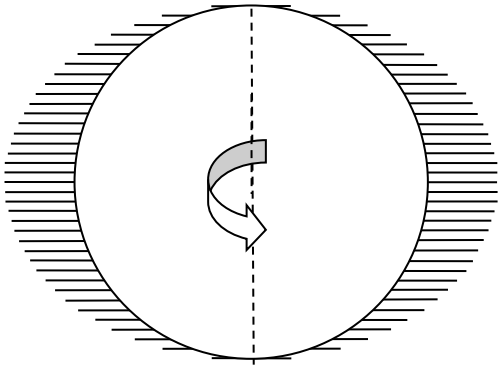
Centrifugal force is directed perpendicularly-outward from the axis. It is greatest at the equator and zero at the poles, because there, r is zero.

Other rotations about axes in different orientations and of differing angular velocities could be added -- spinning the spin, so to speak -- but regardless of how many spins are imposed, the sphere ends up rotating about but one resultant axis at some constant ω. It's just a tipped version of the same diagram with proportionally longer or shorter lines sideways to the axis.

We on earth are influenced by both gravitational and centrifugal force, but at a ω of 1 rotation/day, the centrifugal force on an object at the earth's surface varies from 1/300 of gravitational force at the equator to zero at the poles. (We've exaggerated the illustrated horizontal lines to make them apparent; plotted to scale, the longest of them would be but a line-width in length.) Thanks to the earth's spin, we weigh 3/10 of one percent less at the North Pole than we do at the equator, but we don't find it worth hauling our scales to the Arctic.



Case 3: Gravitation plus 17.1 rotation/day centrifugal force



Case 4: 17.1 rotation/day centrifugal force alone

Case 3 spins our earth 17.1 times/day -- a "day" by our current timepiece, that is, not the solar day in the faster-rotating world -- the ω required for centrifugal acceleration at the equator to be 9.81 meters/second^2, counterbalancing the inward gravitational force. Could we do this, objects would weight nothing at the equator. At the poles, however, gravity would be unopposed and they'd weigh the weights to which we're accustomed.

Case 4 is Teed's model, that of a hollow earth with centrifugal force pushing us against the shell's inside. What physics tells us -- though it may not be what we expect -- is that there's no gravitational attraction between a shell of any thickness and an object within. There is no gravitational pull whatsoever on objects within this world; there's just the centrifugal push that the rotation exerts.

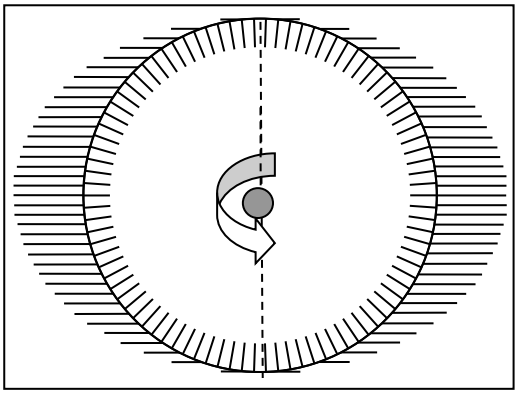
To make Teed's world function like the one we see, we need this centrifugal force to equal the gravitational force with which we are familiar. At a ω of 17.1 rotations/day, an object dropped at the interior world's equator travels straight toward the surface, accelerating at 9.81 meters/second^2, exactly as Teed would want.

At higher latitude, however, *r* is smaller. As centrifugal force is reduced, an object falls toward the shell more slowly than does an object dropped at the equator. Moreover, the path of descent is inclined to what the locals would call "down."

At the poles where there's no centrifugal force, objects in Teed's world don't fall. While few of us have been to either pole, we're quite certain that a dropped glove falls to the snow.

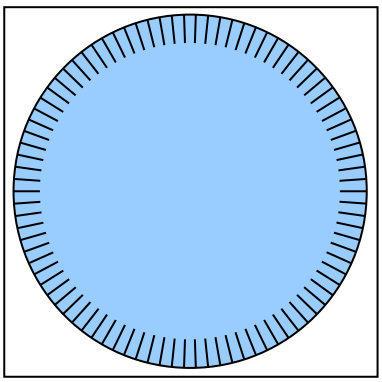
In Case 5, a miniature sun at the sphere's center exerts a thin ring of inward gravitational pull. An object loosened at the poles would obey the small sun's gravity and lift away from the shell's inner surface. Rotating the interior sun about a sister changes nothing but the gravitational magnitude. Add a pair of internal moons and we're approaching Seaborn's universe, but we're not helping our case.

Our conclusion: Centrifugal force cannot simultaneously maintain the same centrifugal force at every point on the shell, what's needed for falling objects to behave the same, independent of latitude.



Case 5: Gravitation plus 17.1 rotation/day centrifugal force

Such Newtonian quibbling would not have phased Symmes, however, as according to J. McBride's Symmes's Theory of Concentric Spheres; Demonstrating that the Earth Is Hollow, Habitable Within, and Widely Open about the Poles (1826), gravity is not an attractive force related to mass, but rather a pushing force (a pressure in modern terminology) exerted by a universal ether.



Case 6: The pressure of ether

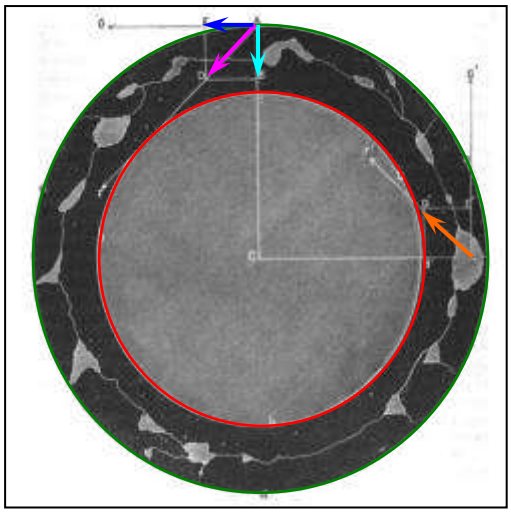
The hollow earth can be dismissed by any number of physical arguments, but our observation is suffice. Everywhere on the earth objects fall straight downward with the same acceleration. We can't say that we've proven the gravitational earth theory to be correct, but we can say that we've proven Teed's hollow earth theory to be incorrect.

Symmes and Teed were not alone, however, in their application of alternative physics to problems of fluid flow. Although the paper was written to establish why springs emit from outside-world -- as opposed to inside-world -- mountaintops -- the higher, the better, actually -- we see like confusion in "Why Do Springs and Wells Overflow?" Popular Science, November 1879, by Nelson W. Green.

Here's the essence of the proof with items colored to assist quick identification.

*Let **aaa**, be a great circle of the earth attained by passing a plane through the earth's center C, perpendicular to its axis, and **bbb**, the circle cut by the same plane through the inner surface of the earth's supposed crust. In order to obtain room for the illustration, this section is exaggerated.*

*Let the line **AB** represent the force of gravity, and **AE** the centrifugal force at the point A, which will operate in the direction of the tangent AG. These two forces, for the purposes of this discussion, may be assumed to be equal, as the question of their relative intensities does not enter into the problem.*



*Erect upon the lone **AB** the square ABCD and draw the diagonal **AD** produced to F. By a well-known law we shall have **AD** representing the resultant of the forces of **AB** and **AE** -- that is, the line **AD** will represent the direction of AF, and the intensity of the resultant of the force of gravity and centrifugal force acting at the point A.*

*It will be observed that since the diagonal of either square or of a parallelogram is longer than either of its sides, the resultant **AD** will have a greater intensity than gravity represented by **AB**.*

Now suppose the point A' to be some point inside the earth's crust, and some distance from the surface, and suppose that it is a particle of water in a body of water imprisoned by surrounding rocks. This particle will be acted upon by a continual impulse to move in the direction of A'F',

*with an intensity represented by **A'D'**. This will be true of every other water particle in the imprisoned body of water...*

Since the resultant has been shown to be greater in all circumstances than gravity, certainly the vast aggregations must also be greater than the aggregated gravity, and will be able to overcome it under all circumstances...

The intensity of the centrifugal force will increase with the distance from the center of the earth, while gravity will decrease; the resultant will also increase. Thus we find the most abundant overflows at the tops of mountains or on high plateaus.

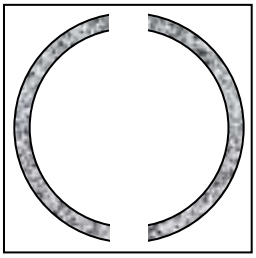
Green's physics isn't Newton's, as the former's centrifugal force is tangential, while the latter's is radial. But even if we overlook the 90-degree turn, Green's resultant ***AD*** (or **A'D'** if we move to the waterbody) is by inspection still not outward.

But back to our topic at hand, hollow globes.

Teed died before a German pilot Peter Bender came across Koreshen literature in a World War I prisoner-of-war camp. After armistice, Bender discarded the religious aspects to form the hollow earth doctrine, "Hohlweltlehre." Bender's writings led to the interests of the German Naval Research Institute for a method to locate enemy ships. A telescope pointed upward from Rügen Island in the Baltic failed to detect His Majesty's Navy, however, and the Germans lost the next war.

We will look a bit more at Teed's model in Chapter 27, Subterranean Waterbodies.

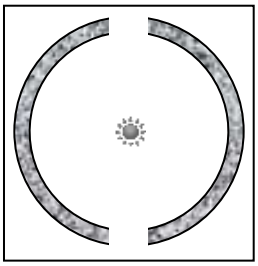
Like Symmes, William Reed (1830-1920) believed that sunlight shining into the polar openings would be sufficient to illuminate the interior and suggested that outer-crust folk colonize the inner earth. The reason the North Pole had not been yet discovered, Reed explained as a point of proof, is because it lies in the center of the opening.



Reed's Phantom of the Poles (1906),

I am able to prove my theory that the earth is not only hollow, but suitable in its interior to sustain human life with as little discomfort as on its exterior, and can be made accessible to mankind with one-fourth the outlay of money, time and life that it costs to build the subway in New York City.

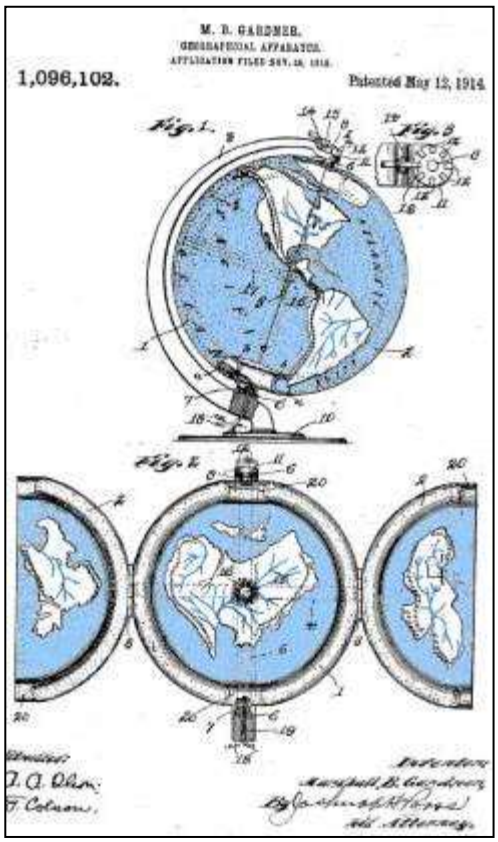
Marshall B. Gardner (b. 1854), a maintenance man in a corset factory, wrote A Journey to the Earth's Interior or Have the Poles Really Been Discovered in 1913. The earth's crust is 800 miles thick and the interior sun is 600 miles in diameter.



Here, indeed, we may expect to find a new world, a world the surface of which is probably subdivided, like ours, into continents, oceans, seas, lakes, and rivers.

Gardner cited the 1846 discovery of a woolly mammoth frozen in Siberia as evidence. Subscribing to the single-sun theory, Gardner suggested that the mammoth had wandered outside the hole at the North Pole and was frozen and carried to Siberia on an ice flow.

To the right is Gardnet's 1914 patent for a hinged model of our hollow earth.



> *Upon the outer surface of the globe are the usual geographical illustrations or maps indicating the continents of the world. Upon the inner surface of the globe are also arranged geographical indications indicating illustrating continents which according to the theory of the inventor exist on the inner surface of the globe.*

We've added the blue to make apparent the oceans and rivers.

As the patent is for a device -- not an idea -- its issuance was legally valid, but as the patent has since expired, we are free today to saw a globe in half and sketch the interior with whatever geography we favor.

The polar-hole arguments of Gardner and Reed are the same as Symmes'. Reed suggested that the flattening of the poles proves that there must be an opening, as this would detract from the roundness. As for how the central sun came to be, Gardner cited the Ring Nebula in the constellation Lyra which looks like shells of gas surrounding a star.

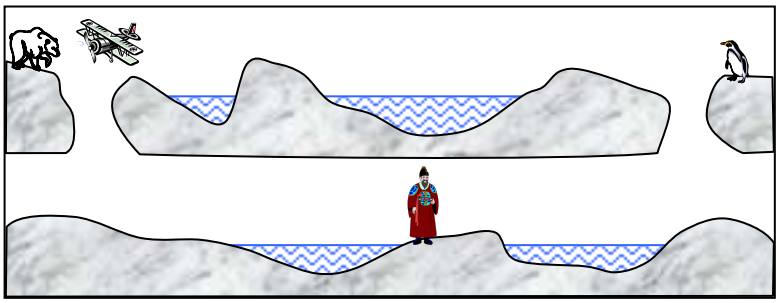
Both Reed and Gardner believed the earth's interior to be inhabited. Gardner believed it was the original home of both the Eskimos and all the East Asians, even suggesting that the "up and outward position" of Oriental eyes may be

> *A modification of the ordinary eye position induced by the fact that in the interior the sun is always in the zenith.*

Raymond W. Bernard, a Rosicrucian, dedicated The Hollow Earth (1964) to Admiral Richard Byrd.

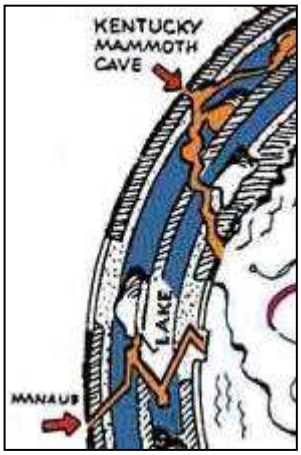
The Greatest Geographical Discovery in History Made by Admiral Richard E. Byrd in the Mysterious Land Beyond the Poles.

DEDICATED To the Future Explorers of the New World that exists beyond North and South Poles in the hollow interior of the Earth. Who will repeat Admiral Byrd's historic Flight for 1,700 Miles beyond the North Pole and that of his Expedition for 2,300 Miles beyond the South Pole, entering a New Unknown Territory not shown on any map, covering an immense land area whose total size is larger than North America, consisting of forests, mountains, lakes, vegetation and animal life?



The King and Queen of the subterranean civilization Aghartha worry about atomic weapons, but allowed Byrd to enter because of his high moral character. We'll visit Aghartha again in Chapter 77, Sub-Saharan Streamflow, the Sarasvati and Shambhala.

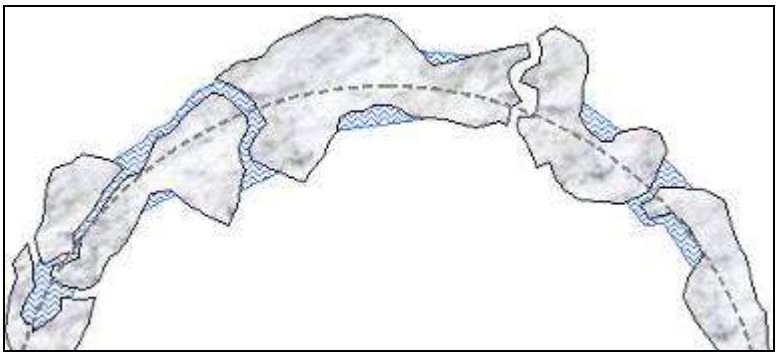
While Bernard marketed his work as non-fiction, there no longer existed Boys Clubs as gullible as those of a half-century prior.



Let's take a closer look at Bernard's cross-section. We see two tunnels to the earth's interior, one from Manaus, Brazil, the other from Mammoth Cave in the United States. We'll look at the karst geology of Mammoth Cave in Chapter 55. Note what the Brazilian route passes within the crust. A subterranean lake! Esoteric hydrology!

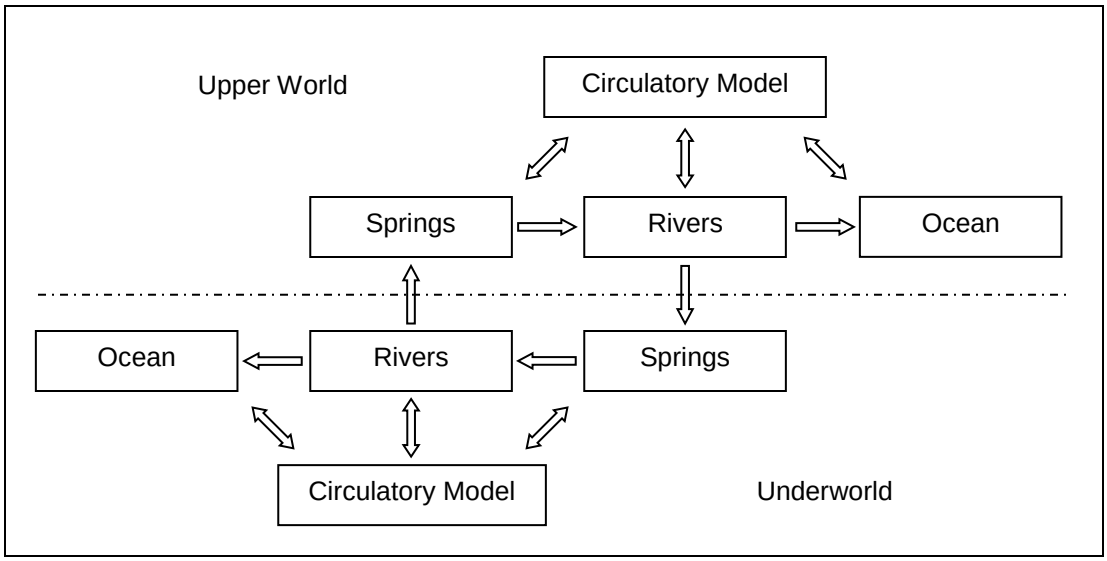
If caverns connect upper land surfaces to the fresh water reservoirs of the lower side, an artesian water well (a well in which the water level rises up the borehole) is explained by a deep lake on the bottom side.

We create the figure below to illustrate a variety of hydrologic correspondences. On the left is an underground lake fed by an underground river. The spring feeding that river is fed by a lake on the underside. We've got a dry tunnel (safer than a polar maelstrom for human expeditions) and a few other waterbodies for good measure.



Underworld hydrology is much like that of our own, just upside down to us. Inhabitants on either side would see the other as "underground."

To envision a unified hydrologic cycle, mirror an upside-down schematic beneath the one we know with River-Spring vertical links.

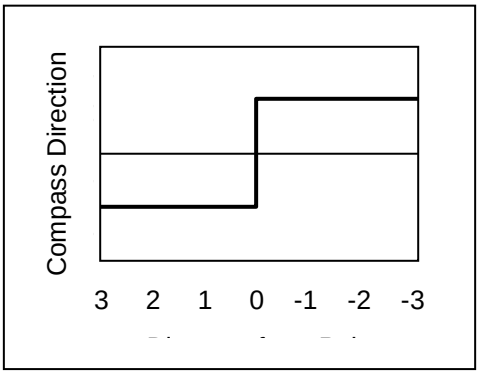


In our pursuit of our elusive underground rivers, we've passed through a potpourri of geophysical propositions. We might think that it was a lot of effort for not much result, but if we were among writers -- famous ones even -- we'd be substantially out-voted.

CHAPTER 16
THE MAELSTROM

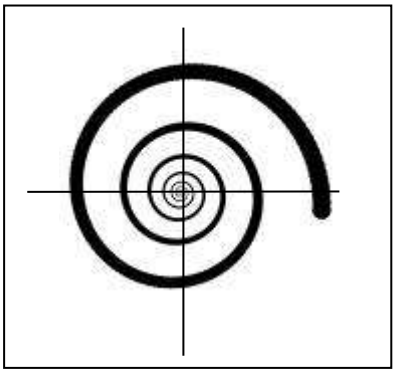
Singularities

A mathematical "singularity" is a point at which a mathematical object fails to be well-behaved. If the mathematical object were the direction of a compass needle, it would point straight ahead as one walked toward the north magnetic pole, but flip when passing over that point. The pole is thus a magnetic singularity.



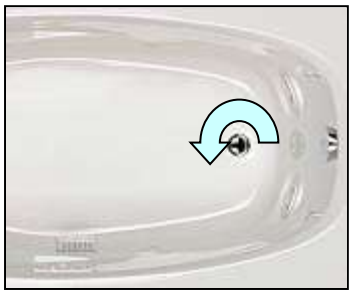
A whirlpool (a "vortex" in hydraulic jargon, a "maelstrom" in literature) represents another natural singularity. Conservation of angular momentum causes the water to spin faster and faster as the radius decreases. In crossing the center, the direction of flow shifts from right to left. The center represents a singularity.

Both singularities exist in the earth's polar region. One is indeed due to an underground river; the other is not. But which?



There are two general types of whirlpools -- those caused by water drawn down a drain and those caused by deflection. The millennia-old cultural association between underground rivers and whirlpools is largely due to not recognizing the difference.

A bathtub drain whirlpool is caused by a subsurface outflow. Absent another outside force such as the direction of the inflowing water, water will rotate counterclockwise north of the equator and clockwise south of the equator, the Coriolis effect named after Gaspard-Gustave Coriolis, who described it in 1835. Once this begins, centrifugal force drives the water to the outside and a cavity forms into which floating objects descend. The Coriolis effect is extremely slight, however, and the effect of almost anything will be greater, setting the whirlpool's direction.



The most powerful "natural" whirlpools are the result of fast-flowing tidal waters through narrow and shallow straits. Unlike the bathtub, however, there is no lower outlet. A related phenomenon can be seen along a riverbank where a rock or fallen tree branch creates an eddy.

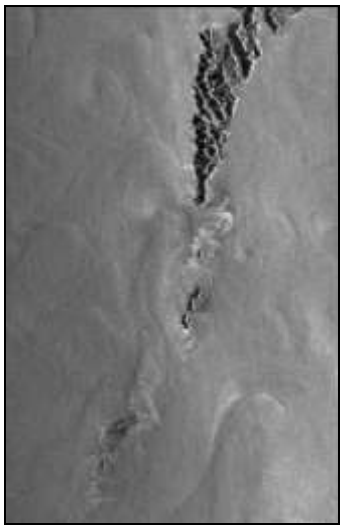
At latitudes above the Equator, Coriolis force propels cyclones and sea currents in a clockwise manner; below the Equator, in a counter-clockwise sense. Our graphics thus illustrate a vortex in

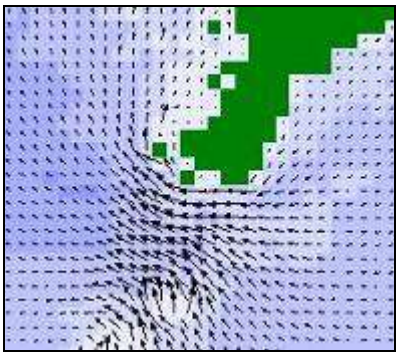
the southern hemisphere. When shorelines are nearby, however, the deflection can be in either direction. Likewise, in fictional accounts of oceanic whirlpools -- we'll note many in chapter ahead -- the direction is up to the author, and the standard's been set by no less than the descent into Dante's Inferno (Chapter 6). Motion is to the left -- counter-clockwise, on other words -- the direction of evil.

We will take a look at a particular maelstrom long the subject of geographic speculation.

The Moskenstrom

An Arctic whirlpool, the Moskenstrom, can be observed at 67° N, its cause being tidal currents between Norway's Lofoten Point and Vaeroy Island. The satellite photo reveals the complexity of ocean currents. The figure on the left is from a hydrodynamic computer model.





Animation of the tidal current

The Moskenstrom isn't a single funneling vortex, but rather a family of eddies, each at most 50 meters in diameter, no more than 1 meter in amplitude and persisting from a few minutes to an hour. The spread of disturbances can span 8 kilometers. The eddies rotate clockwise during the rising tide and counterclockwise during the falling tide.

Ocean fog spills over the Mosken mountains

A close-up

A combination of factors contributes to the Moskenstrom's creation.

About 370 million cubic meters of water are transferred through a narrow channel in 6 hours, creating currents of up to 22 knots.

The seabed gradient steeply rises from 500 to 20 meters.

The Moskenstrom faces the winds of the North Atlantic.

The current is most powerful when the tide is the greatest. Local lore that the vortex is at its strongest on Good Friday has reason, as the holy day is determined by lunar calendar.

It's a phenomenon that engenders tales.

The Tales

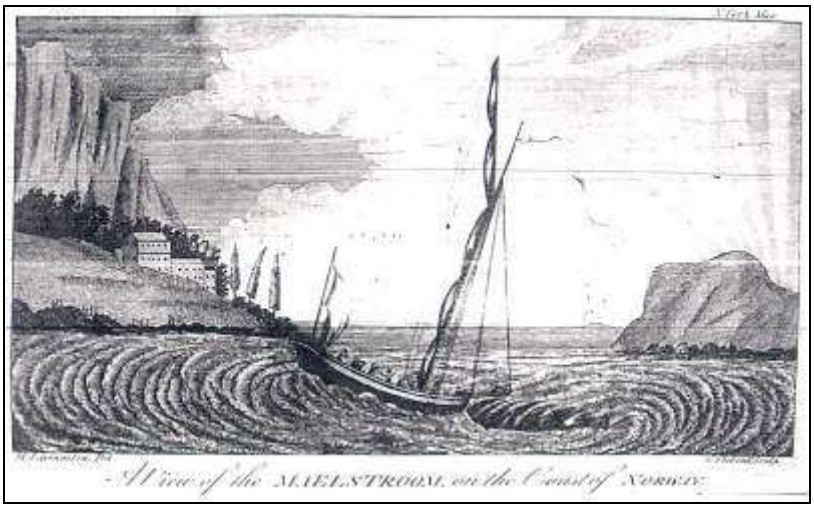
The Mariner's Chronicle: Containing Narratives of the Most Remarkable Disasters at Sea (1934) by Archibald Duncan cites accounts of this celebrated phenomenon.

M. Jonas Uamus describes the fate of ships, whales, bears and even nearby houses.

> *When it is flood the stream runs up the country between Lofoten and Moskoe with a boisterous rapidity, but the roar of its impetuous ebb to the sea is scarce equaled by the loudest and most dreadful cataracts: the noise being heard several leagues off, and the vortices or pits are of such an extent and depth that if a ship comes within its attraction it is inevitably absorbed and carried down to the bottom, and there beat to pieces against the rocks; and when the water relaxes, the fragments thereof are thrown up again. But these intervals of tranquility are only at the turn of the ebb and flood, and calm weather; and last but a quarter of an hour, its violence gradually returning. When the stream is most boisterous, and its fury heightened by a storm, it is dangerous to some within a Norway mile of it; boats, ships and yachts having been carried away by not guarding against it before they were within its reach. It likewise happens frequently that whales come too near the stream and are overpowered by its violence; and then it is impossible to describe their bowlings and bellowings in their fruitless struggles to disengage themselves.*
>
> *A bear once attempting to swim from Lofoten to Moskoe, with a design of preying upon the sheep at pasture in the island, afforded the like spectacle to the people; the stream caught him and bore him down, whilst he roared terribly, so as to be heard on shore. Large stocks of firs and pine trees, after being absorbed by the current, rise again, broken and torn to such a degree as if bristles grew on them. This plainly shows the bottom to consist of craggy rocks, among which they are whirled to and fro. This stream is regulated by the flux and reflux of the sea; it being constantly high and low water every six hours. In the year 1645, early in the morning of Sexagesima Sunday, it raged with such noise and impetuosity that on the island of Moskoe the very stones of the houses fell to the ground.*

An unnamed American captain provides a first-hand account. Note the "It is evidently a subterranean passage."

> *I had occasion some years since to navigate a ship from the North Cape to Drontheim, nearly all the way between the islands or rocks and the min... Two good seamen were placed at the helm, the mate on the quarter-deck, all hands at their station for working ship, and the pilot standing on the bowsprit between the night-heads. I went on the main topsail yard with a good glass. I had been seated but a few moments, when my ship entered the dish of the whirlpool. The velocity of the water altered her course three points toward the center, although she was going three knots through the water. This alarmed me extremely for a moment. I thought destruction was inevitable... Imagine to yourselves an immense circle running round, of a diameter of one and a half miles, the velocity increasing as it approximated toward the center, and gradually changing its dark blue color to white -- foaming, tumbling, rushing to its vortex, very much concave, as much so as the water in a tunnel when half run out; the noise too, hissing, roaring, dashing, all pressing on the mind at once, presented the most awful, grand, and solemn sight I ever experienced. We were near it about 18 minutes, and in sight of it two hours. It is evidently a subterranean passage. From its magnitude, I should not doubt that instant destruction would be the fate of a dozen of our largest ships, were they drawn in at the same moment. The pilot says that several vessels have been sucked down, and that whales have also been destroyed.*



Historical Allusions

When in doubt about a legend's genesis, look to Homer's Odyssey.

> *You will see the other cliff lies lower, no more than an arrow's flight away. On this there grows a great leafy fig-tree; under it, awesome Kharybdis sucks the dark water down. Three times a day she belches it forth, three times in hideous fashion she swallows it down again. Pray not to be caught there when she swallows down.*
>
> *But when she sucked the sea-water in, one might look right down through the swirling eddy while the rock roared hideously around her and the sea-floor came to view, dark and sandy. Ashy terror seized on the crew. We had looked her way with the fear of death upon us; and at that moment Skylla snatched up from inside my ship the six of my crew who were the strongest of arm and sturdiest.*

As retold by John Milton in Paradise Lost (1658),

> *Or when Ulysses on the larboard shunned*
> *Charybdis, and by the other Whirlpool steered.*

"Sirens, Scylla and Charybdis," a 17th-century etching by Theodor van Thulden.

Odysseus shipwrecked. After meeting Charybdis, nothing remained of his ship except the mast and the keel. Drawing by Bonaventura Genelli, 1798-1868.

As in the sea between Scylla and Charybdis the helmsman is ever in danger, yet he will be thought shrewd and sagacious, if, keeping his ship on a straight course between the two, avoiding the rocks on the one side and the maelstrom on the other, he brings his ship safely to harbor.

Carlo Vitali, Dichiarazione dell'Impresa Generale della nuova Accademia Peloritana detta de' Pericolanti (1729)

Odysseus' encounter with Cyclops corresponds with an ancient Norse “kenningar” tale. Sorceress Circe's island, where there is a midnight sun and revolving dawns, speaks of northern latitudes. As the cacophony of Moskenstrom backwash on half-hidden rocks could deceive sailors that land is at hand, the Sirens could be Lofoten shoals made even more dangerous by fog and tide. South of Homer's Charybdis stands the island Thrinakia (“trident”). Mosken Island is three-tipped.

It indeed seems that a portion of Greek lore was drawn from locales far from Greece.

The eighth-century German, Paulus Warnefridi alluded to legend that there lies to the north a "very deep abyss of the waters which we call the ocean's navel. It is said twice a day to suck the waves into itself and spew them out again."

By the 16th century, the Moskenstrom was known to mapmakers.

Gerardus Mercator (1512-1594) made his livelihood as a craftsman of mathematical instruments and an engraver of brass plates. He is best remembered, however, as a mapmaker.

The Arctic map, the first ever of that region, was published a year after his death. At the center lies "Rupes nigra et altissima," a "very high black rock."

Why would such a rock be there?

As all seamen know, the needle of a compass is drawn by lodestone.

The map failed to show the Moskenstrom, but in a 1577 letter to English astrologer John Dee, the geographer placed both polar singularities -- the loadstone and the whirlpool -- at 90º latitude.

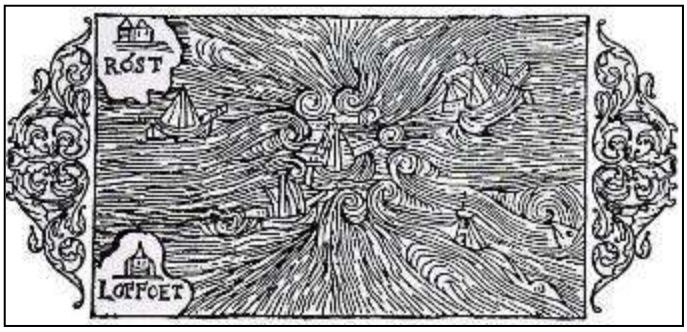
In the midst of the four countries is a Whirlpool... into which there empty these four indrawing Seas which divide the North. And the water rushes round and descends into the earth just as if one were pouring it through a filter funnel. It is four degrees wide on every side of the Pole,

that is to say eight degrees altogether. Except that right under the Pole there lies a bare rock in the midst of the Sea. Its circumference is almost 33 French miles, and it is all of magnetic stone.

The true magnetic pole is closer to Canada (labeled by Mercator as "California"). In Chapter 48, Subterranean Geophysics, we'll have more to say about this singularity.

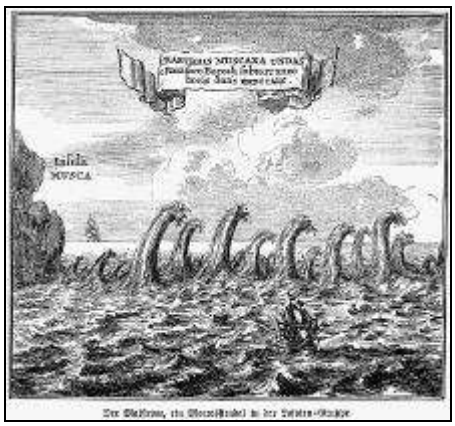
The Carta Marin (1539), the earliest detailed Scandinavian map, was crafted by the Swedish ecclesiastic Olaus Magnus. Note the "Horrenda Caribdis," sea monsters and icebergs.

Magnus's depiction of the Moskenstrom in Historia de Gentibus Septentrionalibus (1555) is shown to the right. He attributed the vortex to divine forces and deemed it stronger than the previously-known Sicilian whirlpool Charybdis.

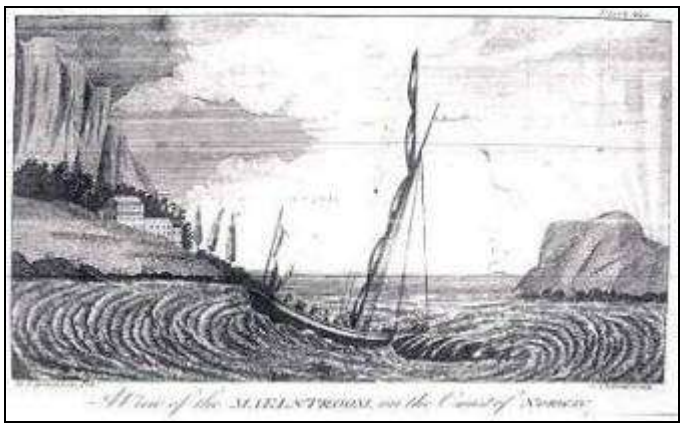


Norwegian priest Petter Das accurately described the Moskenstrom in The Trumpet of Nordland (c. 1685), attributing its strength to the phases of the moon, the current being strongest at the full and new phases. Unfortunately, Das wasn't translated into English.

Johannes Herbinius, the "Calvinist Copernicus," wrote his thesis on "waterfalls" in 1678.



Unattributed, 1678



Unattributed

An interesting topic, we may agree, but --we may wonder -- have oceanic whirlpools to do with underground rivers?

It took a great mind to deduce the tie.

Kircher's Meatus Subterraneus

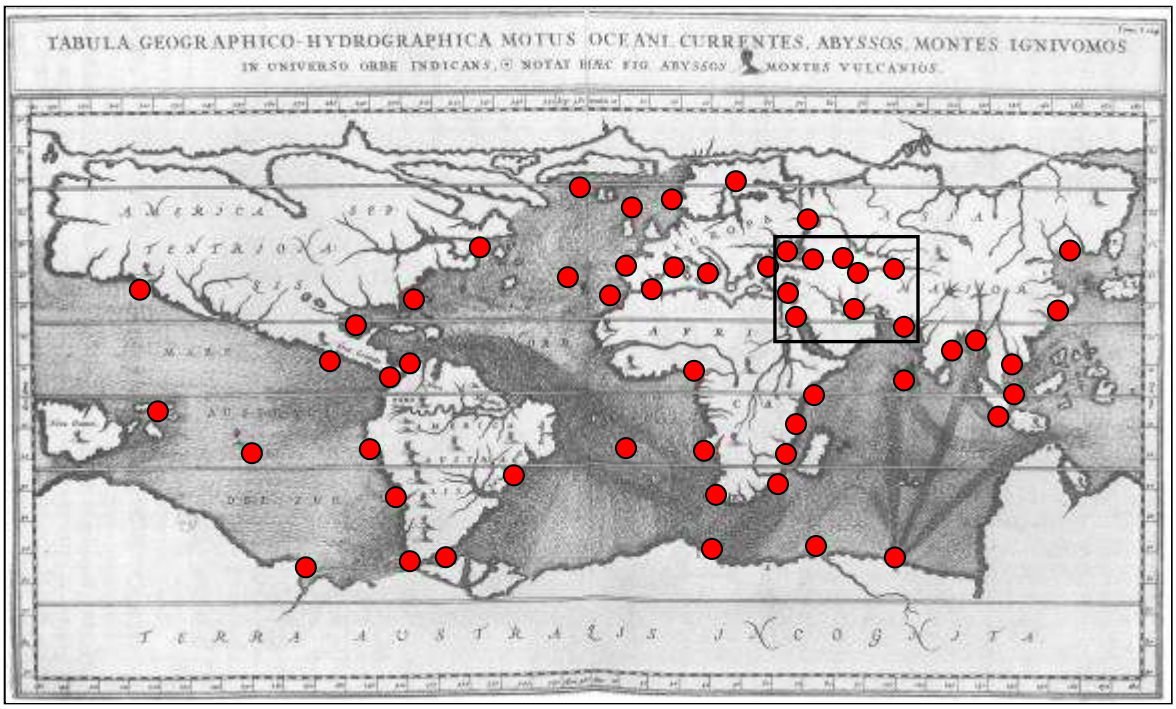
To the 17th-century polymath Athanasius Kircher, whom we met in Chapter 8, a whirlpool in the high sea would have seemed akin to the vortex observed when draining a cask. Ergo, there must be a hole in the floor of the sea.

The earliest chart of the global ocean circulation appeared in Kircher's Mundus Subterraneus (1665).

> *A breach swallowed up by the sea and carried into the entrails of the earth, circular ducts incomprehensible to human imagination, regurgitates at the other end opposite the South Pole.*

Holding to Aristotle's "primum mobile" the map charts the seas' the general westward flow. As to why particular currents should deviate from the ideal, Kircher turned to subterranean channels and cavities. The earth rhythmically sucks water into its interior near the North Pole (thus explaining the general pattern in the North Atlantic portion of his global map) and reissues it near the South Pole, mainly at three sites radiating into the Indian Ocean.

The map featured small markers -- enlarged below in red -- marking subterranean entrances and exits. Wherever an oceanic perplexity arose, such a marker provided a solution. The pair of dots straddling the Isthmus of Panama, for example, facilitates the globe's general westward current, a belief dating to Plato.

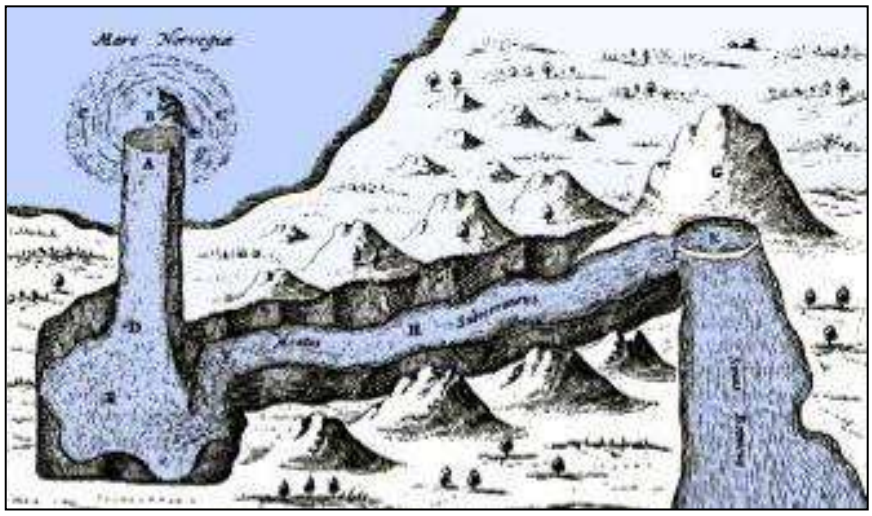


The box marks the Caspian Sea region, the subject of Chapter 75.

Mundus Subterraneus misplaced the Moskenstrom, but Kircher provided a more accurate location in other publications. Below is his portrayal of the Moskenstrom feeding a "Meatus Subterraneus," Latin for "burrow," to the interior.

When the level of the Gulf of Bothnia is raised to a sufficient height, the current reverses and aided by flow through a subterranean tunnel from the White Sea, raises the tide on the Norwegian coast.

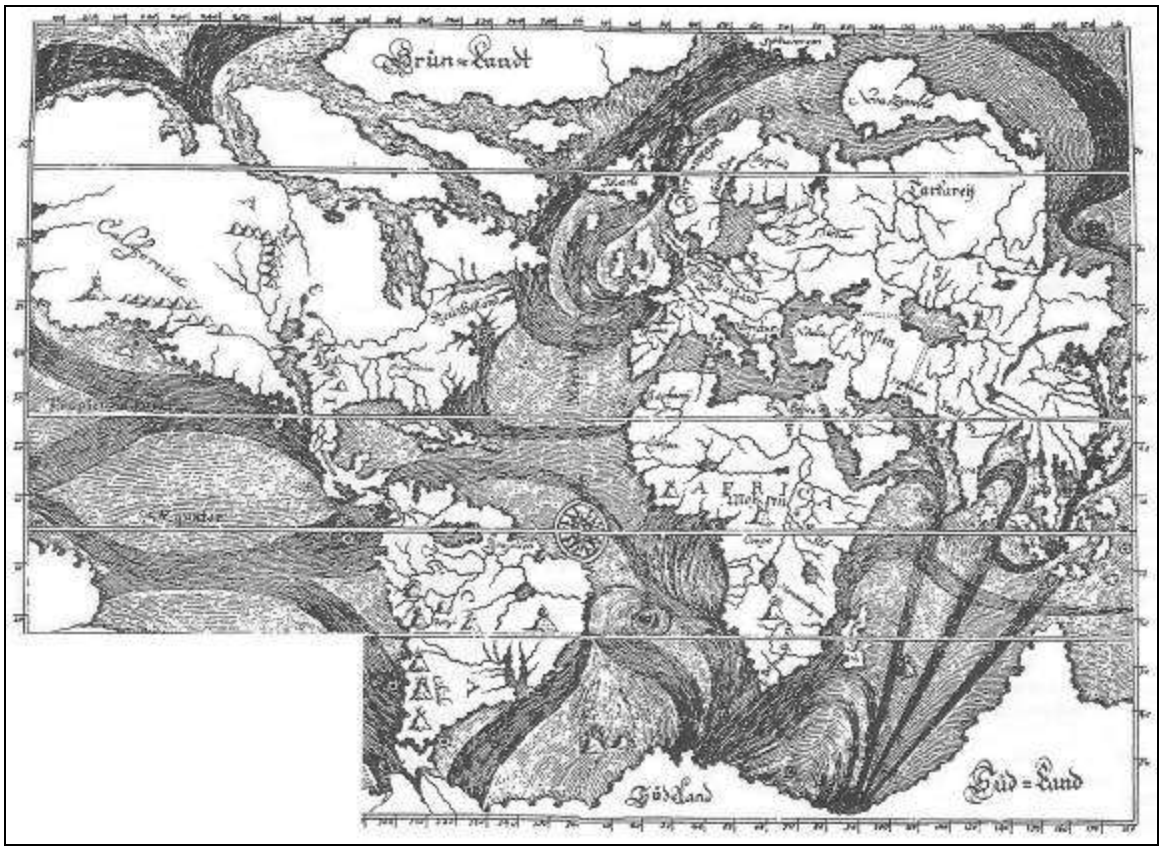
In the sketch to the right, the Moskenstrom ports to the Baltic, but there's no indication of an eastward extension.



Kircher's theory wasn't confined to points north. His map of the Stretto di Messina between Calabria and the island of Sicily depicts a "Canalis Subterraneus in Charybdis" having a lateral to -- or from, we can't be sure -- Mt. Etna.

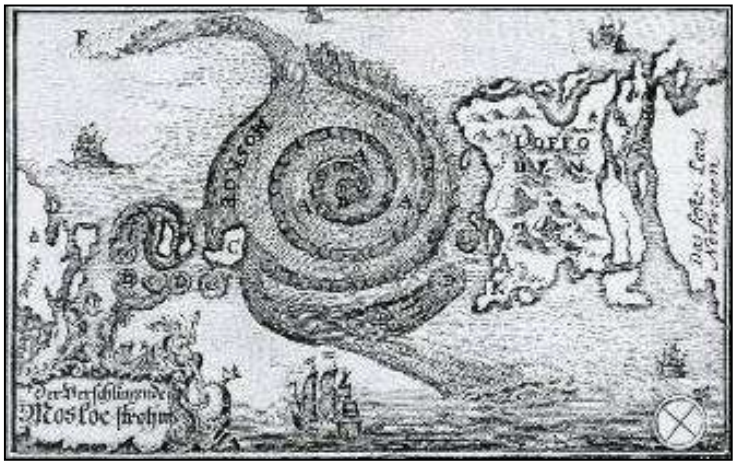
Traditional geography recognized a global ocean current flowing from south to north and from west to east (the Atlantic Gulf Stream). An underground circuit explained the return of these waters, interior pipes from east to west and from the North Pole to the South Pole.

Below is Eberhard Happel's map of oceanic currents from Groste Denkwiirdigkeiten der Welt oder Sogenannte Relationes Curiosae (1685). Borrowing from Kircher, Happle assumed a vast reservoir beneath each polar region, imbibing water at certain hours and expelling it at others.



Happle included a detail in the lower-left corner which we enlarge to the right.

It's the Moskenstrom.



The etching to the right is Doré's illustration "The Whirl," for the 1876 edition of The Rime of the Ancient Mariner, not the Norwegian Maelstrom, we recognize, but worth including for three reasons:

The dramatic whirlpool.

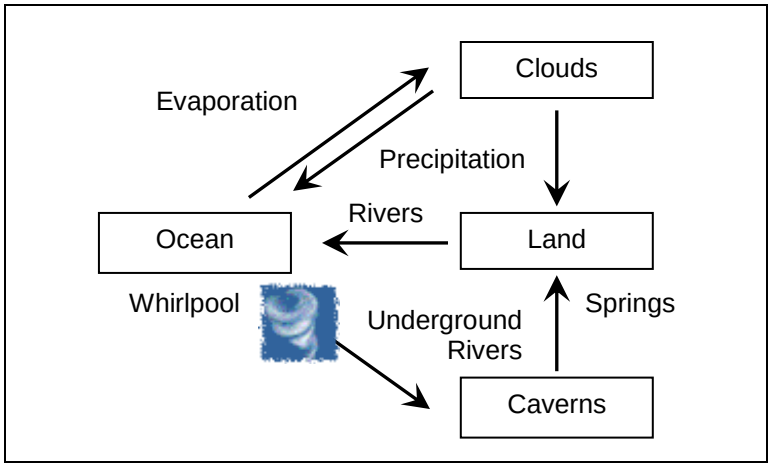
We encounter Doré's immediately-recognizable work elsewhere in our voyage, particularly in Chapter 34, Twenty-Five Centuries of Subterranean Portraits.

The Rime of the Ancient Mariner is by the poet Samuel Coleridge, author of "Kubla Kahn," the subject of Chapter 31, Down to a Sunless Sea.

It's an example of what so often we will find in our exploration of underground rivers. The tunnels intertwine.

The idea of water circulating deep within remained acceptable into the 18th century, as evidenced by Joseph Mead's An Essay on Currents at Sea (1758), and we will see in Chapter 28, Virtualizing the Imagined: Underground Rivers in Games, that such geography is yet with us.

Here's a schematic of how Kircher's "umbilicus maris" maintaining "a circulation like that of the blood in the human body" fits within a dual hydrologic cycle.



The Dual Hydrologic Cycle with Whirlpool

We earlier cited Moskenstrom lore from Duncan's The Mariner's Chronicle (1934). Duncan, however, was explicit in distancing himself from Kircher's subterranean hydrologic scheme.

> *The Maelstrom, a very dangerous whirlpool on the coast of Norway... Its violence and roarings exceed that of a cataract, being heard to a great distance, and without any intermission except a quarter every sixth hour, that is, at the turn of high and low water... This circumstance, among others, makes strongly against Kircher and others, who imagine that there is here an abyss penetrating the globe, and issuing in some very remote parts, which Kircher is so particular as to assign, for he names the gulf of Bothnia. But after the most exact researches*

> *which the circumstances will admit, this is but a conjecture without foundation: for this and three other vortices among the Ferroe islands, but smaller, have no other cause than the collision of waves, rising and falling at the flux and reflux, against a ridge of rocks and shelves which confine the water so that it precipitates itself like a cataract and thus the higher the flood rises the deeper must the fall be; and the natural result of this is a whirlpool or vortex, the prodigious suction whereof is sufficiently known by lesser experiments.*

The USS Nautilus glided under the polar ice in 1958 and found no downward opening. We can't be certain regarding the finding of the USS Thresher, we must allow, but that submarine's secret story must wait until Chapter 97, Extraterrestrials and Lost Races of the American West.

"Bottomless Pit Found on the Ocean's Floor," Far Out Magazine, April 1982, tells of an opening in the ocean floor between Panama and the Galapagos Islands, through which "scientists" say a constant flow of ocean water is being sucked beneath the marine floor.

It'd quite impossible to prove the absence of a hole.

Final Thoughts

We began this chapter with a question. Near the North Pole, there exist two singularities, the magnetic pole and the legendary Moskenstrom. Which is caused by an underground river?

For Kircher, the whirlpool was the doorway to below. He and his literary legacy -- Poe and his imitators whom we'll meet in 12-14 -- would have voted for the Moskenstrom.

But we now hold to a less-imaginative tidal explanation for the Norwegian seascape. The whirlpool is not of the bathtub drain variety. No water exits through the floor.

Kircher was wrong regarding the hydraulics, but his fanciful concept of the earth's fiery core was somewhat correct regarding the magnetic singularity. As we will see in Chapter 48, Subterranean Geophysics, there is indeed an underground river beneath us, one of molten iron, and that's compasses point the way they do.

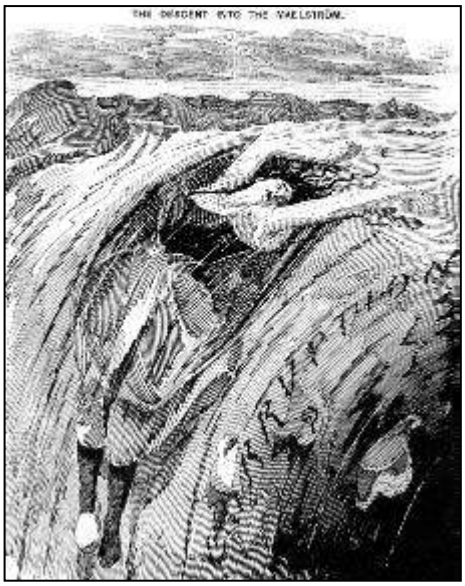
As we're in the area, we should note Norway's Gronligrotta, the world's northernmost underground river. The karst springs have attracted tourists since the 16th century.

World Record
Most Northern Underground River
66º 25'

In Chapter 99, we'll pursue why it is that we believe things and observe that there's more that intellect involved.

There's drama in a whirlpool. The Punch cartoon of 1893 could not have been more vivid in its denouncement of corruption.

And when it comes to hydrology, a bit of drama helps sell the presence of underground rivers.



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CHAPTER 17
UNDERGROUND RIVERS IN ENGLISH FICTION

In the telling of stories, we sail upon underground rivers. Writers who incorporate subterranean waters into their settings contribute to our collective imagination.

In Chapter 15, we reviewed pseudoscientific speculation regarding a hollow-earth. As the geophysical assumptions never passed the muster of scientific scrutiny, however, let us consider not the facts, but rather -- Hello again, Plato -- the ideals.

When asked about literary meaning, T.S. Elliot (1888-1965) reflected,

> *At what point in its course does the Mississippi become what the Mississippi means?*

Or as we might revise it, pursuant to our particular journey,

> *At what point in its course does an underground river become what an underground river means?*

Is it when the underground river meanders our imagination?

Before us lie ten chapters concerned with underground rivers in fiction. Ten chapters may seem to be overkill, we agree, but there are many shelves of such literature.

We'll not belabor the arching question as we march through our library, but we'll return to it at the end.

What commonalities of literary device do we detect in our bibliographic sojourn?

Were we to advise a novice author on proven ways to incorporate an underground river in a work of fiction, to what would we point?

While we could test hypotheses by tallying works, we'll not be that academic. We'll just meander through the bookshelves, skimming what catches our fancy. At the end, we'll reflect on our subjective impressions.

In this and the next chapter, we'll look at authors acclaimed in English literature; in the chapter after, we'll look at some who wrote other languages. In the three chapters following, we'll meet writers who aimed at the quintessential readership of underground river fiction, the Boys Club. In the interest of brevity and with our apologies to the authors, the excerpts are pared to quotations related to subterranean waters.

William Shakespeare (1564-1616)

Though no works of the Bard refer to underground rivers, per se, Shakespeare indeed mentions Charon in his less-remembered Troilus and Cressida (1602) through the mouth of Troilus,

> *No, Pandarus, I stalk about her door,*
> *Like a strange soul upon the Stygian banks*
> *Staying for waftage. O, be thou my Charon,*
> *And give me swift transportance to those fields (Act 3, Scene II)*

Perhaps when Hamlet says in Act 1,

> *There are more things in heaven and earth, Horatio,*
> *Than are dreamt of in your philosophy.*

But perhaps he intended to say,

There are more streams under the earth, Horatio,
Than are dreamt of in your philosophy.

Ben Jonson (1572-1637)

Ben Johnson likewise didn't write of subterranean waters, but he'd no right to daylight the boatman. From Catiline (1611),

The rugged Charon fainted,
And asked a navy, rather than a boat,
To ferry over the sad world that came.

John Milton (1608-1674)

In Milton's Paradise Lost (1658), archangel Lucifer rebels against the Almighty and is hurled over the ramparts of Heaven and down through Chaos "nine times the space that measures day and night" to the vaults of Hell, where,

Of four infernal Rivers that disgorge
Into the burning Lake their baleful streams;
Abhorred Styx the flood of deadly hate,
Sad Acheron of sorrow, black and deep;
Cocytus, nam'd of lamentation loud
Heard on the rueful stream; fierce Phlegeton
Whose waves of torrent fire inflame with rage.
Farr off from these a slow and silent stream,
Lethe the River of Oblivion rules
Her watery Labyrinth, whereof who drinks,
Forthwith his former state and being forgets,
Forgets both joy and grief, pleasure and pain.

The illustration is Gustave Doré's etching, "Satan Rising from the Burning Lake."

As Adam and Eve dwell joyously in Paradise, Lucifer ascends into Eden by means of an underground river, disguising himself as a serpent and presenting the apple. What could worse be recorded about an underground river than that it brought us sin?

Robert Paltock (1697-1767)

The Life and Adventures of Peter Wilkins (1751) tells of a sailor who enters a chasm at the South Pole through which a great river surges, and after five weeks, emerges into the inner world of "Graundevolet."

The debt to Robinson Crusoe, the Arabian Nights and Gulliver's Travels is clear.

The descent.

> *I expected every moment my poor little vessel would be staved against the rock, and I overwhelmed with waters; and for that reason never once attempted to rise up, or look upon my peril, till after the commotion had in some measure ceased. At length, finding the perturbation of the water abate, and as if by degrees I came into a smoother stream, I took courage just to lift up my affrighted head; but guess, if you can, the horror which seized me, on finding myself in the blackest of darkness, unable to perceive the smallest glimmer of light.*
>
> *However, as my boat seemed to glide easily, I roused myself and struck a light; but if I had my terrors before, what must I have now! I was quite stupefied at the tremendous view of an immense arch over my head, to which I could see no bounds; the stream itself, as I judged, was about thirty yards broad, but in some places wider, in some narrower.*
>
> *I had now cut a piece of my shirt for a wick to my last drop of oil, which I twisted and lighted. I burnt the oil in my brass tobacco-box, which I had fitted pretty well to answer the purpose Sitting down, I had many black thoughts of what must follow the loss of my light, which I considered as near expiring, and that, I feared, forever.*
>
> *A series of these meditations brought me (at the end of five weeks, as nearly as I could compute it by my lamp) to a prodigious lake of water, bordered with a grassy down, about half a mile wide, of the finest verdure I had ever seen: this again was flanked with a wood or grove, rising like an amphitheater, of about the same breadth; and behind, and above all, appeared the naked rock to an immense height.*

Arrival at land.

> *I perceived a small hollow or cut in the grass from the wood to the lake; thither I hasted with all speed, and blessed God for the supply of a fine fresh rill, which, distilling from several small clefts in the rock, had collected itself into one stream, and cut its way through the green sod to the lake.*
>
> *I lay down with infinite pleasure, and swallowed a most cheering draught of the precious liquid; and, sitting on the brink, made a good meal of what I had with me, and then drank again.*

Aquatic life.

> *In five hauls, I caught about sixteen fish of three or four different sorts, and one shell-fish, almost like a lobster, but without great claws, and with a very small short tail; which made me think, as the body was thrice as long as a lobster's in proportion, that it did not swim backwards, like that creature, but only crawled forwards (it having lobster-like legs, but much shorter and stronger), and that the legs all standing so forward, its tail was, by its motion, to keep the hinder part of the body from dragging upon the ground, as I observed it did when the creature walked on land, it then frequently flicking its short tail.*

Strange sight on the lake.

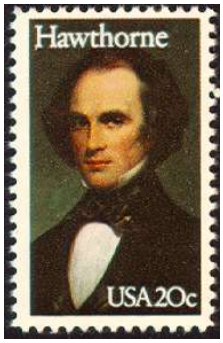
> *I went forward towards the sound, till I came to the verge of the wood, where I could see the lake very well by the dazzle of the water. Thereon, as I thought, I beheld a fleet of boats, covering a large compass, and not far from the bridge. I was shocked beyond expression*

Jane Austen (1775-1817)

In Frederic & Elfrida (c. 1792), the teenage Austen is exuberant in the sentimental conventions of her day.

> *On her return to Crankhumdunberry (of which sweet village her father was Rector), Charlotte was received with the greatest Joy by Frederic & Elfrida, who, after pressing her alternately to their Bosoms, proposed to her to take a walk in a Grove of Poplars which led from the Parsonage to a verdant Lawn enameled with a variety of variegated flowers & watered by a purling Stream, brought from the Valley of Tempé by a passage underground.*

Nathaniel Hawthorne (1804-1864)



And for the morbid, consider Hawthorne's chapter "On the Edge of a Precipice," The Marble Faun (1860),

> *"Doubtless, too," resumed the sculptor (for his imagination was greatly excited by the idea of this wondrous chasm), "all the blood that the Romans shed, whether on battlefields, or in the Coliseum, or on the cross, -- in whatever public or private murder, -- ran into this fatal gulf, and formed a mighty subterranean lake of gore, right beneath our feet. The blood from the thirty wounds in Caesar's breast flowed hitherward, and that pure little rivulet from Virginia's bosom, too! Virginia, beyond all question, was stabbed by her father, precisely where we are standing."*

Edgar Allan Poe (1809-1849)

One the greatest and surely the unhappiest of American authors, Poe married his 13-year-old cousin Virginia and strove to publish his writings. But as his works gained notice -- Poe was the first American author to be widely read outside the United States -- Virginia died of tuberculosis and Poe became increasingly depressed and erratic. In 1849 Poe disappeared in Baltimore and was found five days later, intoxicated and near death near the river front. He died four days later.

Poe's fiction dealt with paranoia, obsessions, death, feverish fantasies, the cosmos as source of both horror and inspiration.

The Narrative of Arthur Gordon Pym (1850), Poe's longest tale, is a dramatization of the beliefs of John Cleves Symmes (Chapter 15), the hollow-earth proponent whom Poe would have read in his youth.

“My name is Arthur Gordon Pym” is less gripping than Herman Melville's “Call me Ishmael,” but Poe's narrative does involve disaster in the South Pacific. Pym’s schooner is in the pack-ice where (due to Poe’s misinformation of Antarctic fauna) the explorers encounter a “gigantic creature of the race of the Arctic bear.”

Sailing further south, Pym's vessel encounters warmer weather and lands upon a wooded island where treacherous savages lead them to a chasm inland which descends into the bowels of the earth. Excerpts of Pym’s diary entries catch the gist of the sojourn.

March 9 -- The range of vapor to the southward had arisen prodigiously in the horizon, and began to assume more distinctness of form. I can liken it to nothing but a limitless cataract, rolling silently into the sea from some immense and far-distant rampart in the heaven. The gigantic curtain ranged along the whole extent of the southern horizon. It emitted no sound.

March 21 -- The summit of the cataract was utterly lost in the dimness and the distance. Yet we were evidently approaching it with a hideous velocity. At intervals there were visible in it wide, yawning, but momentary rents, and from out these rents, within which was a chaos of flitting and indistinct images, there came rushing and mighty, but soundless winds, tearing up the enkindled ocean in their course.

March 22 -- The darkness had materially increased, relieved only by the glare of the water thrown back from the white curtain before us. Many gigantic and pallidly white birds flew continuously now from beyond the veil, and their scream was the eternal Tekeli-li! as they retreated from our vision... And now we rushed into the embraces of the cataract, where a chasm threw itself open to receive us. But there arose in our pathway a shrouded human figure, very far larger in its proportions than any dweller among men. And the hue of the skin of the figure was of the perfect whiteness of the snow.

The white curtain. The white birds. A white human figure. Nothingness.

There is no March 23 entry, and Pym leaves untold how he came to write his memoir.

In the January 1837 Southern Literary Messenger, Poe reviewed the Congressional address by Symmes' devotee, Jeremiah Reynolds, discussed in the previous chapter.

He has seen his measures adopted in the teeth of opposition, and his comprehensive views thoroughly confirmed in spite of cant, prejudice, ignorance and unbelief… With mental powers of the highest order, his indomitable energy is precisely of that character which will not admit of defeat.

In writing Pym, Poe lifted some 700 words of Reynolds' speech.

Poe pursues his fascination with whirlpools in Descent into the Maelstrom (1841), citing the 1823 Encyclopedia Britannica for historical and geographical reality, but this maelstrom was many times the size of the Norwegian Moskenstrom of Chapter 16. Poe's maelstrom, as seen from the mountain,

Suddenly -- very suddenly -- this assumed a distinct and definite existence, in a circle of more than half a mile in diameter. The edge of the whirl was represented by a broad belt of gleaming spray; but no particle of this slipped into the mouth of the terrific funnel, whose interior, as far as the eye could fathom it, was a smooth, shining, and jet-black wall of water, inclined to the horizon at an angle of some forty-five degrees, speeding dizzily round and round with a swaying and sweltering motion, and sending forth to the winds an appalling voice, half shriek, half roar, such as not even the mighty cataract of Niagara ever lifts up in its agony to Heaven.

And as seen from within,

The current acquired a monstrous velocity. The vast bed of the waters, seamed and scarred into a thousand conflicting, channels, burst suddenly into frenzied convulsions—heaving, boiling, hissing -- gyrating in gigantic and innumerable vortices, and all whirling and plunging on to the eastward with a rapidity water never elsewhere assumes, except in precipitous descents. In a few minutes more there came over the scene another radical alteration... The gyratory motions of the subsided vortices seemed to form the germ of another more vast.

The narrator refers to the whirlpool as a "Phlegethon," one of the rivers in the Greek underworld, and recalls Athanasius Kircher's claim that,

In the center of the channel of the Maelstrom is an abyss penetrating the globe, and issuing in some very remote part -- the Gulf of Bothnia being somewhat decidedly named in one instance.

That instance being Kircher, as per the pan-Scandinavian map of Chapter 16.

Poe even includes some applied physics,

I made, also, three important observations. The first was, that as a general rule, the larger the bodies were, the more rapid their descent; -- the second, that, between two masses of equal extent, the one spherical, and the other of any other shape, the superiority in speed of descent was with the sphere; -- the third, that, between two masses of equal size, the one cylindrical, and the other of any other shape, the cylinder was absorbed the more slowly.

The observations provide the narrator an escape scheme -- cling to an empty cask -- allowing his tale to be written.

Although Poe called Kircher's views regarding the Maelstrom as "idle," he admitted that upon viewing the Norwegian vortex, Kircher's explanation "was the one to which, as I gazed, my imagination most readily assented."

Poe's MS. Found in a Bottle (1833) is a somewhat-similar tale, but by virtue of the bottle, a story we'll withhold until Chapter 87.5.

In all three tales, Poe leaves unwritten what lies below the whirlpool; there's terror enough in the approach. And, as we will see in the chapter to follow, grist enough for many lesser mills.

Charles Dickens (1812-1870)

Dickens' classics deal with the underside of 19th-century London in a social sense, not a hydrologic one, but we'll visit the underground river that did draw his literary attention in Chapter 79, The Sinking of the Fleet.

J.W. De Forest (1826-1906)

There is a body of serious fiction that's lost in the libraries -- perhaps for good reason -- but when it comes to underground rivers, is thunderous English. We'll cite just one, De Forest's "Overland," The Galaxy, February 1871.

> *Isolated turrets, domes, and pinnacles came out in gleaming relief against the dark-blue background of the heavens. The opposite crests of the canyon shown with broad illumination. All the uncouth demons and monsters of the rock awoke, glaring and blinking, to menace the voyagers in the depth below. The contrast between this supereminent brilliancy and the sullen obscurity of the subterranean river made the latter seem more than ever like the Styx or Acheron.*

Literary overkill, but it would have worked a century ago.

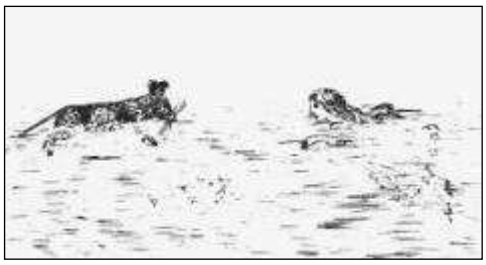
Lewis Carroll (Charles L. Dodgson, 1832-1898)

What Carroll first entitled Alice's Adventures under Ground came to be what we know as Alice's Adventures in Wonderland (1865). We'll pursue the challenge of tunnels through the globe in Chapter 27, Subterranean Waterbodies, one of many perplexities for our young friend.

> *"I wonder if I shall fall right through the earth! How funny it'll be to come out among the people that walk with their heads downwards! But I shall have to ask them what the name of the country is, you know. Please, Ma'am, is this New Zealand or Australia?" -- and she tried to curtsey as she spoke (fancy curtseying as you're falling through the air! do you think you could*

manage it?) "and what an ignorant little girl she'll think me for asking! No, it'll never do to ask: perhaps I shall see it written up somewhere."

Down in what's now forgotten as being underground, Alice finds the sea,



At this moment her foot slipped, and splash! she was up to her chin in salt water. Her first idea was that she had fallen into the sea: then she remembered that she was underground, and she soon made out that it was the pool of tears she had wept when she was nine feet high.

"Goldilocks' Adventure in Fairyland Under Old Mount Tamalpais" by David H. Walker, San Francisco Call, September 16, 1906, lifts unabashedly from Alice, except in this case, the heroine gets to sail on the underground river.

Enter the door that bears the words. "This Way to Fairyland," as you climb up Mount Tamalpais, and you shall come on a flight of marble steps that leads down, down, down ever so far going round and round, and then you will come to see an underground river and a boat. If you get into the boat it will sail wherever the fairies wish it to go, only it is sure to stop at some places or other in Fairyland, the land that is under Tamalpais Mountain.

Mark Twain (Samuel Langhorne Clemens, 1835-1910)


WONDERS OF THE CAVE.

Mark Twain
Cave
$15.95

Twain, on the other hand, wasn't bound by classical precedent. His underground river pointed to literary frontiers.

With the publication of The Adventures of Tom Sawyer (1876), McDougal's Cave became a celebrated tourist attraction and it has been so ever since, by lantern until 1939, electrically lit since. Tom and Becky's underground adventure has probably been responsible for more candles and string taken into the dark than can be counted.

When Tom and Becky encounter an underground stream, note Twain's care to describe the river's role in cave formation.

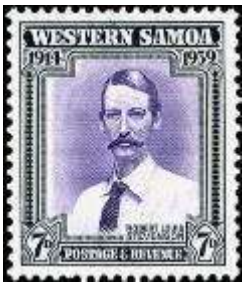
> *Presently they came to a place where a little stream of water, trickling over a ledge and carrying a limestone sediment with it, had, in the slow-dragging ages, formed a laced and ruffled Niagara in gleaming and imperishable stone... This shortly brought them to a bewitching spring, whose basin was incrusted with a frostwork of glittering crystals; it was in the midst of a cavern whose walls were supported by many fantastic pillars which had been formed by the joining of great stalactites and stalagmites together, the result of the ceaseless water-drip of centuries... Tom found a subterranean lake, shortly, which stretched its dim length away until its shape was lost in the shadows. He wanted to explore its borders, but concluded that it would be best to sit down and rest awhile, first. Now, for the first time, the deep stillness of the place laid a clammy hand upon the spirits of the children.*

It's no wonder Tom and Becky got lost; the cave contains nearly 3,500 meters of passages within its 6-hectare mapping.

Tom went on to other explorations, but it was Tom's companion, Huckleberry Finn (1884) who pushed American literature into the arena of social criticism.

What is less well known is the story of the cave itself. Discovered in 1820, the 3-kilometer maze of crisscrossed passages became notorious in 1849 when its owner, a physician interested in cadavers, put a wooden door on the cave and locked it. When it became known that the cave held a copper and glass flask containing the body of the doctor's 14-year-old daughter, the local citizens intervened.

Robert Lewis Stevenson (1850-1894)



We'd have liked to include Stevenson in our catalog, but his adventures were under the sun. It wasn't for lack of familiarity with Charon, however.

Suffering from a severe illness in California in 1880, he drew freely on Charon and the Styx in his correspondence. As noted to his friend, James Walter Ferrier,

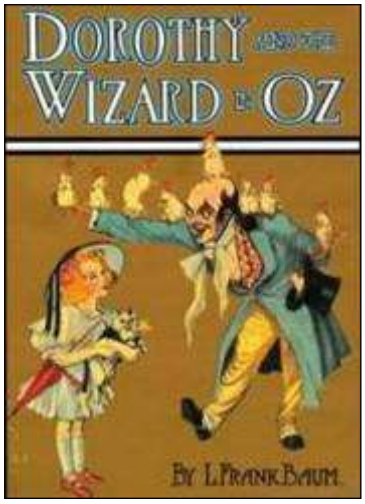
> *I am fresh from giving Charon a quid instead of an obulus; but he, having accepted the payment, scorned me, and I had to make the best of my way backward through the mallow-wood, with nothing to show for this displacement but the fatigue of the journey.*

In another letter,

> *I keep returning, and now hand over fist, from the realms of Hades. I saw that gentleman between the eyes, and fear him less after each visit. Only Charon, and his rough boatmanship, I somewhat fear.*

L. Frank Baum (1856-1919)

Baum is fondly remembered for The Wonderful Wizard of Oz (1900), but not stopping with the Yellow Brick Road, he followed with three more volumes. Dorothy and the Wizard in Oz (1908) was the last. Yes, this one's "in" not "of." Most of the action is outside of Oz, actually, but Baum liked close titles.



Dorothy is sent to visit her uncle who ranches in California. There, Dorothy and friends are riding a buggy when an earthquake swallows them.

> *Yes; there was land below them; and not so very far away, either. But they were floating very, very slowly -- so slowly that it could no longer be called a fall -- -and the children had ample time to take heart and look about them.*
>
> *They saw a landscape with mountains and plains, lakes and rivers, very like those upon the earth's surface; but all the scene was splendidly colored by the variegated lights from the six suns.*

It's not all folly, however. Dorothy encounters her old friend, the Wizard, and they fight invisible bears.

> *"Run for the river!" shouted the Wizard, and Jim quickly freed himself from his unseen tormenters by a few vicious kicks and then obeyed. As soon as he trotted out upon the surface*

of the river he found himself safe from pursuit, and Zeb was already running across the water toward Dorothy.

"I think we'd better stick to the river, after this," said Dorothy. "If our unknown friend hadn't warned us, and told us what to do, we would all be dead by this time."

"That is true," agreed the Wizard, "and as the river seems to be flowing in the direction of the Pyramid Mountain it will be the easiest way for us to travel."

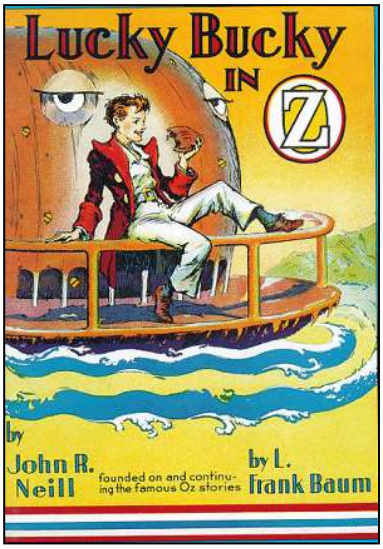
So what do we make of this?

That Dorothy should be remembered not only for travel by tornado and balloon, but also by underground river.

That Baum should have stopped with his first Oz volume, as by the fourth, the novelty's spent.

And if the spell was wearing thin by the fourth, what must be the quality of the 36th?

Lucky Bucky in Oz (1942) was by John R. Neill, but the series is still credited to Baum. Caught in a tugboat explosion in New York Harbor not far from the Statue of Liberty, young Lucky Bucky is pitched high into the stratosphere, eventually landing safely on a volcanic island next to Oz. Rescued by Davy Jones, a wooden whale, the new friends travel together to the Emerald City. But along the way, the two are swept down the underground river and into the kingdom of the gnomes.



And of course Jim Henson's Muppets would want to find the Emerald City. The Muppets' Wizard of Oz (2005).discussion from The Muppet Central Forum speaks to the nature of the underground river,

Okay! Onward to the water and to find our way to the Emerald City Palace!

The Muppets began walking down the cave toward the running water and soon they found an underground river. There was little space beside it to walk, but what appeared to be a little boat carved from a tree floated near them and was tied to a rock. The river was deep enough that you couldn't really see the bottom, and it was still and quiet, but the water was flowing in one direction, so the Muppets hopped into the boat and began riding the underground river wherever it would take them.

This is nice! I like this. It's like the ride at the fair where you ride the boat through the little tunnel...except there, there's monsters and stuff and you don't think anything will happen in this river do you?

Do you?

Naaahhh. It's too still of water for something to be going on.

Lessons:

Keep that river moving.

Don't keep licensing a beloved classic. Reputation is worth more than royalties.

Arthur Conan Doyle (1859-1930)

Arthur Conan Doyle practiced medicine in Hampshire. But once his A Study in Scarlet (1887) introduced Sherlock Holmes and his sidekick Dr. Watson to the reading public, its creator had no time to practice medicine.

Doyle wrote much more than mysteries. The Lost World (1912) was his effort at a popular "boy's book," a tale chronicling the adventures of explorers who discover dinosaurs and ape-men in the jungles of South America. At one point, the explorers evaluate a lake with no visible outlet.

> *"It is more than likely that the lake may be an old crater," said Summerlee. "The whole formation is, of course, highly volcanic. But, however that may be, I should expect to find the surface of the plateau slope inwards with a considerable sheet of water in the center, which may drain off, by some subterranean channel, into the marshes of the Jaracaca Swamp."*
>
> *"Or evaporation might preserve an equilibrium," remarked Challenger, and the two learned men wandered off into one of their usual scientific arguments, which were as comprehensible as Chinese to the layman.*

In the manner of his popular mysteries, Doyle added a professorial character to elucidate the reader. Elementary, my dear Watson. Outflow equals inflow less evaporation less underground discharge to Jaracaca Swamp.

Doyle's wife, chronically ill, died in 1907. His son perished in the Great War and Dole's last years turned increasingly toward spiritual quest, and in particular, desire to communicate with the deceased. Doyle's Tales of Terror and Mystery (1922) included the short story "The Terror of Blue John Gap." This work was, as its title suggests, not written to celebrate science.

> *The farm consists of grazing land lying at the bottom of an irregular valley. On each side are the fantastic limestone hills, formed of rock so soft that you can break it away with your hands. All this country is hollow. Could you strike it with some gigantic hammer it would boom like a drum, or possibly cave in altogether and expose some huge subterranean sea. A great sea there must surely be, for on all sides the streams run into the mountain itself, never to reappear.*
>
> *My view is -- and it was formed, as is shown by my diary, before my personal adventure--that in this part of England there is a vast subterranean lake or sea, which is fed by the great number of streams which pass down through the limestone. Where there is a large collection of water there must also be some evaporation, mists or rain, and a possibility of vegetation. This in turn suggests that there may be animal life, arising, as the vegetable life would also do, from those seeds and types which had been introduced at an early period of the world's history, when communication with the outer air was more easy.*

As Doyle embraced spiritualism, the behavior of his great underground sea became less elementary.

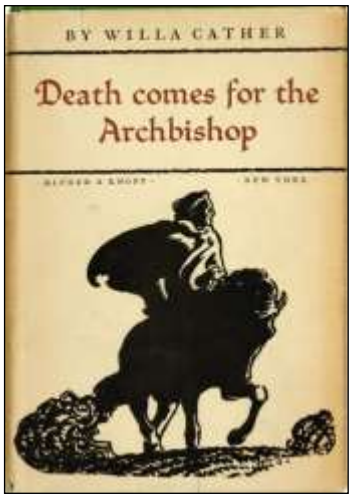
Willa Cather (1873-1947)

We'll have more to say about the literary device in Chapter 30, but here's a metaphor from Cather's O Pioneers, Winter Memories, II (1913).

> *Her personal life, her own realization of herself, was almost a subconscious existence; like an underground river that came to the surface only here and there, at intervals months apart, and then sank again to flow on under her own fields. Nevertheless, the underground stream was there*
> *.*

"Coming, Aphrodite!" in Youth and the Bright Medusa (1920),

> *The Captive took out the bar that was beneath a stone in the floor of the passage, and put in its stead a rush-reed, and the youth stepped upon it and fell through into a cavern that was the bed of an underground river, and whatever was thrown into it was not seen again.*



And here is arguably the best penned passage pertaining to an underground river in the whole of literature. It's worth reading twice.

> *Father Latour lay with his ear to this crack for a long while, despite the cold that arose from it. He told himself he was listening to one of the oldest voices of the earth. What he heard was the sound of a great underground river, flowing through a resounding cavern. The water was far, far below, perhaps as deep as the foot of the mountain, a flood moving in utter blackness under ribs of antediluvian rock. It was not a rushing noise, hut the sound of a great flood moving with majesty* and power. -- Death Comes for the Archbishop (1927)

The archbishop-to-be listens to the earth giving birth.

Cather spent time in southern France seven years before publication of Death Comes to the Archbishop. Geographic references in the novel bracket the site of Gouffre de Padirac (Chapter 54). Cather would have been acquainted with tales of its iconic river.

Jack London (1876-1916)

A Son of the Sun (1912),

> *Several times filling and emptying his lungs in diver fashion, Grief turned over and went down through the water. Salt it was to his lips, and warm to his flesh; but at last, deep down, it perceptibly chilled and tasted brackish. Then, suddenly, his body entered the cold, subterranean stream. He removed the small stopper from the calabash, and, as the sweet water gurgled into it, he saw the phosphorescent glimmer of a big fish, like a sea ghost, drift sluggishly by.*

James Joyce (1882-1941)

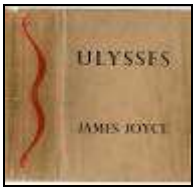
Ulysses Rivers, Dublin

We attach Joyce because we cannot ignore a penultimate work that draws so explicitly upon four of the five classical underground rivers. Joyce saw the Odyssey as literature's most well-rounded human portrait. That much said, Joyce's literary style is beyond most of us.

A few riverine quotations,

> *I moved among them on the frozen Liffey, that I, a changeling, among the spluttering resin fires. I spoke to no-one; none to me.*
>
> *From its sluice in Wood quay wall under Tom Devan's office Poddle River hung out in fealty a tongue of liquid sewage.*
>
> *A covey of gulls, storm petrels, rises hungrily from Liffey slime with Banbury cakes in their beaks.*

Here's how Joyce's' Ulysses stacks up against the Odyssey.

	 Odyssey (c. 855 BC)	 Ulysses (1922)
Author	Homer	James Joyce
Protagonist	Odysseus	Leopold Bloom
Setting	Mythical Mediterranean, Mythical times	Dublin, 1904
Opening	*Tell me, O muse, of that ingenious hero who travelled far and wide after he had sacked the famous town of Troy.*	*Stately, plump buck Mulligan came from the stairhead, bearing a bowl of lather on which a mirror and a razor lay crossed.*
Characters	Lotus Eaters Cyclops Sirens	Pharmacist Citizen in pub Barmaids
Rivers	Acheron Cocytus Styx Lethe Pyriphlegethon	Grand Canal Royal Canal Dodder Liffey

D.H. Lawrence (1885-1930)

Women in Love (1920),

> *Strange, and desolate above all things, like disembarking from the Styx into the desolated underworld, was this landing at night. There was the raw, half-lighted, covered-in vastness of the dark place, boarded and hollow underfoot, with only desolation everywhere.*

J.R.R. Tolkien (1892-1973)

Tolkien, a professor of philology (the use of language in literature) at Oxford, is best remembered not for his expertise in ancient tongues of Northern Europe, but for his fantasy Middle Earth imagined in meticulous linguistic, geographic and historical detail. It took Tolkien four-volumes to tell the story.

> The Hobbit (1937). The Hobbit Bilbo Baggins joins a company of dwarves and the Wizard Gandalf in a quest to reclaim an old dwarfish kingdom from the dragon Smaug.

The Fellowship of the Ring (1954), Part 1 of The Lord of the Rings. Bilbo's cousin and heir Frodo Baggins sets out on a quest to rid Middle Earth of the One Ring, joined by the Fellowship of the Ring.

The Two Towers (1954), Part 2 of The Lord of the Rings. The Fellowship is split apart while Frodo and his servant Sam continue their quest. Aragorn, Gimli and Legolas fight to rescue the hobbits Pippin and Merry from the Orcs and to save the Kingdom.

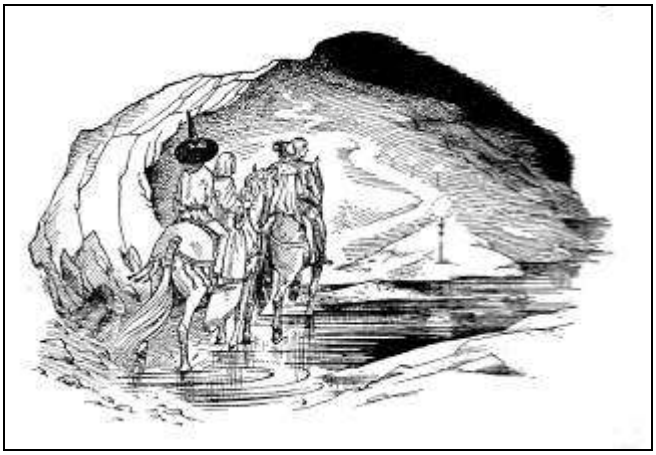
The Return of the King (1955), Part 3 of The Lord of the Rings. Frodo and Sam reach Mordor, while Aragorn arrives in Gondor and reclaims his heritage.

Good battles Evil and, at last, triumphs.

As a setting, Tolkien's geographic creation wasn't underground at all. To Tolkien, "Middle Earth" was an historical term derived from Old English "middangeard," the physical world in which humans live, as opposed to the unseen Heaven and Hell. Tolkien's Middle Earth is our earth ages ago when hobbits quietly dwelt before humans were aware of them.

Tolkien's setting does contain underground rivers, however. The saga features gloomy caverns and ultimately, Mengroth, the underground palace. Gollum, as drawn to the right by Nicholas Bayrachny, lives in a cave near a subterranean river. The river in Silmarillion dips underground and flows out of a cliff miles away. The source of the River Running is under the Lonely Mountain, the waters pouring out of an opening in the rock wall just inside the Front Gate.

C.S. Lewis (1898-1963)



River Shribble, marking the boundary
between Narnia and the lands of the giants

The Silver Chair (1953). Narnia is in peril and only Eustace and Jill can help. Along with gloomy Marsh-wiggle Puddleglum, they are sent by the mighty lion Aslan to find Prince Rilian, heir to the throne. Their quest leads them deep into the dark underground.

> *In this way they came to the edge of the chasm. It was about a thousand feet long and perhaps two hundred wide. They dismounted from their horses and came to the edge, and looked down into it. A strong heat smote up into their faces, mixed with a smell which was quite unlike any they had ever smelled. It was rich, sharp, exciting, and made you sneeze. The depth of the chasm was so bright that at first it dazzled their eyes and they could see nothing. When they got used to it they thought they could make out a river of fire, and, on the banks of that river, what seemed to be fields and groves of an unbearable, hot brilliance-though they were dim compared with the river.*

Of another underground river, less Pyriphlegethon,

> *Low tide was running up the valley like a mill-race, and if it had come to swimming, the horses could hardly have won over. But it was still only a foot or two deep, and though it swished terribly round the horses' legs, they reached the far side in safety.*

When in a parallel to Plato's cave, Lewis' Lady of the Green Kirtle tries to convince the children that there is no world outside, Puddleglum notes, "And there's one thing about this underground work, we shan't get any rain."

John Cheever (1912-1982)

In Cheever's "The Swimmer" (1978), a familiar landscape is seen anew.

> *This was at the edge of the Westerhazys' pool. The pool, fed by an artesian well with a high iron content, was a pale shade of green. It was a fine day. In the west there was a massive stand of cumulus cloud so like a city seen from a distance -- from the bow of an approaching ship -- that it might have had a name. Lisbon. Hackensack. The sun was hot. Neddy Merrill sat by the green water, one hand in it, one around a glass of gin.*
>
> *He had been swimming and now he was breathing deeply, stertorously as if he could gulp into his lungs the components of that moment, the heat of the sun, the intenseness of his pleasure. It all seemed to flow into his chest. His own house stood in Bullet Park, eight miles to the south, where his four beautiful daughters would have had their lunch and might be playing tennis. Then it occurred to him that by taking a dogleg to the southwest he could reach his home by water. He seemed to see, with a cartographer's eye, that string of swimming pools, that quasi-subterranean stream that curved across the county. He had made a discovery, a contribution to modern geography; he would name the stream Lucinda after his wife.*

William Kittredge (b. 1932)

In "The Underground River" (1984), such a river is where one disposes of a body,

> *Lately, since Lonnie'd left, he had been imagining the water sound even when he wasn't hearing it. All his life had gone to bed with that murmur, awakened with it, slept beneath it lain sleepless listening to Lonnie's tubercular breath and the summer water.*
>
> *A half mile below his house the river vanished underground. Cleve had dreamed of the river, and because of that dream, because Lonnie's death and the dream were all connected with the sound of water falling, he wanted to send Lonnie down through the boulders to the place where the water was sucked into the earth. The water fell between boulders in a long black lava rockslide to resurface at the bottom of the ridge, over a mile away, and the sound of the falling was hollow, as if the water dropped a great distance onto a plate of steel.*

"Mysterious Pools," Quincy Daily Herald; June 20, 1894, mentions an ominous rumor along this very line.

> *North of Gainesville is a pretty any mysterious spot called the "Devil's Millhopper." A large stream of water comes down a hill with considerable force and disappears in a pool that has no*

visible outlet. Near Brooksville is another stream very similar to Devil's Millhopper. A stream of water pours into it and disappears in a whirlpool in the center. Throw a log in it and it will circle the pool many times, gradually drawing near to the center. Suddenly the log disappears.

Some gruesome stories are connected to the Brooksville pool. It is said that the place is haunted, for the reason that many a man, and woman, too, has mysteriously disappeared in it, never to be heard of afterward. In the pioneer days of that part of the country, so the stories go, there was a secret society which washed all its dirty linen in that pool. In other words, if a man or woman gave offense to any member of the society, he or she was gagged, bound and in the darkness of night thrown into the pool.

The table summarizes the variety of the subterranean hydrologic features envisioned by some of our authors.

Author	Works	Entrance	Springs	Rivers	Seas	Flesch-Kincaid Grade Level
John Milton	Paradise Lost (1658)	Satan's Trickery	Yes	Yes	Yes	N.A. because of poetic style
Robert Paltock	The Life and Adventures of Peter Wilkins (1751)	Antarctic whirlpool	Yes	Yes	Yes	9.5
Edgar Allan Poe	MS. Found in a Bottle (1833) A Descent into the Maelstrom (1841) The Narrative of Arthur Gordon Pym (1850)	Antarctic whirlpool Arctic whirlpool. Antarctic whirlpool			Yes.	11.5
James Carroll	Alice in Wonderland (1865)	Rabbit hole			Yes	6.3
Mark Twain	The Adventures of Tom Sawyer (1876)	Cave		Yes		5.7
L. Frank Baum	Dorothy and the Wizard in Oz (1908)	Swallowed by earthquake		Yes		4.2
Arthur Conan Doyle	The Lost World (1912)	South American jungle		Yes		8.0
J.R.R. Tolkien	Lord of the Rings (1954-1955)	Fantasy	Yes	Yes	Yes	4.1
C.S. Lewis	The Silver Chair (1953)	Willpower		Yes	Yes	4.2
James Joyce	Ulysses (1922)					4.1
Willa Cather	Death Comes for the Archbishop (1927)	Cave sacred to the Indians		Yes		6.8

The Flesch-Kincaid Grade Level score rates text on a US grade-school level, based on sentence length and syllables/word, but not on vocabulary. An 8.0 means that an eighth grader can understand the document. When it comes to underground rivers in English fiction, only Poe

requires the proficiency of high school graduate. Joyce's 4.1 seems inexplicable until we realize that his short words are sufficient to tax our comprehension.

Acclaimed as these authors may be, however, none demonstrates much hydrologic imagination. Chapters 20-26 consider writers of perhaps less literary , but more creativity regarding waters below.

CHAPTER 18
UNDERGROUND RIVERS IN CONTINENTAL FICTION

The previous chapter dealt with contributions to English literature; this chapter deals with writings in other languages.

We'll begin with a collection of Persian tales from times long past -- the legend of Sinbad the Sailor, popularized as part of Richard Burton's (not the actor of the same name) 1885 translation of 1,001 Arabian Nights, the number 1,001 being Burton's embellishment.

According to Christa A. Tuczay, "Motifs in the Arabian Nights and in Ancient and Medieval European Literature, a Comparison," Folklore, December 2005, seven motifs from 1,001 Arabian Nights made their way into the fabric of Western sensibilities.

The Magnetic Mountain
The Congealed Sea
The Flying Griffins
The Automaton and the Genie in the Bottle
The Walled City and the World's Vanities
The Living Island
The Subterranean River, our precise interest.

In Sinbad's sixth voyage he is shipwrecked once again -- our adventurer has a propensity for such misfortune, it seems -- and from his raft he discovers a subterranean waterway emerging from a rocky archway beneath the cliffs of a mysterious island.

Sinbad falls asleep as he drifts into the channel -- it is not clear why he floats upstream, but this is Sinbad -- to awaken in the Kingdom of Serendib (modern-day Sri Lanka) where "diamonds are in its rivers and pearls are in its valleys."

The illustration of Sinbad emerging is from a German publication of the 1930s. We can blame the Nazis for the racial stereotypes, but we'd have given it little thought back then.

As testament to the legacy of the Persian adventurer, we quote William McCardell description of his 1853 discovery of mist-filled Sulphur Cave in what would later become Banff National Park

> *Like some fantastic dream from a tale of the Arabian Nights*.

Below, a pair of Sulfur Cave postcards,

In the medieval German saga Herzog Ernst (c. 1180), the protagonist travels through the Orient in search of the Holy Grave, encountering such wonders as creatures with human bodies and crane's heads and as a nod to Odysseus, a Cyclops. After escaping from a magnetic mountain, Ernst follows a river too broad and swift to cross which carries him into another mountain. From the channel wall, our hero breaks off the "orphan" jewel destined to adorn the German imperial crown.

In the 13th-century French epic Chanson de Esclarmonde, an angel advises the hero, Huon, to follow the subterranean river lined with precious stones into the mountain Tenebree.

In the Old English Boke of Duke Huon of Burdeux, a retelling of the French, the duke's jeweled boat is hurled down a dark passage having great bars of red-hot iron hissing in the water. It's an 11-day underground sail until Huon emerges in the Persian Sea.

In German, French and English, it's the same bejeweled sojourn on a subterranean river.


HISTOIRE
DE HUON
DE BORDEAUX.
PAIR DE FRANCE, DUC DE GUIENNE,

Voltaire's Candide (1758) contains parallels to the story of Sinbad, notably where Candide and his valet Cacambo visit the utopian South American city of Eldorado, surrounded by unscalable mountains and reachable only by a 24-hour underground boat ride. Whereas the Arabian Nights focuses on the narrative themes of providence and destiny, Voltaire substitutes the interference of divine power with human intervention.

Cacambo speaks,

> *"We can go no farther, we have walked far enough; I can see an empty canoe in the bank, let us fill it with cocoanuts, get into the little boat and drift with the current; a river always leads to some inhabited place. If we do not find anything pleasant, we shall at least find something new."*

The river continually became wider; finally it disappeared under an arch of frightful rocks which towered up to the very sky. The two travelers were bold enough to trust themselves to the current under this arch. The stream, narrowed between walls, carried them with horrible rapidity and noise. After twenty-four hours they saw daylight again; but their canoe was wrecked on reefs; they had to crawl from rock to rock for a whole league, and at last they discovered an immense horizon, bordered by inaccessible mountains. The country was cultivated for pleasure as well as for necessity; everywhere the useful was agreeable.

Johann Jakob Christoffel von Grimmelshausen published Der Abenteuerliche Simplicissimus (1669, The Adventurous Simplicissimus), chronicling portions of the Thirty Years War, but not constrained to bellicose history. Grimmelshausen's protagonist, the speculative Simplicissimus, visits Lake Mummelsee, the portal to an underworld not unlike that of Greek mythology.

I did inspect the lake, and found lying in it certain hewn timbers of the Würtemberg raft; and I by geometry took or estimated the length and breadth of the water (for 'twas far too wearisome to go round the lake and measure it by paces or feet), and entered the dimensions, by means of the scale reduction, in my tablets.

I walked along the lake to the left, where the water, which elsewhere is as clear as a crystal, doth begin, by reason of the monstrous depth, to show as black as coal, and therefore is so dreadful of appearance that the mere look of it doth terrify. And there I began to cast in stones as great as I could carry.

[I] *turned not mine eyes away from the depths of the lake, expecting to see certain bladders or bubbles rising up from the bottom, as is wont to happen when stones are thrown into deep water whether still or running*

Yet saw I naught of the kind, but was ware of certain creatures floating far down in the depths which in form reminded me of frogs, and flitted about like sparks from a mounting rocket which in the air doth work its full effect, and as they came nearer and nearer to me they seemed to grow larger and more like to human form, at which at first great wonder took hold of me, a great fear and trembling. "Ah," said I then to myself in my terror and wonder, and yet so loud that my dad, that stood beyond the lake, could her me, though the noise of the thunder was dreadful, "how great are the wondrous works of the Creator! yea, even in the womb of the earth and the depths of the waters!"

Simplicissimus is spokesperson of the Natural Philosophy of his times (Chapter 13, Hydrotheology/Theohydrology). The flittering water spirits then guide him to the center of the earth where the traveler unfortunately (for us, at least) ceases to maintain his hydrological journal.

Charles Perrault (one of the talented brothers we met in Chapter 12, Superterranean Metrics) did not invent the moralistic plots of his stories, but gave literary legitimacy to what were already folk tales. Modern readers know his Histoires ou Contes du Temps Passé (1697, Tales and Stories of the Past with Morals) by its subtitle Les Contes de ma Mère l'Oie, Tales of Mother Goose.

Within Mother Goose were Blue Beard, Sleeping Beauty, Little Red Riding Hood, Puss in Boots and Cinderella. (We'll get to Walt Disney, who capitalized greatly on such lore, but not until Chapter 25, Underground Rivers in the Comics.)

Perrault's "The Fairies" is set at a spring, the story of a younger sister, gentle and sweet, and her older sister, disagreeable and arrogant. Of the younger,

> *One of the poor child's many duties was to go twice a day and draw water from a spring a good half mile away, bringing it back in a large pitcher. One day when she was at the spring an old woman came up and begged for a drink.*
>
> *"Why, certainly, good mother," said the beautiful girl. Rinsing the pitcher, she drew some water from the cleanest part of the spring and handed it to her, lifting up the pitcher so that she might drink more easily.*
>
> *Now this old woman was a fairy.*

The remainder is somewhat predictable, as Mother Goose tends to be. Charles did not publish Mother Goose under his own name, but rather under the name of his son Pierre. Thus there were two Pierre Perraults, uncle and nephew, who wrote about water from springs, one for the Académie des Sciences, the other for les enfants.

Le Passage du Pôle Arctique au Pôle Antarctique par le Centre du Monde (1721), author anonymous, republished two years later as Relation d'un voyage du Pôle Arctique au Pôle Antarctique par le Centre du Monde is an early novel of the Maelstrom.

A whaling vessel bound for Greenland encounters a violent storm that drives it far into the Arctic Ocean where it is caught in a leftward vortex, 60 or 80 leagues in circumference -- Chapter 16 explains why the direction matters -- around a "kind of floating island whiter than snow" formed by the foam of the downward-rushing water. When the survivors return to the light, they are on a calm Antarctic sea.


RELATION D'UN VOYAGE DU POLE ARCTIQUE, AU POLE ANTARCTIQUE, PAR LE CENTRE DU MONDE, Avec la description de ce périlleux Passage, & des choses merveilleuses & étonnantes qu'on a découvertes sous le Pole Antarctique. AVEC FIGURES.

A AMSTERDAM, Chez N. ETIENNE LUCAS, Libraire, dans le Beurs straat, près du Dam, à la Bible d'Or. M. DCC. XXI.

Disembarking in what seems to be a new world, the sailors discover a crack into a "very large and spacious underground, divided into various large vaults... all carved by Nature in the Rock, some higher and more extensive than those of largest churches."

A "well of a prodigious depth" opens to the center of the earth where a lake bridged by a single arch "feeds the river that sustains the surface."

It's an adventure to be told over and over in centuries ahead

Norwegian **Ludvig Holberg**'s Nicolai Klimii iter Subterraneum (1741, Nicholas Klim's Subterraneous Journey, written in Latin) was pure and simple science fiction, a description of a utopian society from an outsider's (literally) point of view. Philosophy and theology student Klim falls into a cave and finds himself orbiting a planet revolving around an inner sun. He's attacked by a gryphon, but survives to lands on the planet and explores such topics as the morality, science, sexual equality, religion, and government of this interior world.

But most of interest (to us, at least) is Holberg's hydrology.

> *The country is intersected by greater and lesser canals, on which boats propelled by oars, skim with wonderful celerity. The oars are driven by self-moving machines, so quietly that very little motion is given to the water.*
>
> *The waters are filled with fish, and upon the banks of the rivers are seated splendid country houses.*
>
> *There are numberless silver mines within its borders; the sand of its rivers is colored by gold, and its coasts are paved with pearl oysters of the finest water.*
>
> *At the time of my arrival the water was very high, owing to the nearness of Nazar. This planet has the same effect upon the tides of the firmament, as our moon has upon those of the earth.*

> *Every movable thing on deck floated off, for besides the ever-rolling billows, an immense rain fell in terrific water-spouts, accompanied by thunder and lightning. It seemed as though all the elements had conspired for our destruction.*

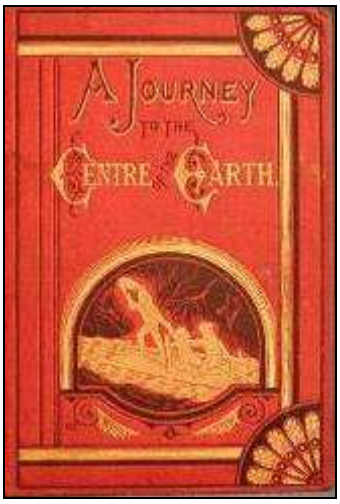
Based on Klim's account, water in the underworld seems to satisfy the same needs and present the same challenges as water in the outer world. As Holberg would wish us to believe, we've much to learn from such places.

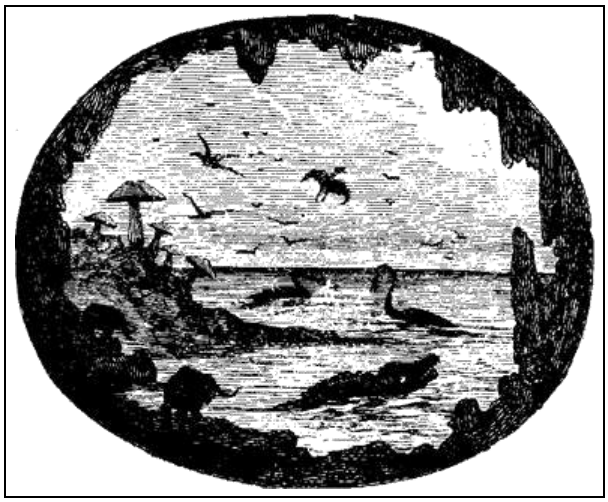
Victor Hugo's Les Miserables (1862) is an underground river tale, albeit an unpleasant waterway, but it can wait until Chapter 64, The Grand Tour, European Sewers of Distinction.

And now we arrive at perhaps the most-celebrated underground adventurist of all, **Jules Verne** (1828-1905).

Edgar Allan Poe was translated into French when Verne was 26 and Verne became a devoted admirer of the American, writing a sequel to Poe's unfinished narrative of Gordon Pym, The Sphinx of the Ice-Fields (1897).

At the center of Verne's works is the heroic scientist whose startling discoveries caught the enterprising spirit of the 19th century and its uncritical fascination with scientific progress. The popular science context in which Verne wrote Voyage au Centre de la Terre (1864, Journey to the Center of the Earth) included notions of a hollow earth proposed by John Cleves Symmes (Chapter 15). But Verne wasn't satisfied with make-believe, interviewing geographer Charles Sainte-Claire Deville who had explored the volcanoes of Teneriffe and Stromboli, where the Journey adventurers emerge at the end of their expedition.





Verne's rivers are pathways to discovery. An excerpt from Journey,

> *Then I began to hear distinctly quite a new sound of something running within the thickness of the granite wall, a kind of dull, dead rumbling, like distant thunder. During the first part of our walk, not meeting with the promised spring, I felt my agony returning; but then my uncle acquainted me with the cause of the strange noise.*

"Hans was not mistaken," he said. "What you hear is the rushing of a torrent."

"A torrent?" I exclaimed.

"There can be no doubt; a subterranean river is flowing around us."

And not much later, they puncture the steam below.

The pick had soon penetrated two feet into the granite partition, and our man had worked for above an hour. I was in an agony of impatience. My uncle wanted to employ stronger measures, and I had some difficulty in dissuading him; still he had just taken a pickaxe in his hand, when a sudden hissing was heard, and a jet of water spurted out with violence against the opposite wall.

The gallery dipped down a very little way from the horizontal, scarcely more than two inches in a fathom, and the stream ran gently murmuring at our feet. I compared it to a friendly genius guiding us underground, and caressed with my hand the soft naiad, whose comforting voice accompanied our steps. With my reviving spirits these mythological notions seemed to come unbidden.

The naiad of mythological notion is the Greek nymph who presides over fresh water fountains, wells, springs, streams, and brooks. Hylas of the Argo was lost when he was taken by naiads fascinated by his beauty. To the right is an engraving after Herbert James Draper's (1864-1920) painting.

Beyond such allusions to classical myth -- the mention of Virgil and his entrance to the underworld and Pluto, god of that realm, being two others -- Verne's science supersedes mythology. The journey to the underworld is a young explorer's initiation into manhood.

At first I saw absolutely nothing. My eyes, wholly unused to the effulgence of light, could not bear the sudden brightness; and I was compelled to close them. When I was able to reopen them, I stood still, far more stupefied than astonished. Not all the wildest effects of imagination could have conjured up such a scene! "The sea -- the sea," I cried.

"Yes," replied my uncle, in a tone of pardonable pride; "the Central Sea."

We began to walk along the shores of this extraordinary lake. To our left were abrupt rocks, piled one upon the other -- a stupendous titanic pile; down their sides leaped innumerable cascades, which at last, becoming limpid and murmuring streams, were lost in the waters of the lake. Light vapors, which rose here and there, and floated in fleecy clouds from rock to rock, indicated hot springs, which also poured their superfluity into the vast reservoir at our feet.

Journey to the Center of the Earth, film version (2008)

"What," I cried, rising in astonishment, "did you say the tide, Uncle?"

"And pray why not? Are not all bodies influenced by the law of universal attraction? Why should this vast underground sea be exempt from the general law, the rule of the universe? Besides, there is nothing like that which is proved and demonstrated. Despite the great atmospheric pressure down here, you will notice that this inland sea rises and falls with as much regularity as the Atlantic itself."

They blast a hole in the roof of the inner earth and the sea crashes down upon them, carrying their raft downward "at an angle steeper than that of the swiftest rapids in America." Their speed increases and then "a water-spout, a huge liquid column" strikes them and then they are propelled up to the outer world. As the Professor explains, "The water has reached the bottom of the abyss and is now rising to find its own level, taking us with it."

The Professor's grasp of hydraulics is questionable, but it works in fiction.

Twenty Thousand Leagues Under the Sea (1870) opens in 1866, three years prior to the opening of the Suez Canal, and thus while Captain Nemo is verbose regarding the navigation advancement, he can't actually use the waterway. For the Nautilus, however, that's scarcely a problem, as there's the underground channel between the Red Sea and the Mediterranean.

"Unfortunately," he [Captain Nemo] *continued, "I cannot take you through the Suez Canal; but you will be able to see the long jetty of Port Said after tomorrow, when we shall be in the Mediterranean."*

"The Mediterranean!" I exclaimed.

"Yes, sir; does that astonish you?"

"Well, it is the fearful speed you will have to put on the Nautilus, if the day after tomorrow she is to be in the Mediterranean, having made the round of Africa, and doubled the Cape of Good Hope!"

"Who told you that she would make the round of Africa and double the Cape of Good Hope, sir?"

"Well, unless the Nautilus sails on dry land, and passes above the isthmus."

"Or beneath it, M. Aronnax."

"Beneath it?"

"Certainly," replied Captain Nemo quietly. "A long time ago Nature made under this tongue of land what man has this day made on its surface."

"What! Such a passage exists?"

"Yes; a subterranean passage, which I have named the Arabian Tunnel. It takes us beneath Suez and opens into the Gulf of Pelusium.

"I noticed that in the Red Sea and in the Mediterranean there existed a certain number of fishes of a kind perfectly identical. Certain of the fact, I asked myself was it possible that there was no

communication between the two seas? If there was, the subterranean current must necessarily run from the Red Sea to the Mediterranean, from the sole cause of difference of level.

"The entrance cannot be easy?"

"No, sir; for that reason I am accustomed to go into the steersman's cage and myself direct our course. And now, if you will go down, M. Aronnax, the Nautilus is going under the waves, and will not return to the surface until we have passed through the Arabian Tunnel."

At a quarter-past ten, the Captain himself took the helm. A large gallery, black and deep, opened before us. The Nautilus went boldly into it. A strange roaring was heard round its sides. It was the waters of the Red Sea, which the incline of the tunnel precipitated violently towards the Mediterranean. The Nautilus went with the torrent, rapid as an arrow, in spite of the efforts of the machinery, which, in order to offer more effective resistance, beat the waves with reversed screw.

On the walls of the narrow passage I could see nothing but brilliant rays, straight lines, furrows of fire, traced by the great speed, under the brilliant electric light. My heart beat fast.

At thirty-five minutes past ten, Captain Nemo quitted the helm, and, turning to me, said:

"The Mediterranean!"

In less than twenty minutes, the Nautilus, carried along by the torrent, had passed through the Isthmus of Suez.

Verne, forever the spokesperson for science, keeps his readership abreast of recent discoveries. From The Underground City, or, The Black Indies (1877), sometimes called The Child of the Cavern,

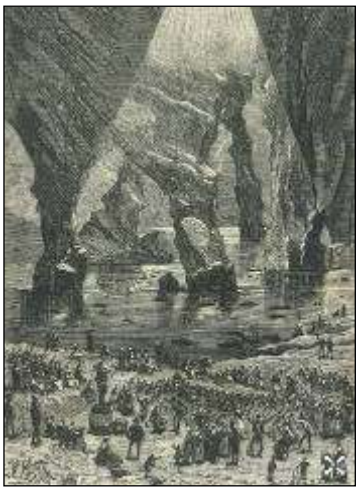
It could be compared to nothing but the celebrated Mammoth caves, which, in an extent of more than twenty miles, contain two hundred and twenty-six avenues, eleven lakes, seven rivers, eight cataracts, thirty-two unfathomable wells, and fifty-seven domes, some of which are more than four hundred and fifty feet in height. Like these caves, New Aberfoyle was not the work of men, but the work of the Creator.

However that might be, there was, under the Scottish subsoil, what might be called a subterranean county, which, to be habitable, needed only the rays of the sun, or, for want of that, the light of a special planet.

Water had collected in various hollows, forming vast ponds, or rather lakes larger than Loch Katrine, lying just above them. Of course the waters of these lakes had no movement of currents or tides; no old castle was reflected there; no birch or oak trees waved on their banks. And yet these deep lakes, whose mirror-like surface was never ruffled by a breeze, would not be without charm by the light of some electric star, and, connected by a string of canals, would well complete the geography of this strange domain.

The gallery ended in an enormous cavern, neither the height nor depth of which could be calculated. At what altitude arched the roof of this excavation -- at what distance was its opposite wall -- the darkness totally concealed; but by the light of the lamp the explorers could discover that its dome covered a vast extent of still water--pond or lake -- whose picturesque rocky banks were lost in obscurity.

"Mr. Starr," said he, "you see this immense cavern, this subterranean lake, whose waters bathe this strand at our feet? Well! it is to this place I mean to change my dwelling, here I will build a new cottage, and if some brave fellows will follow my example, before a year is over there will be one town more inside old England."



In terms of a true underground river, however, Verne's epic Mediterranean adventure, Mathias Sandorf (1895) stuck closer to factual (if exaggerated) geology.. "I wish my readers to learn everything they should know about the Mediterranean," Verne wrote, "which is why the action transports them to twenty different places."

Verne may have heard about the foiba (sinkhole) beneath Pisino Castle in the works of Charles Yriarte who described Count Esdorff's search for the end of the connecting underground river. Unfortunately the count's boat never made it out.

This abyss is the Buco, as it is called in the district. Through it runs a river known as the Foiba. This river finds its only outlet in a cavern which it has gradually cut out of the rocks, and into which it falls with the impetuosity of a tide-race or a whirlpool. Where does it go as it passes under the town? No one knows. Where does it reappear? Of this cavern, or rather this channel, bored in the schists and clays -- no one- knows the length, the height, or the direction. Who can say what thousands of angles, what forests of pillars supporting the enormous substructure of the fortress and entire city its waters are dashed against in their course? Many bold explorers, when the water-level has been neither too high nor too low, have taken a light boat and endeavored to descend the Foiba through the gloomy tunnel, but the arches have been too low, and have soon interposed an impracticable obstacle. In fact, nothing was known of this subterranean river. Perhaps it was lost in some still deeper cavern, and perhaps it entered the Adriatic below the tide- mark.

Such, then, was the Buco, of which Count Sandorf did not even know the existence; and as the only escape was by the window of his cell, which opened above the Buco, he would be almost as certain to meet his death there as if he stood in. front of the firing party on the morning of his execution.

For a minute, for eighty feet and more, they glided down -- down -- asking themselves if the abyss in which they were engulfed were really bottomless. Already the roar of the raging

waters below them could be heard. Then they understood that the lightning-conductor led down into the torrent. What was to be done? To climb back to the base of the donjon they could not; their strength was un- equal to the task. And death for death, it was better to chance that which waited for them in the depths below.

To the danger of being dashed against some projecting rock, or the side of the cavern, or the hanging prominences of the roof, there was added that of being sucked down in one of the whirlpools which foamed in many a corner where a sharp angle of the bank gave the current a sudden curve. Twenty times were Sandorf and his friend seized in one of these liquid suckers and irresistibly drawn to its center in the manner of the Maelstrom. Then they would be spun round by the gyratory movement, and then thrown off from the edge like a stone from a sling as the eddy broke.

Sandorf, energetic as he was, felt his heart wrung with anguish. He saw that the supreme moment was approaching. The tree-roots ground against the overhanging rocks more violently, and at times the top of the trunk was driven so deeply into the current that the water entirely covered it.

"But," said Sandorf, "the outlet cannot be far off."

And then he looked to see if some vague streak of light did not filter into the darkness ahead. By this time was the night advanced enough for the darkness outside to have lifted. Was the lightning still flashing beyond the Buco? If so a little light perhaps would show itself in this channel which threatened to get too small to hold the Foiba. But there was nothing. Nothing but absolute darkness and roaring waters of which even the foam remained black!

And after a tumultuous ride

The light, at last!

The Foiba had emerged from the subterranean channel and was flowing in the open. But where was it flowing? On what sea-coast was its mouth? That was still the insoluble question -- a question of life or death.

We earlier noted Symmes' influence on Poe, who in turn influenced Verne, who, if nothing else, inspired others to pen such titles as 1,000 Fathoms Deep, 100 Miles Below the Surface of the Sea, 7,000 Miles Underground and City of the First Men, or 90 Days at the Center of the Earth.

Admiral Richard Byrd said on the eve of his polar flight, "Jules Verne guides me" and we saw to where in Chapter 15, Hollow Earth Geophysics.

Weird Tales from Northern Seas (1893), a short story by **Jonas Lie** (1833-1908), offers a Norwegian take on the hole-in-the sea tale. As the story's brief and no longer in copyright, we'll quote it in full.

It was such an odd trout that Nona hauled in at the end of his fishing-line. Large and fat, red spotted and shiny, it sprawled and squirmed, with its dirty yellow belly above the water, to wriggle off the hook. And when he got it into the boat, and took it off the hook, he saw that it had only two small slits where the eyes should have been.

It must be a huldrefish, thought one of the boatmen, for rumor had it that that lake was one of those which had a double bottom.

But Nona didn't trouble his head very much about what sort of a fish it was, so long as it was a big one. He was ravenously hungry, and bawled to them to row as rapidly as possible ashore so as to get it cooked.

He had been sitting the whole afternoon with empty lines out in the mountain lake there; but as for the trout, it was only an hour ago since it had been steering its way through the water with its rudder of a tail, and allowed itself to be fooled by a hook, and already it lay cooked red there on the dish.

But now Nona recollected about the strange eyes, and felt for them, and pricked away at its head with his fork. There was nothing but slits outside, and yet there was a sort of hard eyeball inside. The head was strangely shaped, and looked very peculiar in many respects.

He was vexed that he had not examined it more closely before it was cooked; it was not so easy now to make out what it really was. It had tasted first-rate, however, and that was something.

But at night there was, as it were, a gleam of bright water before his eyes, and he lay half asleep, thinking of the odd fish he had pulled up.

He was in his boat again, he thought, and it seemed to him as if his hands felt the fish wriggling and sprawling for its life, and shooting its snout backwards and forwards to get off the hook.

All at once it grew so heavy and strong that it drew the boat after it by the line.

It went along at a frightful speed, while the lake gradually diminished, as it were, and dried up.

There was an irresistible sucking of the water in the direction the fish went, which was towards a hole at the bottom of the lake like a funnel, and right into this hole went the boat.

It glided for a long time in a sort of twilight along a subterranean river, which dashed and splashed about him. The air that met him was, at first, chilly and cellar-like; gradually, however, it grew milder and milder, and warmer and warmer.

The stream now flowed along calmly and quietly, and broadened out continually till it fell into a large lake.

Beyond the borders of this lake, but only half visible in the gloom, stretched swamps and morasses, where he heard sounds as of huge beasts wading and trampling. Serpent like they rose and writhed with a crashing and splashing and snorting amidst the tepid mud and mire.

By the phosphorescent gleams he saw various fishes close to his boat, but all of them lacked eyes.

And he caught glimpses of the outlines of gigantic sea-serpents stretching far away into the darkness. He now understood that it was from down here that they pop up their heads off the coast in the dog days when the sea is warm.

The sea serpent, with its flat head and duck's beak, darted after fish, and crept up to the surface of the earth through the slimy ways of mire and marsh.

Through the warm and choking gloom there came, from time to time, a cooling chilling blast from the cold curves and winds of the slimy and slippery greenish sea serpent, which bores its way through the earth and eats away the coffins that are rotting in the churchyards.

Horrible shapeless monsters, with streaming manes, such as are said to sometimes appear in mountain tarns, writhed and wallowed and seized their prey in the fens and marshes.

And he caught glimpses of all sorts of humanlike creatures, such as fishermen and sailors meet and marvel at on the sea, and landsmen see outside the elfin mounds.

Then the boat glided into miry pulpy water, where her course tended downwards, and where the earth-vault above darkened as it sank lower and lower.

All at once a blinding strip of light shot down from a bright blue slit high, high, above him.

A stuffy vapor stood round about him. The water was as yellow and turbid as that which comes out of steam boilers.

And he called to mind the peculiar tepid undrinkable water which bubbles up by the side of artesian wells. It was quite hot. Up there they were boring down to a world of warm watercourses and liquid strata beneath the earth's crust.

Heat as from an oven rose up from the huge abysses and dizzying clefts, whilst mighty steaming waterfalls roared and shook the ground.

All at once he felt as if his body were breaking loose, freeing itself, and rising in the air. He had a feeling of infinite lightness, of a wondrous capability for floating in higher atmospheres and recovering equilibrium.

And, before he knew how it was, he found himself up on the earth again.

Georg Ebers (1837-1898) was a German novelist and Egyptologist whose The Greylock is undated. It, too, is about a fish.

"And shall I never see my mother and Wendelin again?" George asked, and the tears poured down over his cheeks like the water over the stalactites.

"Oh yes!" the fish replied, "if you are courageous, and do something good and great, then you may return to your home."

"Something good and great," George repeated, "that will be very difficult; and, if I should succeed in doing something that I thought good and great, how could I know whether the fairy considered it so?"

"Whenever the greylock grows on your head, you may declare yourself to be the son of a duke and go home," the fish whispered. "Follow me. I will light the way for you. It is lucky that you have run about so much and are so thin, otherwise you might stick fast on the way. Now pay attention. This pool drains itself, through a passage under the mountain, into the lake. I shall swim in front of you until we come to the big basin into which the springs of these mountains empty their waters. After that I must keep to the right, in order to get back into the lake, but you must take the left passage, and let the current carry you along for an hour, when it will join the head of the great Vitale River, and flow out into the open air. Continue with the stream until it turns towards the east, then you must climb over the mountains, and keep ever northwards. Hold your hand under my mouth that I may give you money for your journey."

George did as he was bid, and the fish poured forty shining groschen into his hand. Each one of them would pay for a day's nourishment and a night's lodging.

The fish then dived under, George plunged after it into the pool, and followed the shimmering light that emanated from his scaly guide. Sometimes the rocky passages, through which he crawled on his stomach in shallow water, became so small that he bumped his head, and had to press his shoulders together in order to pass, and often he thought that he would stick fast among the rocks, like a hatchet in a block of wood. He always managed to free himself, however, and finally reached the big basin, where a crowd of maidens with green hair and scaly tails were sporting, and they invited him to come and play tag with them. But the fish advised him not to stop with the idle hussies, and then parted from him.

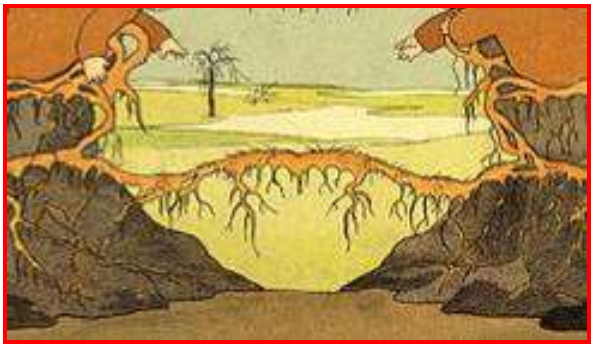
George was alone once more, and he let himself be borne along on the rushing subterranean stream. At length it poured out into the open air, as the Vitale River, and the boy fell with it over a wall of rock into a large pool surrounded by thick greenery. There was a great splash, the trout were frightened to death, a dog began to bark, and a shepherd, who was sitting on the bank, sprang up, for the colored bundle that had just shot over the falls, now arose from the water and bore the form of a pretty boy of thirteen years.

The spectrum of European literature of contains many more examples of such subterranean waters, but our point's made -- underground rivers are a staple setting across Western literature.

CHAPTER 19
PICTURE BOOKS

Our underground river journey now passes through several chapters dealing with juvenile literature. This such chapter is about illustrated works for young children in which the story is largely told through pictures.

When the Root Children Wake Up (1906) by **Sibylle von Olfers** has been re-issued with various illustrators. The root children who have been sleeping all winter awake to become flower children and experience the new life, the color, and the joys of spring. To the right, a German edition chosen for its underground river depiction.



The Firelight Fairy Book (1919) by **Henry Beston** is a collection of tales, one being "The Queen of Lantern Land."

> *Once upon a time the youngest son of a king became filled with the desire to go abroad and see the world. He got his father's permission to depart, kissed his parents good-bye, mounted his black horse, and galloped away down the high road. Soon the gray towers of the old castle in which he was born hid themselves behind him...*

And soon he was following an underground river.

> *The Prince made his way toward the light, along a narrow beach of white sand lying between the wall of the cavern and the racing waters of the mysterious river, and found that the glow came from a magnificent lantern studded with emeralds, topazes, amethysts, and rubies, which hung by a chain from the roof of the grotto. Directly under this lantern, drawn up on the sand, lay a little boat with a lantern fastened to the bow. The Prince pushed the boat into the river, and got into it, and the swift current seized him and hurried him away.*
>
> *At first the cavern grew higher and wider; then it shrank again, and the boat, borne along with incredible speed, shot down a rocky passageway into the very heart of the earth. The passageway broadened once more, and the boat rode gently through monstrous caves whose roofs were upheld by twisted columns taller than the tallest tree. There were times when all was so still that the Prince could easily have imagined himself back in the solitude of the mountains; there were times when the foaming and roaring of the underground river grew so deafening that the Prince feared lest he might be approaching the brink of a subterranean cataract.*

And into the underground ocean.

At length, while the boat was gliding through a vast hall, he fell asleep. When he awoke, he found that the boat was floating on the black, glassy surface of an immense underground ocean. All signs of the cavern had disappeared. Far away, over the edge of this ocean, a strange, beautiful glow mounted into the starless sky of the underworld. And while the Prince was gazing at the glow, the boat swung into a new current, and was borne swiftly toward the light. In a short time the light grew so wide and bright that one would have believed that a strange, golden sun had risen. The boat passed between two giant marble pillars supporting enormous crystal globes filled with a golden fire, and the Prince found himself in the harbor of Lantern Land.

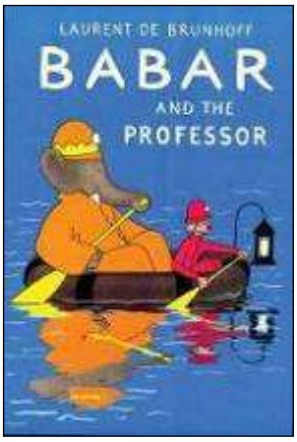
In the harbor, but not out of harms' way.

Suddenly the air became filled with a terrible moaning; the sea became troubled; the whirlpool awoke. And the Prince saw the red lights of the Enchanter's ship whirled round and round, faster and faster, till they disappeared forever in the waters of the sunless sea.

But, of course, all ends well for our little Prince.

As for the Prince, he soon found another boat, and taking with him the talisman, his fellow servants, and the black cat and her kittens, he returned to Lantern Land, married the Queen, and lived happily ever after.

In Babar and the Professor (1957) by **Laurent de Brunhofff**, Professor Grifaton, a butterfly collector, and his children visit King Babar and Queen Celeste. As a result of one of the children falling down a tunnel, a cave is discovered, and in it, among other things, a statue of a giant mammoth and an underground river that leads to the sea.



Splash and Trickle, A Conservation Story, The Adventures of Two Raindrops (1968) by **Ivan Green** and **Bill Connor** describes the Big Adventure of two raindrops. Splash becomes engulfed in a flood.

Tickle and thousands of other raindrops had joined together for become a little stream, running through the roots and soil underground. He had not traveled far before he found the river.

Slowly and quietly they all moved on together, through the cool dark earth. Then after days and weeks of the quiet traveling they saw sunlight again.

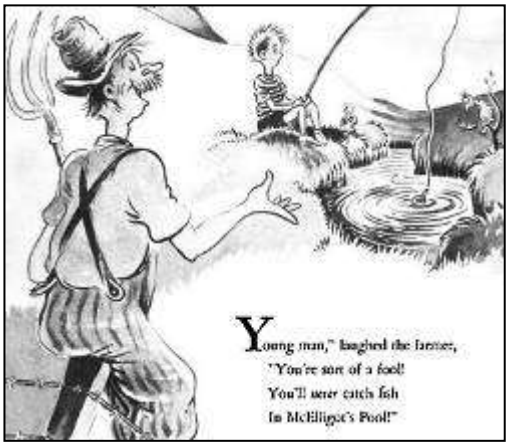
The sequence is explicit: Trickle joins an underground stream
Which joins a river
Which later reaches daylight.

The adventure's fine; the hydrology is not.

McElligot's Pool (1947, long before The Cat in the Hat) by **Dr. Seuss** contrasts the sour pessimism of an adult farmer and the unboundedly optimistic dangling boy his fishing line into a small water-filled crack in the earth.

You're sort of a fool!

You'll never catch fish in McElligot's Pool!



The youngster takes that as a challenge to keep doing what they are doing, and this one certainly did.

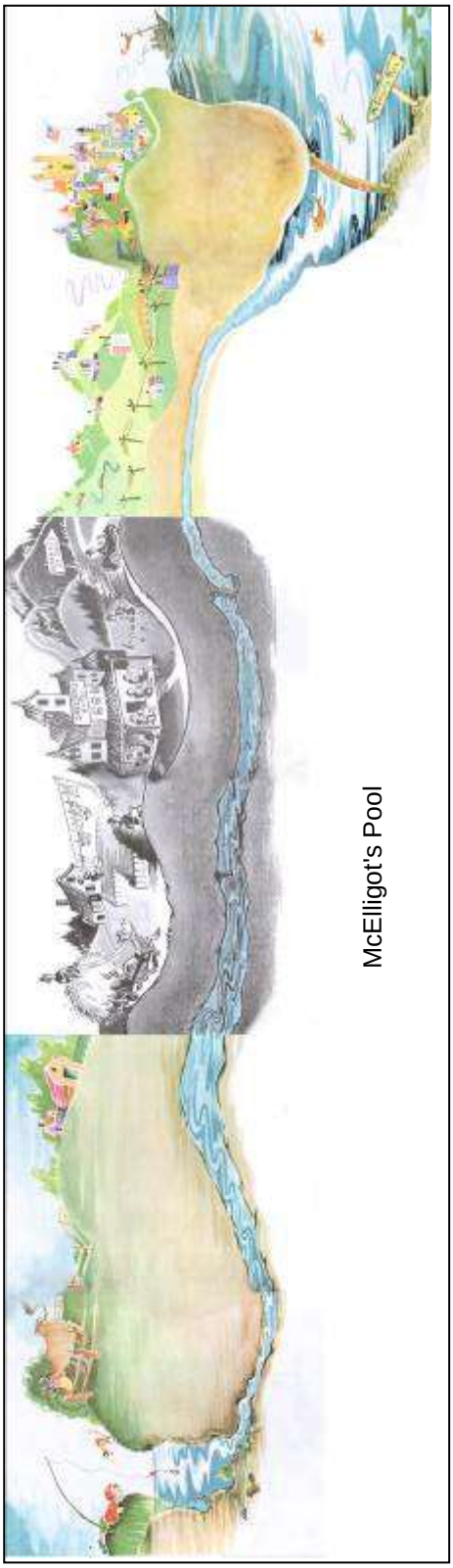
This pool might be bigger than you or I know!

Perhaps it connects underground all the way to the sea and contains many dog fish, catfish, or "even a fish made of strawberry jelly" not to mention one with a pinwheel-like tail and another with fins like a sail. The book's core is a series of fantastic fish, each more remarkable than the last.

Having thought about all of these fish, the boy ponders,

There might be a pool, like I've read of in books,
Connected to one of those underground brooks.
An underground river that starts here and flows
Right under the pasture! And then... well, who knows?
It might go along, down where no one can see,
Right under State Highway Two-Hundred and Three!
Right under the wagons! Right under the toes
Of Mrs. Umbroso who's hanging out clothes!
It might keep on flowing... perhaps... who can tell?
Right under the people in Sneeden's Hotel!
Right under the grass where they're playing croquet!
The under the mountains and far, far away!
This might be a river,
Now mightn't it be,
Connecting
McElligot's
Pool
With
The
Sea!
Then maybe some fish might be swimming toward me!

The map, which requires six pages in the book, we'll reduce to fit on the next page.



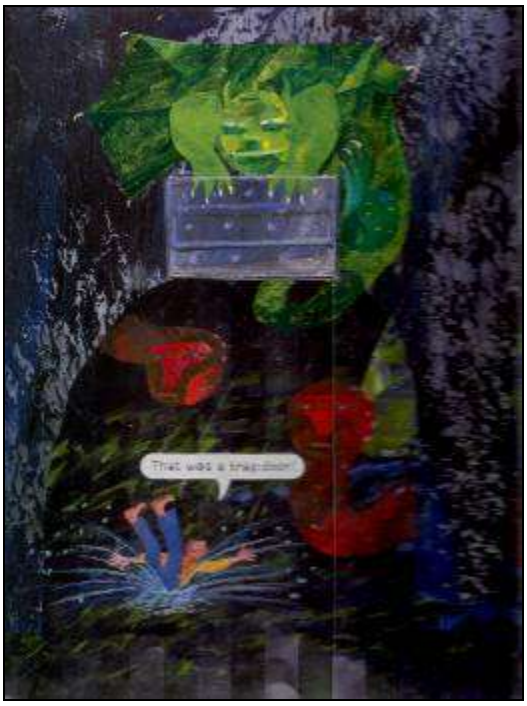
McElligot's Pool

And on that uplifting rhyme, the fanciful geology and thoughts of a wonderful underground river flowing from such a small pond, we'll bid adieu to the poets.

What Watch Out! A Giant! (1978) by **Eric Carle** lacks in words,

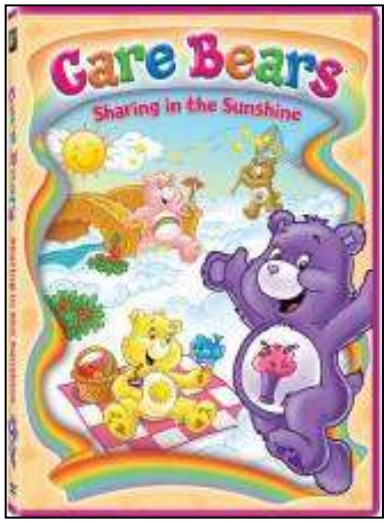
That was a trap door!
Swim this way, I see a tunnel!,

it makes up in artwork.



The text-free Rooster's Revenge (2011) by **Beatrice Rodriguez** portrays Rooster's sail over the sea into a strange cave with a mysterious glowing ball.

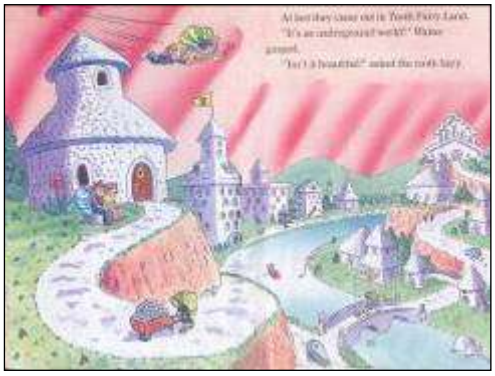
A video is of course not a picture book, but as more and more works for children are marketed -- and for that matter, available from the library -- in both paper and electronic forms, we'll be inclusive.



In the 1985 Care Bears video, Sharing in the Sunshine, our furry friends must find a way for Patti's dad to make it to her pageant on time. Professor Coldheart dumps concrete from his airplane so little Suzy can roller-skate everywhere and Jill's pals get trapped in a cellar because she sent them on a phony treasure hunt. And then Joey and Elaine discover an underground river and get stuck in a cave.

Whatever the problem, the Care Bears are there to lend a paw.

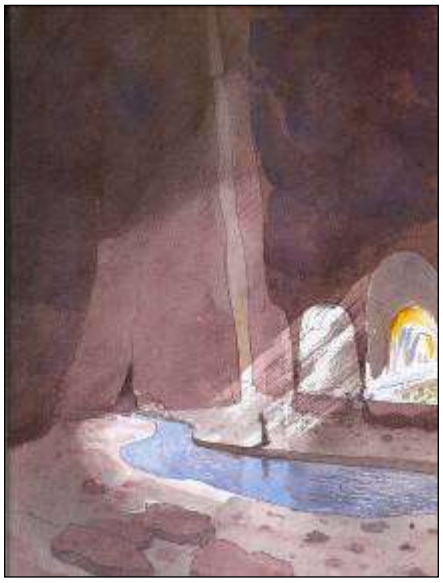
No Tooth, No Quarter by (1989) by **Jon Buller** and **Susan Schade** is about a tooth fairy.



At last they came to Tooth Fairy Land.
"It's an underground world!" Walter gasped.
"Isn't it beautiful?" asked the tooth fairy.

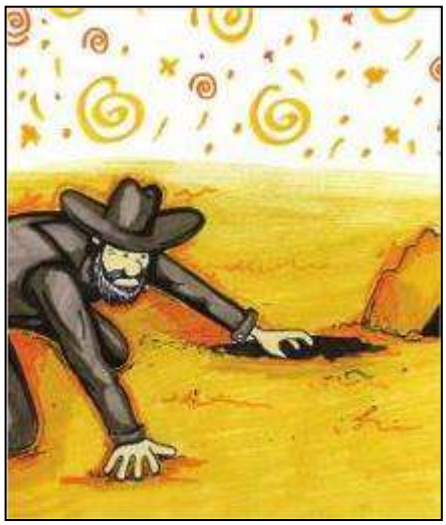
As can be seen, the underground Tooth Fairy Land contains a river.

In the legend Persephone (1994) told by **Warwick Hutton**, having eaten six pomegranate seeds in Hades' cavernous domain where only a sinuous underground river and a few forlorn pomegranate trees relieve the austerity, the earth goddess Persephone is consigned to spend half of each year there, during which months the earth darkens.



A lone shaft of light penetrates a deep, gray chasm.

The Rodeo (2007) by **David W. Canterbury**,

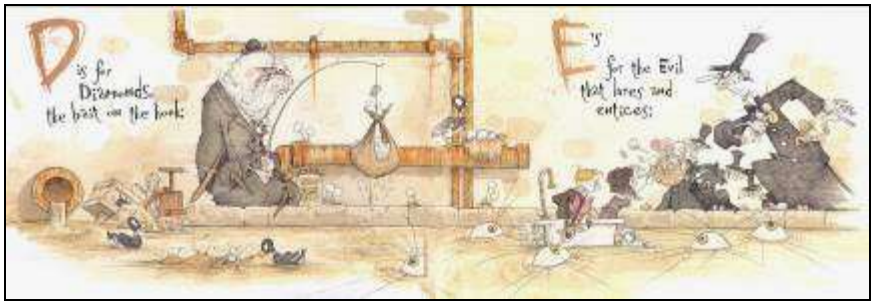


Cowboy Bob took a deep breath and walked toward the stranger. As Cowboy Bob grew close, he yelled, "Hey there!"

The stranger was startled and jumped back and then fell right into the hole. Cowboy Bob ran over and discovered the hole was actually the opening to the cave of the underground river.

Cowboy Bob looked into the cave and could only see and hear the rushing water of the underground river. Suddenly there was a yell. "Help!"

The Dangerous Alphabet (2008) by **Neil Gaiman** contains rhyming couplets, each an alliterative and ominous interpretations of what each letter stands for. The tale is a disturbing adventure with a sepia-toned Dickensian setting, in which two children and their pet gazelle venture though an underground river surrounded by monsters and villains. We show just some of the illustrations.



We've barely dipped into the pool of picture books incorporating underground rivers into the settings -- the bibliographic tools to search by illustration just aren't there -- but we've established that such dark waters are regularly employed.

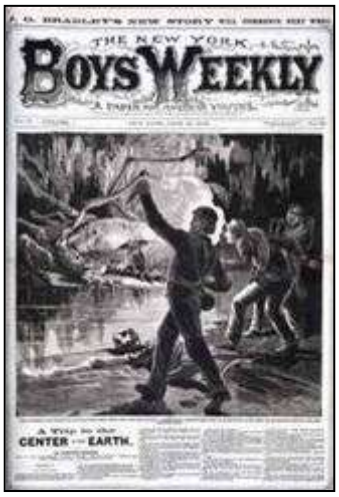
Literary criticism of adult fiction (e.g., works cited in the previous two chapters) is rife with interpretations of such settings, some of which we've mentioned and others woven into chapters ahead, Chapter 38, Achluohydrophobia.

We need not opine to great degree about underground rivers in children's picture books, however. Kids understand without our interpretation. If they didn't grab the essence of such settings, they'd not ask us to read them the books time and time again. Those of us prone toward analysis of such matters, however, can await Chapter 99, Why Do We Believe What We Believe, our journey's ultimate disembarkation.

CHAPTER 20
THE STRATEMEYER BOYS CLUB SERIALS

Boys Club Literature

We've bracketed the spectrum of underground river fiction. Chapters 17 and 18 recognized works well-respected in modern literature. Chapter 19 sampled picture books for young children.

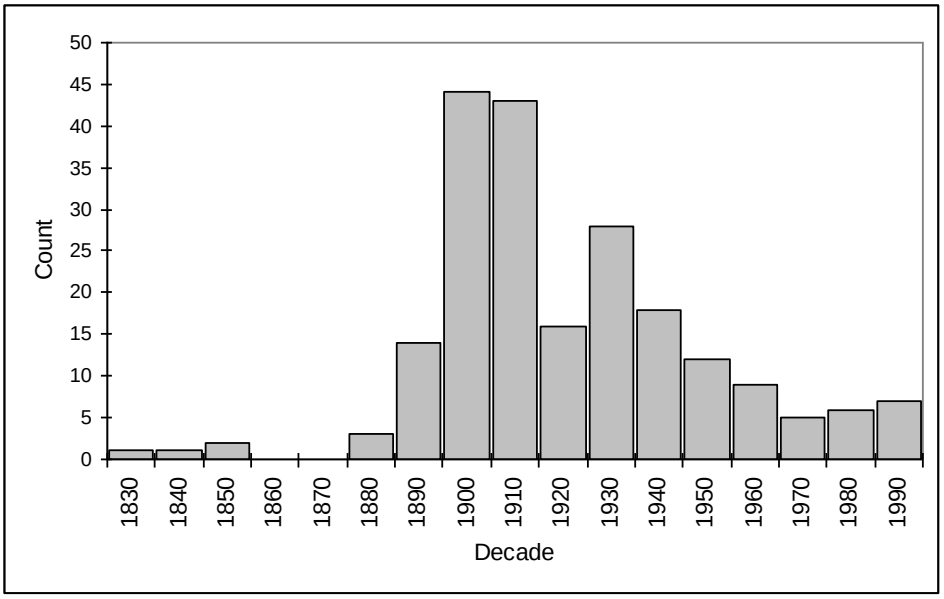


We'd be remiss to ignore the larger portion of underground river literature, that from the ranks of authors who aimed at an intermediate demographic, juvenile readers -- juvenile males, for most part, more likely than girls to pick up a swashbuckling subterranean adventure.

We move to what we'll call "Boys Club" literature, as illustrated by the underground river illustration of Howard De Vere's piece about Mammoth Cave, "A Trip to the Center of the Earth" in the New York Boys Weekly (1894).

Boys Club plots and characterizations tend toward the formulaic -- fast-paced adventures in exotic environments. Casual racism and sexism can be jarring. But, by golly, the boys do have nifty adventures.

The distribution of new releases over time reveals the Boys Club heyday. As such literature tended to be inexpensively bound, shoddily treated and dismissed by archivists, who knows how many like works have been completely forgotten?



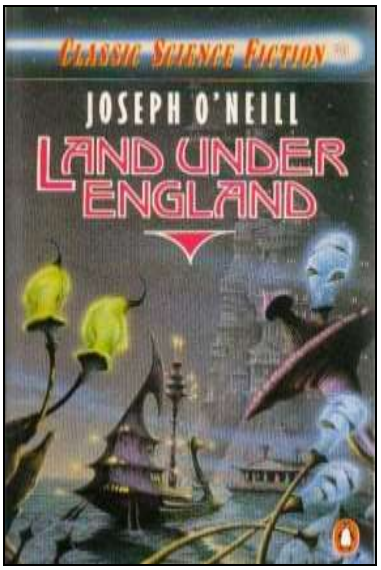
Lost World Books in English, 1800-2000

Boys Club lost world fiction (a larger grouping than underground adventures, but closely akin and well cataloged by modern scholars) exploded in the late 1800s, an era when invention and global

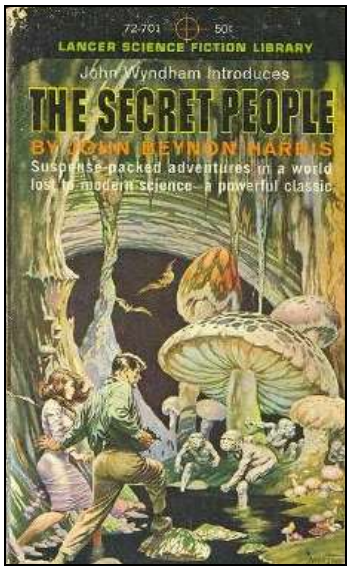
exploration promised great scientific advancement. Every boy wanted to become a part of it. Boys Club fiction of recent vintage is often set in such places as Machu Picchu, the Congo or the Himalayas to couch the tale in nostalgic pastiche.

Of the 1500 books of the genre involving lost worlds, some 200 can be identified by title or summary as being set underground. An exhaustive read would be required to enumerate how many of these 200 subterranean worlds include riverine watercourses, but the proportion would be high. They are "worlds," after all, and as we will come to see, authors of juvenile fiction tend to transport that with which we are familiar to their more exotic geographies.

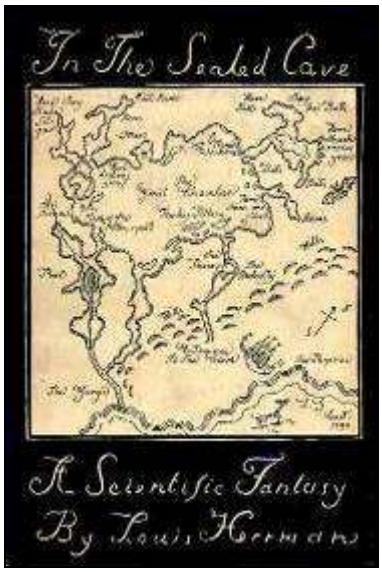
Below are a few 1935 cover illustrations showing underground waters.



Joseph O'Neill
Land Under England (1935)



John B. Harris
The Secret People (1935)



Louis Herrman
In the Sealed Cave (1935)

This and the following three chapters will take brief looks at a large number of Boys Club adventures involving underground rivers. We'll begin with the works of one particular publishing operation that chronicled copyrighted Boys Club heroes over more-or-less the same terrain, volume after volume. We'll then look at similar serials spawned elsewhere. Then we'll mention a number of Boys Club books written in more of a stand-alone manner. And then we'll deal with stories written for the biggest Boys Club of all, the Boy Scouts.

That's a lot of Boys Club literature, but we'd not properly appreciate underground rivers without such a broad foundation.

Girls Club underground river literature is a shorter topic, only a chapter's worth in total.

The Stratemeyer Syndicate

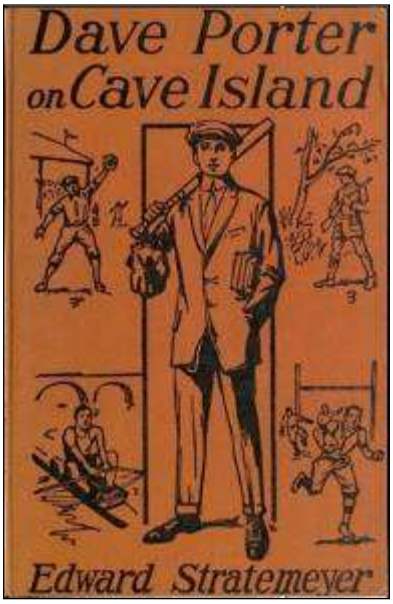
The Stratemeyer Syndicate, a book-packaging firm of juvenile literature founded by in 1905 by Edward Stratemeyer, is best remembered for producing the Bobbsey Twins, Hardy Boys, Nancy Drew, Rover Boys and Tom Swift series.

The syndicate produced over 1200 books in 125 separate series under some 100 pseudonyms. One person wrote an outline for a story or series of stories, another wrote the story itself, and often another refined the work.

Series production was overseen by Stratemeyer until his death in 1930, and the rights to all its series were sold to Simon and Schuster in 1984.

Edward Stratemeyer, the Author

Edward Stratemeyer probably penned 150 books himself, his first success being the 30-volume Rover Boys begun in 1899 under the pseudonym Arthur M. Winfield. Stratemeyer affixed his actual name, however, to the 15-volume Dave Porter series begun six years later. We'll quote a few paragraphs about an underground river.



Dave Porter on Cave Island, or A Schoolboy's Mysterious Mission (1913)

"Whe- where are we?" asked Merwell, and there was a shiver in his tone.

"Down at the bottom of that hole." Dave tried to pierce the darkness. "Looks like some underground river to me."

"The water is salt."

"Then this place must connect with the ocean."...

"Oh, what shall we do?" groaned Merwell, after they had attempted to climb up and had failed. "We are caught like rats in a trap!"

"Perhaps we'll have to swim for it," answered Dave." This water is very salt, which proves it comes from the ocean. Moreover, it is gradually going down, showing it is affected by the tide. Let us follow the stream for a short distance and see where it leads to."

Merwell demurred, but he did not want to remain behind alone in the semi-darkness, so he followed Dave, and both waded and swam a distance of several hundred feet. Here the underground river made a turn around the rocks, and both boys were delighted to see a streak of sunlight resting on the water...

Soon the pair reached a break in the cave. On either side were walls of rocks, uneven and covered with scanty bushes and immense trailing vines. The opening was about a hundred feet in length, and beyond it the stream of salty water plunged into another cavern, undoubtedly on its way to the ocean...

I hate it underground!" And Merwell shivered. "Besides, it's cold," he went on, to cover up the tremor in his voice.

Capt. Ralph Bonehill

Edward Stratemeyer also wrote as Capt. Ralph Bonehill, but so may have contract writers subsequently in his enterprise.

In Bonehill's The Three Young Ranchmen, or Daring Adventures in the Great West (1901), three boys encounter a genuine grizzly, a wolverine, discover of a gold mine, horse thieves, and an explore an underground river on a single Idaho ranch.

Bonehill's Four Boy Hunters, or The Outing of the Gun Club (1906),

"Let us try to find some other way out."

They walked back and forth in the cave and then, by common consent, sat down on some flat rocks to consider the situation.

Nobody felt like joking, for all felt the seriousness of the situation.

"That water must come to the surface somewhere," said Snap. "But it may be a good distance from here."

As they were wet to the knees, one after another got down in the stream and examined the rocks. Some thought they saw daylight under the water beyond the rocks, but nobody was sure.

Bonehill's preface to When Santiago Fell, The Adventures of Two Chums (1899), the last of the 9-volume Flag and Frontier series,

My object in writing this story was to present to American lads a true picture of life in the Cuba of today, and to show what a fierce struggle was waged by the Cubans against the iron-handed mastery of Spain previous to the time that our own glorious United States stepped in and gave to Cuba the precious boon of liberty..

Describing a fictional Cuban underground river,

Putting my hand up, I learned that the rocky ceiling was not over two feet above the surface of the water, and the distance between the two was gradually but surely growing less!

I was horrified over the discovery that I had made. Here I was, in absolute darkness, hemmed in by water and rocky walls, and drifting rapidly I knew not whither.

In my terror I cried aloud, but only echo answered me -- a peculiar echo which made me shiver from head to foot.

On and on, and still on, was I dashed by the underground current, which seemed to grow more powerful as I advanced, until my head grazed repeatedly against the wall over me, and I felt like giving myself up for lost. Oh, how bitterly I regretted the curiosity which had led me to explore the cavern in which chance had so strangely placed me!

But now what was this -- a light? At first I could scarcely believe the evidence of my senses. There was a bright flash -- then total blackness again.

What could it mean? Perhaps I was dreaming -- or the fearful situation had turned my brain. Then came a second flash and a revelation.

It was the lightning from without, shining through some opening into the waters under and around me! I was nearing the outer world. Oh, for a breath of fresh air again!

Even as the thought crossed my mind, my head struck the rocky ceiling again, and under I went, to find that I could not come up, the water now rising to the very rocks. But a stronger light could be seen, and I dove along, came up once, twice -- and then emerged into the open air with a splutter and a gasp, on the verge of exhaustion.

The underground stream emerged at the very base of the mountain, and on both sides were level stretches of swamps, covered with rushes and other tropical growths. Swimming for the nearest bank, I drew myself up and fell on my breast, too worn out to stand.

Capt. James Carson

We always know where this pseudo-officer's Saddle Boys are saddling up.

The Saddle Boys of the Rockies (1913)
The Saddle Boys in the Grand Canyon (1913)
The Saddle Boys on the Plains (1913)
The Saddle Boys at Circle Ranch (1913)
The Saddle Boys on Mexican Trails (1915)

From The Saddle Boys of the Rockies,

Frank went on, "but if that flood just happened to break loose while we were between those high walls we'd have an experience that would be fierce, let me tell you!"

"But then, it may not come for hours yet?" remonstrated the Kentucky boy, who was anxious to be once again in the saddle, and leaving the haunted mountain well in the rear.

"Oh! for that matter, it may not come at all," Frank went on.

"Although Smith did say he really believed that this was going to finish the old geyser, which he believed empties into one of those queer underground rivers we know are to be found all through the Southwest. And Smith ought to know something about it, for he's been watching this business a whole year now, from close quarters."

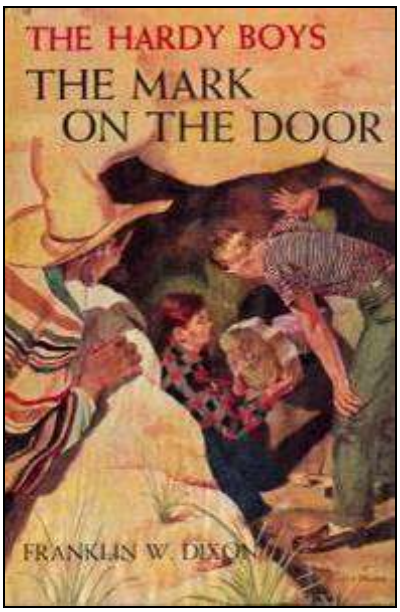
"Good gracious! Do you mean that the old geyser has turned into a river, and will keep on running like this right along?" cried the other.

"Looks that way to me," Frank replied. "It is a great big siphon, and once started, the water that has for centuries been wasting in some underground stream is now flowing down this canyon. Perhaps long ago it did this same thing, till some upheaval -- an earthquake it might have been -- turned things around."

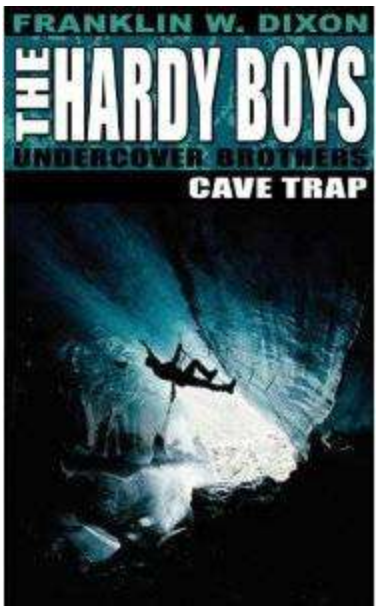
We've also the syndicate's Captain Quincy Allen, but in none of this officer's eight Outdoor Chums adventures do the chums stumble upon an underground river.

Franklin W. Dixon

Stratemeyer's strict rules for his publications required that the youthful heroes remain youthful. Franklin W. Dixon's -- Hardy Boys series remains in perpetual publication, 190 and counting, the boys still at their 1926 age. Scores of authors can claim to be Dixon.



In The Hardy Boys, The Mark on the Door (1934), Frank and Joe investigate a mystery more dangerous than any before. A mark on the door leads the boys to Mexico in search for a kidnapped scientist. In following the clues to a gang of desperados, they discover the deadly secret. To escape from the mountain hideout, the Hardys are swept towards their doom in the swirling currents of an underground river.



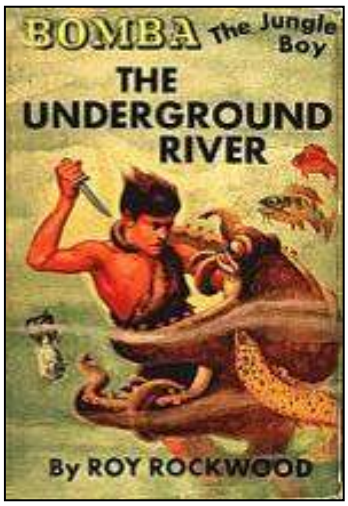
In Cave Trap (1996), the Hardys join a team of spelunkers in Cathedral Cave State Park, a Mammoth Cave surrogate. Stumbling upon an uncharted cavern, the boys encounter murderers, ancient booby traps, ill health, an enemy among the team and a vicious whirlpool.

Roy Rockwood

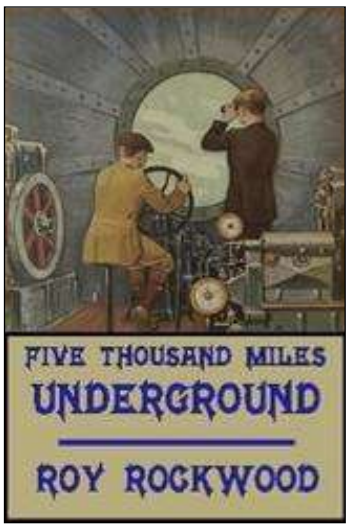
Roy Rockwood was the house pseudonym for Stratemeyer's 20-book Bomba series, 1905-1937, tales of a lad dwelling deep in the Amazon with a half-demented professor.

In Bomba the Jungle Boy, The Underground River *(*1930), after a jaguar attack and an opera, Bomba and friend stumble into a deep cavern through which flows an underground river. Caught in a subterranean flood, the two discover a series of shelves above the tunnel floor and step by step, the two climb as the relentless waters pursue.

As any Boys Club would like an author with the name Roy Rockwood, the authorship turned out the Dave Fearless series, the Dave Dashaway series and the Speedwell Boys series.



Rockwood's Five Thousand Miles Underground, or The Mystery of the Center of the Earth (1908),



With a tremor the Mermaid left the surface of the inner earth and went sailing upward toward the-- well it wasn't exactly the sky, but it was what corresponded to it in the new world, though there were no clouds and no blue depths such as the boys were used to. At all events the Mermaid was flying again, and, as the adventurers felt themselves being lifted up they gave a spontaneous cheer at the success which had crowned their efforts.

The ship went up several hundred feet, and then, the professor, having brought her to a stop, sent her ahead at a slow pace. He wanted to be sure all the apparatus was in good working order before he tried any speed.

The Mermaid responded readily. Straight as an arrow through the air she flew...

"Well, this is almost as good as being on the regular earth!" exclaimed Jack.

"It's better," put in Mark. "We haven't seen half the wonders yet. Let's open the floor shutter, and see how it looks down below."

He and Jack went to the room where there was an opening in the floor of the ship, covered by heavy glass. They slid back the steel shutter and there, down below them, was the strange new, world they had come to, stretched out like some big map

They could see mountains, forests, plains, and rivers, the water sparkling in the colored light. Over green fields they flew, then across some stretches where only sand and rocks were to be seen. Faster and faster the ship went, as the professor found the machinery was once more in perfect order...

From the center of an immense mound of rock and earth there spouted up a great column of water, three hundred feet or more, as straight as a flag staff. It was about ten feet in diameter, and at the top it broke into a rosette of sparkling liquid, which as the varicolored lights played on it, resembled some wonderful flower.

"It's a great geyser!" the professor exclaimed. "We have come to a place like Yellowstone Park. We must be very careful. The crust may be very thin here, and let us down into some boiling spring."...

All that afternoon they sailed, the country below them unfolding like a panorama. They passed over big lakes, sailing on the surface of some, and over rivers, and vast stretches of forest and dreary plains...

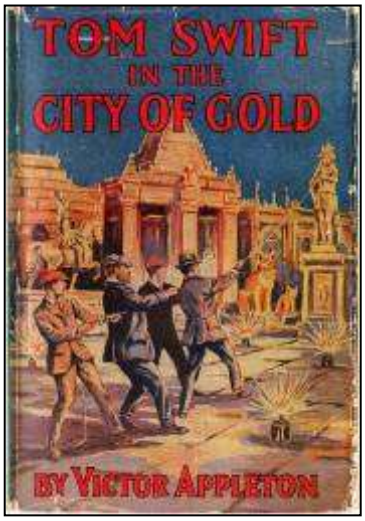
After the requisite adventures, the underworld is exited under the instruction of the professor -- a character often present in Boys Club literature. At the end,

Their cylinder, which might now be termed a boat, was floating on the great Atlantic. The blue sky was overhead and the air of the sea fanned their cheeks.

Victor Appleton

Victor Appleton is the collective pseudonym for the author of more than 100 Tom Swift books, the adventures of the likable and formidable teenage inventor. Tom's challenges are resolved with hard work, original thought, respect for others and of course, good manners.

Tom Swift in the City of Gold, or Marvelous Adventures Underground (1912)



"A river! It's an underground river and we can't go any further! We're blocked!"

They saw rushing along, between two walls of stone, a dark stream which caused the roaring sound that had come to them. The tunnel was cut squarely in two by the stream, which was at least thirty feet wide, and how deep they could only guess. Swiftly it flowed on, its roar filling the tunnel.

"Well, I guess this is the end of it," remarked Ned ruefully, as they stood contemplating the roaring stream by the gleam of their electric flash lamps... "But it seems to me as if this river isn't a natural one -- I mean that it flows along banks of smooth stone, just as if they were cut for it, a canal you know."

"Don't you see," continued Ned, "that this river hasn't always been here."

"Bless my gaiters!" gasped Mr. Damon, "what does he mean? The river not always been here?"

"No," proceeded Tom's chum. "For the ancients couldn't have cut the channel out of stone, or made it by cementing separate stones together while the water was here. The channel must have been dry at one time, and when it was finished they turned the water in it... [I]f the river was turned aside from this channel once it can be done again... We've got to shut that stream of water off, or turn it into some other channel, then we can cross, and keep on to the city of gold."

Eradicate, who was searching as eagerly as the others, went back a little, flashing his lamp on every square of stone. Suddenly he uttered a cry.

"Look yeah, Massa Tom! Heah's suffin' dat looks laik a big door knob. Maybe yo' kin push it or pull it."

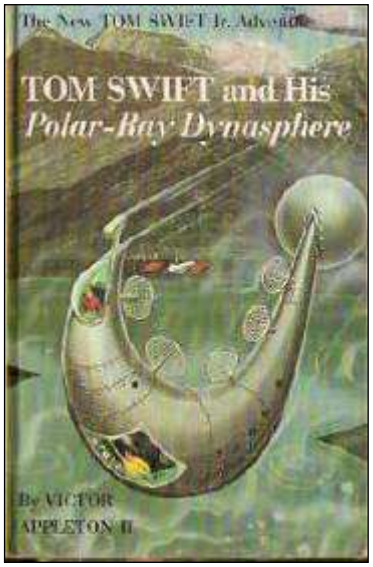
Racism seems to be part of the writing formula.

In a flash Tom did so. For a moment no result was apparent, then, from somewhere far off, there sounded a low rumble, above the roar of the black stream.

"It's going down!" he yelled, capering about. "Now we can go on!"

"Dish suah am a mighty long tunnel," remarked Eradicate. "Dey ought t' hab a trolley line in yeah."

In Tom Swift and His Polar-Ray Dynasphere (1964), our lad takes on plumbing problems.



"But will not more water be welling up all the time from the underground river?"

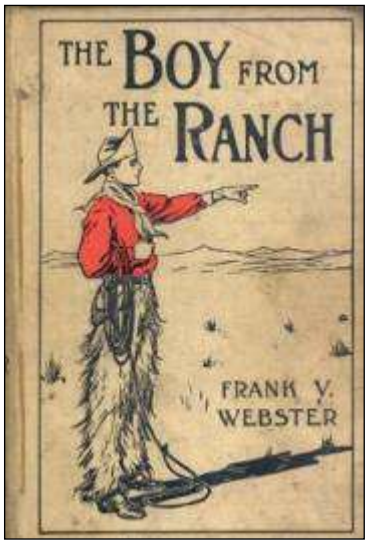
"Not if I plug the inlet first," Tom replied quietly. "After the water has been vaporized, I can clean out all the poisonous sediment and plant growth with a machine of mine called a Spectromarine selector. Then I'll remove the plug and allow the lake basin to fill up again -- with pure, fresh water."

Fortunately he'd packed along his Spectromarine selector

!

Appleton also churned out seven volumes of Motion Picture Chums, 15 of Moving Picture Boys, and 17 of Movie Boys, leaving others in the Stratemeyer corral to write the Motion Picture Comrades, but the movie formula failed to include underground rivers.

Frank V. Webster



Webster is credited with some 25 Boys Club volumes, but as the characters changed, the result is simply known as the "Webster Series."

A Boys Club enjoys a good chuckle. From Webster's The Boy from the Ranch, or Roy Bradner's City Experiences (1909),

"Excuse me, stranger," he began, in his broad western tones. "But how long is this tunnel, anyhow?"

"Tunnel? This ain't no tunnel!"

"No? What is it then? It's a pretty good imitation. Looks like an underground river that has gone dry."

"Why, this is the subway."

The passing mention of an underground river in An Undivided Union: (1899), a Civil War novel, merits mention for its authorship.

Crawfish Springs was a most beautiful spot, a typical scene for a landscape painter. The spring was really the outlet for a subterranean river, and flowed forth between beautiful hills covered with trees and flowering bushes. It was on the estate of a widow, Mrs. Gordon, whose fine brick mansion stood not far away. In the vicinity of the spring was the house of Lowry, Second Chief of the Cherokees, and it was here that the Army of the Cumberland had, for the time being, established its hospital.

The book's credited to both Edward Stratemeyer and **Oliver Optic**, an admiral pseudonym of **William Adams**, a non-syndicate writer. What's surer than the work's bibliographic roots is the fact that, once again, there's an underground river.

And we've just skimmed the Stratemeyer surface. Holding strictly to like-titled series, there are also the

The Radio Boys by Allen Chapmen
The Motor Boys and the Racer Boys by Clarence Young
The Fairview Boys by Frederick Gordon
The Pioneer Boys by Harrison Adams
The White Ribbon Boys by Raymond Sperry, Jr.
The Rushton Boys by Spencer Davenport
The Y.M.C.A. Boys by Brooks Henderley
The X Bar X Boys by James Cody Ferris
The Air Service Boys by Charles Emory Beach

Were we to plough through the lot, we'd expect to find mostly the same underground rivers. A stable of writers working under a catalog of pseudonyms produces a plethora of predictably narrow escapes.

We'll see more of the Stratemeyer Syndicate in Chapter 24, Girls, Too!, but there we'll encounter works less penetrated by underground rivers because girls tend to be more intelligent about exploring such waterways.

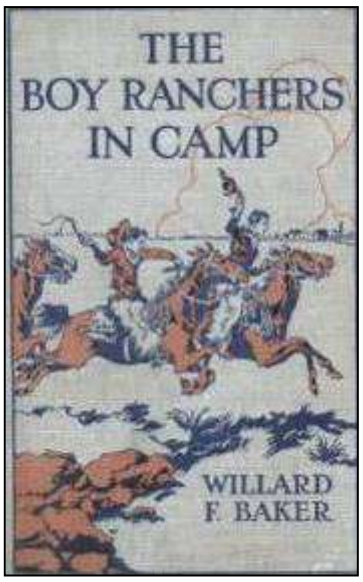
CHAPTER 21
MORE BOYS CLUB SERIALS

As prolific as was the Stratemeyer Syndicate, that organization was by no means the sole source of Boys Club serials. This chapter notes such series produced by other publishers, some of the sets likewise hack-written to formula specification, others the product of a consistent author who may yet be familiar to us. The chapter to follow will alphabetically gather together Boys Club tales not written as sets.

Willard F. Baker

According to the publisher's advertisement, Willard Baker's Boy Ranchers series are,

> *Stories of the great west, with cattle ranches as a setting, related in such a style as to captivate the hearts of all boys. In each volume there is, as a background, some definite historical or scientific fact about which the tales hinge.*



In The Boy Ranchers in Camp, or The Water Fight at Diamond X (1921), two eastern boys visit their cousin, whose father owns the Diamond X ranch, and become involved in a mystery involving a mysterious river.

> *"Doesn't that sound like rushing water?" asked Bud.*
>
> *"Yes," agreed Dick, after a moment of intentness; "it does."*

> *"Look out!" quickly yelled Nort. "It is water, and on the rush, too! Jump for your lives! It's a flood!" and making a grab for one of the lanterns, that they might not be left in total blackness, he sprang toward the rocky side of the tunnel, an example followed by his companions.*
>
> *And the rush of waters filled the underground cave with a mighty, roaring sound.*
>
> *Stumbling, slipping, sliding, half-falling, bruising themselves on the sharp rocks, but ever leaping forward toward the sides of the tunnel, and away from the depressed center down which they could see the rush of waters coming, the boy ranchers at last managed to reach the granite wall. Nort had succeeded in grabbing up one of the lanterns, but there was no time for Dick or Bud to take one, and the food had to be abandoned.*
>
> *"Climb up! Climb up, if there's a ledge!" shouted Bud. "We'll be drowned if we can't get above the water!"*

He had, somehow or other, brought up in the rear. Though he did not admit it, this was because he had shoved his cousins ahead of him, hoping thus to enable them to gain a safe place.

And as Nort and Dick glanced back they saw, in the gleam of the one lantern left alight, a white mass of water bearing down on them, and, seemingly, filling the tunnel from wall to wall, as it rushed foaming and murmuring onward.

It was as though a dam had suddenly burst, or some obstruction had been removed, allowing the pent-up waters to rush along the accustomed channel. And if you have ever noticed a dammed-up stream, say in some gutter, thus quickly released, you can imagine what happened on a larger scale in the tunnel where the boys were.

Note the last sentence's plug for scientific curiosity, a Boys Club strong point.

For similar adventure, we can turn to Baker's

The Boy Ranchers, or Solving the Mystery at Diamond X (1921)
The Boy Ranchers on the Trail, or The Diamond X After Cattle Rustlers (1921)
The Boy Ranchers Among the Indians, or Trailing the Yaquis (1922)
The Boy Ranchers at Spur Creek, or Fighting the Sheep Herders (1923)
The Boy Ranchers in the Desert, or Diamond X and the Lost Mine (1924)
The Boy Ranchers on Roaring River, or Diamond X and the Chinese Smugglers (1926)
The Boy Ranchers in Death Valley, or Diamond X and the Poison Mystery (1928)
The Boy Ranchers in Terror Canyon, or Diamond X Winning Out (1930)

John Blaine

The Rick Brant Science-Adventures were by John Blaine (pseudonym of Harold L. Goodwin), of which we'll cite The Caves of Fear (1951), an atomic-age thriller.

Using infra-red goggles to explore the caverns beneath the Himalayas, Rick Brant, son of noted scientist Hartson Brant, and Rick's buddy, WWII vet Scotty Scott, come across both the Black Buddha and an underground lake of heavy water. The two must stop the bomb-making material from falling into the wrong hands.

The rocky shore of the underground lake receded rapidly. Rick stopped rowing and turned, switching the infrared light toward the direction in which he was heading. He could see the opposite shore now, but dimly. Knowing that the infrared light was effective at eight hundred yards, he estimated the lake to be about twelve hundred yards wide. That was over three-fifths of a mile.

When he shot the light up and down the lake, he saw nothing but the black water. That meant the lake was more than sixteen hundred yards long. He turned the light upward and surveyed the ceiling. It was irregular, varying in height from a dozen feet to over two hundred. In one place, the ceiling came down to within a few feet of the black water.

It was an eerie place. Rick's quick imagination turned him into the mythical Charon, who ferried the dead across the River Styx into Hades.

Then suddenly he realized it wasn't as dark as he had expected!

There was a faint luminous quality that outlined the shore of the lake.

He studied the line of demarcation, then guessed that the faint luminosity must come from microscopic plant or animal life that clung to the rock underwater. Sea water had a phosphorescence sometimes for the same reason.

His eyes followed the faint line up the shore in the direction he had been traveling. The silver phosphorescence turned a faint yellow. Almost out of the range of his vision the yellow was picked up by the water, like the dimmest moonlight.

He studied it for long minutes, trying to figure out the reason for the phenomenon, then he almost leaped out of his skin.

"It is true," he continued, "that heavy water has a tendency to sink. Naturally enough, since it is heavier. But for enough to form on the bottom of a body of water, there would have to be great depth and complete calm. Any current would stir the water up and the heavy water would merge with the normal once more."

"In other words, you need a lake like this one."

Edgar Rice Burroughs

What Burroughs' prose lacked in quality, he made up in quantity. "I write to escape poverty," he noted of his 68 titles, 25 of which featured Tarzan. And escape poverty he did.

Burroughs' Pellucidar Series is set in the hollow earth.

At the Earth's Core (1914)
Pellucidar (1915)
Tanar of Pellucidar (1929)
Tarzan at the Earth's Core (1929), a crossover, bringing the Ape Man himself into the adventure
Back to the Stone Age (1937)
Land of Terror (1944)
Savage Pellucidar (1963, posthumously)

The illustration to the right invokes some of Pellucidar's hydrologic flavor.

By the next novel, Pellucidar (1915), visitors from above have grandly made themselves indispensable to the subterranean world. A la Twain's A Connecticut Yankee in King Arthur's Court (1889), a resourceful American turns the tide of battle with the militarization of underground waters.

The upshot of it was that the boat of which the Sagoth speaker was in charge surrendered. The Sagoths threw down their weapons, and we took them aboard the ship next in line behind the Amoz.

Thus ended the first real naval engagement that the Pellucidarian seas had ever witnessed.

Burroughs' The Land That Time Forgot (1918) is a Darwinian story set on a mysterious island near the South Pole where dinosaurs survive. While this tale is not set in Tarzan's underworld, Burroughs works in the sighting of an underground river as a lesson in inductive reasoning.

"Look there!" And I pointed at the base of the cliff ahead of us, which the receding tide was gradually exposing to our view. They all looked, and all saw what I had seen -- the top of a dark opening in the rock, through which water was pouring out into the sea. "It's the subterranean channel of an inland river," I cried. "It flows through a land covered with

vegetation -- and therefore a land upon which the sun shines. No subterranean caverns produce any order of plant life even remotely resembling what we have seen disgorged by this river. Beyond those cliffs lie fertile lands and fresh water -- perhaps, game!"

Tanar of Pellucidar (1929)

The fall had not hurt him. It had not even stunned him and when he came to the surface he saw before him a quiet stream moving gently through an opening in the limestone wall about him. Beyond the opening was a luminous cavern and into this Tanar swam, clambering to its rocky floor the moment that he had found a low place in the bank of the stream. Looking about him he found himself in a large cavern, the walls of which shone luminously, so considerable was their content of phosphorus.

Then slowly he made a circuit of the outer walls of the grotto, but only where the stream passed out at its far end was there any opening -- a rough archway that rose some six feet above the surface of the underground stream.

And,

Where they had halted a tiny spring broke from the base of the cliff and trickled along its winding channel for a short distance to empty into a natural, circular opening in the surface of the ground. From deep in the bottom of this natural well the water falling from the rim could be heard splashing upon the surface of the water far below. It was dark down there—dark and mysterious, but the bearded ruffians gave no heed either to the beauty or the mystery of the spot.

In Tarzan at the Earth's Core (1929), we have a flash flood.

The raging waters that were filling the gorge reached his knees and for an instant he was swept from his footing. Clutching at the ground above him with his hands, he lost his rifle, but as it slid into the turgid waters he clambered swiftly upward and regained momentary safety.

Land of Terror (1944)

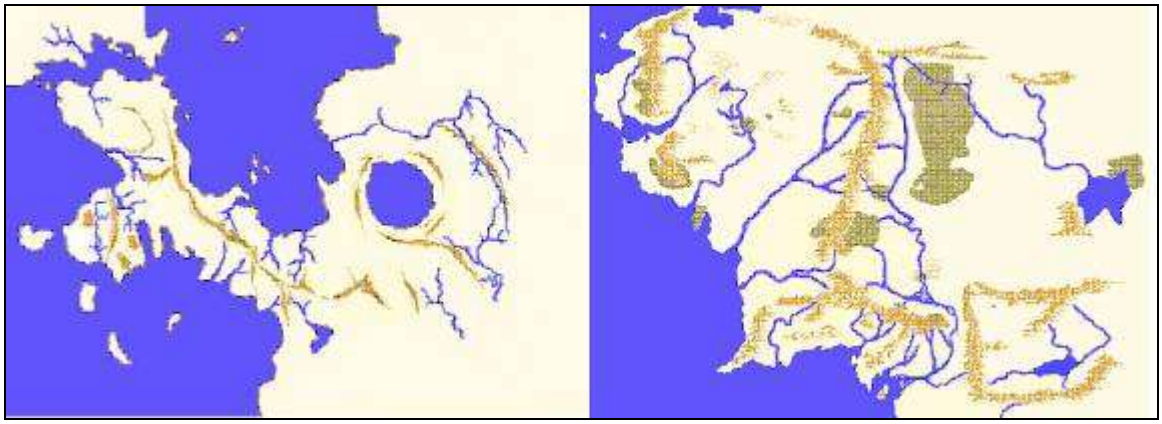
The cave which lay beyond the gate was of limestone formation in a hillside just outside the village. Enough light came through the outer opening to dimly illuminate the interior immediately about us. We could not immediately determine the extent of the cave; but while the walls at one side were discernible, at our left they were lost in darkness out of which trickled a little stream of clear, cold water that made its way across the floor to disappear through the outer opening.

And,

These Pellucidarian rivers, especially the large ones with a sluggish current, are extremely dangerous to cross because they are peopled more often than not by hideous, carnivorous reptiles, such as have been long extinct upon the outer crust. Many of these are large enough to have easily wrecked our raft; and so we kept a close watch upon the surface of the water as we poled our crude craft toward the opposite shore.

We'll catch Burroughs' Martian underground rivers in Chapter 98, Underground Rivers in Outer Space.

Both Burroughs and Tolkien (Chapter 17, Underground Rivers in English Fiction) strove to preserve geographical relationships from novel to novel. Below are hydrologic maps of Pellucidar and Middle Earth derived from the physiography of the respective sagas.



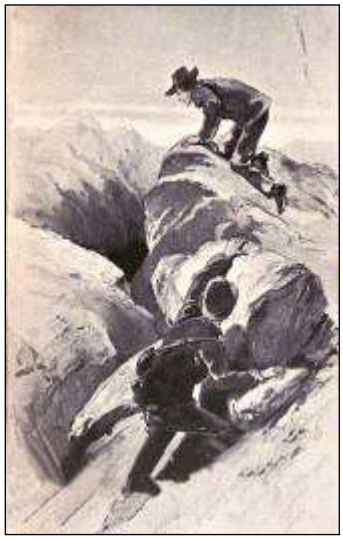
Of hydrologic interest is the similarity between the two imagined worlds. Both maps show enclosed basins. The circular water body in Pellucidar is the Polar Sea. Tolkien's world has two inland seas, the Rhun and the Nurnen on the lower map's right. Both sagas are set on peninsulas transected by mountain ranges, barriers to be crossed by the heroes. Both worlds are endowed by multiple rivers which, among other benefits, provide the heroes a means of transport when the plot needs to move along.

We might correctly surmise that by the time of writing, Burroughs had lived Southern California for a decade and knew about such events.

Burroughs didn't limit underground rivers to Pellucidar. Here, for example is an excerpt from The Chessmen of Mars (1922).

> *His exploration revealed not only the vast proportions of the network of runways that apparently traversed every portion of the city, but the great antiquity of the majority of them. Tons upon tons of dirt must have been removed, and for a long time he wondered where it had been deposited, until in following downward a tunnel of great size and length he sensed before him the thunderous rush of subterranean waters, and presently came to the bank of a great, underground river, tumbling onward, no doubt, the length of a world to the buried sea of Omean. Into this torrential sewer had unthinkable generations of ulsios pushed their few handsful of dirt in the excavating of their vast labyrinth.*

Harry Castlemon



The Mystery of Lost River Canyon (1896), one of some three dozen Boys Club volumes by Castlemon (nom de plume of Charles Austin Fosdick), contains a Native American Legend, but unlike those of Chapter 84, a creation of the author.

> *The valley was watered by a deep stream, which, entering at one end by a succession of lofty cascades, and running through the verdant fields with an almost imperceptible current, finally disappeared in a cavern so dark and gloomy that it made one shudder to look at it.*
>
> *"The Indians about here have a legend to the effect that this country once belonged to a giant, who, by some means or other, succeeded in getting into a row with his nearest neighbor another giant who overcame him in single combat, hurled him into a canyon, and put a mountain on top of him to hold him down.*

"The giant is still a prisoner, and the sound we have just heard is the heavy breathing he makes during his struggles to free himself. At the time the fight took place, there was a small stream running through the canyon; but the mountain blocked it up and made a lake of it. As the lake grew in size, the pressure became so great that the water finally broke a hole through the mountain and ran out, leaving the valley as you see it now."

No pen can describe the anguish of mind experienced by these two boys as they sat there on the bottom of their boat, clinging to the gunwales with a death-grip, holding their breath in suspense, and waiting for their frail craft to be smashed into kindling wood against some unseen obstruction.

The wind whistled past their ears, and deeper and blacker grew the darkness of the canyon as their boat sped on its way.

There was no sound heard save the rush of the water against the bank on either hand, but the speed with which they were moving was simply appalling.

Now and then a little patch of light, far above him, would shoot by with such surprising swiftness that his hair would fairly stand on end, and he would clutch the sides of the boat with a firmer grip, and wonder how much longer this wild ride must continue, and how long it would be before the catastrophe would come.

The channel was as smooth and deep here as it was in the valley they had left how long ago? Was it an hour or a day? Bob did not know, for he could take no note of the flight of time.

The interior of the earth must be a long way off, he thought,; and that he was drawing nearer to it every minute seemed probable, for these little patches of light he had noticed a while back were no longer to be seen. Above, around and beneath him was darkness

From the publisher,

Mr. Castlemon's new book will be welcomed by an army of boys, to whom the remembrance of earlier romances shall have guaranteed his welcome... The book is full of exciting passages, and will please the boyish heart immensely.

Fremont B. Deering

The Border Boys Across the Frontier (1911) by Fremont Deering employs the boys-plus-professor formula.

"Comes to my mind now," said Pete, "that it ain't exactly a well. An old Injun that used ter hang around with the Flying Z outfit tole us oncet that thar was a subterranean river flowed under here, and that once upon a time afore all the country dried up, considerable more water came to the surface here than there does now."

"A subterranean river?" asked the professor, at once interested.

"Yes, sir," rejoined Pete, "and not the only one in the West, either. There's one in Californy that flows underground fer purty near fifty miles, as I've heard tell."

As the book's also cataloged as being by John Henry Goldfrap, we can only speculate on which is the pseudonym, but we can hazard a guess.

"This is most remarkable," said the professor. "I, too, have heard of subterranean rivers in this part of the world, but I have never had the opportunity to explore one. Did this Indian you speak of ever tell you where this river emerges?"

"He said it come out some place across the frontier in Chihuahua; I don't jest rightly recollect where," said Pete carelessly, as if the subject did not interest him much, as indeed it did not.

"I don't see what use a subterranean river is to anybody, anyhow," he went on. "If it was on top, now, it might be some use."

"But this is most interesting," protested the professor, while the boys lay about with their chins propped in their hands in intent attitudes. "Then, too, if this river exists, perhaps it is even navigable."

"Why, professor!" exclaimed Jack. "Is it not possible that it was to this river that those drawings of boats that interested and puzzled you so much had reference?"

"Quite possible, my boy," agreed the man of science.

The Border Boys on the Trail (1911), The Border Boys with the Texas Rangers (1912) and The Border Boys in the Canadian Rockies (1913) give evidence of the Border Boy's territory.

Frederick Gordon

Fairview Boys on a Ranch, or Riding with the Cowboys (1917) by Frederick Gordon was the last of a series of six.

"It'll be dandy to go out on the ranch," mumbled Sammy, "but we surely will miss some of the fun we've had around here this summer."

"That's so," replied Bob, a little regretfully. "I wonder if there'll be any place to swim out there."

"There must be plenty of water somewhere around," said Frank, thoughtfully. "I've read a lot about prairie schooners, and, of course, they can't sail without water."

"Listen to him!" shrieked Bob. "Why, you goose, don't you know that prairie schooners are only big wagons?"

"I don't believe it," said Frank, stoutly.

"Bob's right," declared Sammy. "I saw a picture of one a little while ago. It had four horses hitched to it and a man was driving."

"Maybe that was another kind of schooner," suggested Frank, though weakening somewhat before the positive statements of his chums. "Anyhow, there must be ponds or lakes or rivers of some kind. How could the cattle get water if there wasn't?"

"Maybe we'll run across some underground river that will lead to a robber's cave or something," broke in Sammy, eagerly. "You know, the kind that's running along all right and then suddenly sinks down in the ground and people think that's the end of it until they find it starting up again a good many miles away. But what's it been doing while it's been out of sight? Running through a cave of course. Robbers choose just that kind of place."

William Murray Graydon

With the assistance of the newly-invented Dictaphone, William Murray Graydon wrote more than 100 Sexton Blake Stories and an equal number for the Sexton Blake Library, some which were subsequently used as the basis for Nick Carter stories and others rewritten for the Gordon Keith series. Graydon's pseudonyms include **Alfred Armitage**, **William Murray** and **Tom Olliver**. Adding to the bibliographic dimensionality would be his publishers' propensity to re-release stories under altered titles.

Bluntly put, Graydon sold his works over and over to Boys Clubs having short recall.

Lost Cave (1893) tells of a harrowing boat trip along an underground river, a theme which repeats in Graydon's works. The discovery of Pennsylvania's Lost River Caverns in 1883 ties into Graydon's impressionable years; he would have been 19 at the time of the discovery.

We should pause a moment for geographic clarification. There are numerous American streams named "Lost River," the majority of which could also be named "Found River" some distance downstream. We'll sort them out in Chapter 43.

Here's a taste of Graydon's Pennsylvania underground action.

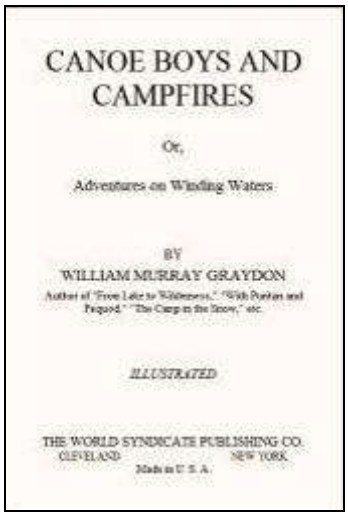
> *Twenty feet below, and separated from them by a precipitous slope of rock, was a beach of shining sand a 19 dozen yards wide. It terminated in a pool of black water that was constantly heaving in turbulent eddies, and washed, on the opposite side, the steep rocky wall of the cavern.*
>
> *This subterranean stream -- for such it was -- cut directly across the corridor that the boys had been following. It issued through a gloomy hole, and where it disappeared by a similar aperture was a great mass of drift -- logs, fence rails and brush.*
>
> *This blockade formed the eddying pool, and the escaping water pouring through the interstices made the deafening roar that the boys heard.*
>
> *"There are just two courses open to us," said Roger. "We can turn back and explore the other corridor, or we can drag the boat over the drift and trust ourselves to the channel. What do you say?"*
>
> *The plan was fully discussed before they finally decided to trust themselves to the unknown perils of the subterranean stream.*
>
> *The angry watery snatched the boat, and away it went with a rush into the narrow and gloomy gorge, swaying from side to side and heaving and pitching with the waves.*
>
> *The subterranean channel varied in width from 10 to 15 feet. On each side was a slimy wall of rock rising a dozen feet or more to the jagged roof of the cavern.*
>
> *All at once the heaving motion ceased and the angry roar of the waves seemed to fade away in the distance. A terrible thought occurred to Roger. Was this the end of the subterranean*

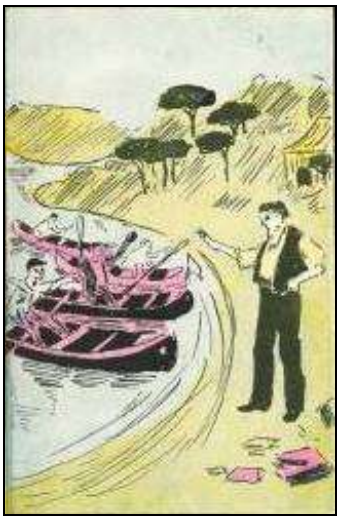
stream? Was its outlet from this point beneath the surface? The fact that the boat was apparently motionless seemed to indicate as much.

"We are shut in here forever," cried Clem despairingly. "I knew how it would be. What fools we were to meddle with this stream."

"That's so," echoed Gid, "and we can't go back the way we came, either."

Canoe Boys and Campfires or Adventures on Winding Waters (1907) was another Graydon tale of subterranean discovery.





A few paragraphs follow. Note Ned's reference to limestone hills. As for the "two outlets," however, he's just making the story work out.

A few yards downstream the wall of rock jutted out slightly and then receded. As the canoes rounded this a great heaving wave -- the vanguard of the flood -- tossed them high on its crest and cast them, like a stone from a catapult, straight toward a black, semi-circular hole in the base of the cliff. A furious current swept in the same direction, and even had the boys realized the nature of this new peril they could have done nothing to help themselves.

The canoe pitched and tossed dizzily, and by the cold air that surged on his face, and the spray that spattered him, Ned knew that he was moving at rapid speed. Suddenly a cry rang in his ears

He understood at once what had happened. The underground stream made a sharp curve at this point, and the force of the current had thrown the canoes far out on a sandy beach. From above, the yellow flood came roaring and tossing through a passage some twenty feet wide, and nearly the same in height. Below the angle it plunged on under the same conditions.

The beach was about ten yards long, and sloped back half that distance to a slimy wall of rock. On the opposite side of the stream the wall fell sheer into the water, and overhead was a jagged roof that glittered and sparkled in the rays of the lantern.

"And what happened to us, Ned? Didn't the current drag us into a hole in the cliff?"

"Yes," said Ned, "that's it exactly, and we are now in an underground cavern. Don't be alarmed," he added quickly, noting the sudden pallor on his companion's face, "our situation is not so terrible after all. Caverns of this sort are always found among limestone hills, and they usually have two outlets. This one is no exception to the rule, and I'll tell you why I think so. In the first place you must remember that the creek was nearly four feet high before that dam broke. The extra volume of water is what makes this terrific current through the cavern and the very fact that the water goes on through without damming up proves to me that it has an outlet."

Without a ray of light to guide them it would be a difficult matter to find the main channel of the stream again, and follow it to the outlet which must certainly exist. There was danger of falling into deep holes, of striking sharp rocks, or blundering into other side passages with which the cavern was doubtless honeycombed.

The Graydon bibliographer might recognize the above publication as On Winding Waters, A Tale of Adventure and Peril (1902), or perhaps as On Winding Waters or The Cruise of the Jolly Rovers, published ten years before that. A rousing story is worth a few titles.

In Graydon's The Wonderful Adventure on the Yukon Tributary (1898), Quin traverses an underground river to a valley of gold.

Quin fell asleep with his head pillowed on a roll of blankets. An hour later, waking with a start, he was alarmed and bewildered to find himself in absolute darkness; he heard the swift rush of water, and felt the cool, damp air.

"Where am I?" he cried.

Don't be scared, man," Cranes voice answered. "It's all right. We're floating underground for a bit, but it won't be long until we get into sunlight again."

Awed by their mystic surroundings, the voyagers were silent for a time. Suddenly a gray glimmer of light was seen in the distance. It rapidly grew larger and nearer, expanding to a spacious archway. Then it seemed to hurl itself forward, and the tossing craft was shot out into the dazzling glare of day.

"Look!" shouted Crane. "The valley of gold!"

But as shown to the right, there's more than precious metals at the headwaters!

On an excursion to Algeria -- our hero is quite the traveler -- Quin takes the opposite route, and underground river ride to escape peril. From A Treacherous Rival (1900),

Before they could realize their peril they were sucked into a cavernous hole, and dragged on at a dizzy speed through the fearful darkness.

A rounded boulder just beneath the surface forced them apart. A foaming wave submerged Quin, and as he rose he heard a wild, desperate cry. Then, as he struck out with his arms and legs, he grasped a pinnacle or rock and clung to it for a short time, while he gained breath and strength.

When he could hold fast no longer he trusted himself to the stream, and after several minutes he floated out from beneath the great mountain, into fresh air and sunshine. He swam clear of the dangerous reefs, and at length, little the worse for the struggle, he was thrown ashore by a circling eddy of smooth water.

In Wildest Africa, a Magnificent Complete Story, Introducing Ex-President Roosevelt and Matthew Quin, Wild Beast Agent, Boys' Friend Library No. 120 (1910) brought on board every Boys Club favorite politician, but Teddy wasn't with the boys when they crept under the Solomon's fortress.

They were under the foundations of the ancient fortress, and they were also considerably below the level of the enclosure. They did not know that, however, else they would have felt less confident of gaining their freedom as they stood peering about them.

It was a place to arouse superstitious terror and make the flesh creep. The flickering glare of the osier torches revealed on all sides natural walls of granite, and showed overhead a low ceiling studded with stalactites. The cavern ended close to the right, where there was a bubbling spring of water, fringed by a strip of hard sand, on which lay a long double-edged sword and several earthen vessels. To the left flowed the stream, vanishing in a winding tunnel that was less than half a dozen yards in width.

As with Graydon's other African adventures, this one is typical of the era's prevailing attitude toward Blacks, as well as having appallingly high death counts of both animals and humans.

The River of Darkness, or Under Africa (1890) was Graydon's tour de force of colonialism, a tale of British adventures in the Dark Continent. It was doubly dark, actually, because the heroes escaped black savages via an underground river. Graydon's position on racial matters was more nuanced, however, than it might seem in modern light. In pre-Civil War Pennsylvania, the Graydon family was adamant abolitionist. The author, however, who lived much of his adult life in Britain, also subscribed to the Victorian concept of noble colonialism. The natives in Graydon's fiction are thus in need of Anglo tutelage, the wise subjects being willing disciples, the foolish ones, inexcusably resistant.

Melton and Canaris were close behind, and together they went up into the vast expanse of the cavern. Under foot was hard, compact sand, and in a moment more the glare of the lamp was reflected on running water, and they stood on the brink of the mysterious underground river.

It was impossible to judge of the width of the stream. It might be very narrow and it might be very broad. The flowing water made not a sound, and yet the current was swift, for a bit of paper that Melton tossed in was snatched from sight immediately.

"If this current continues all the way," observed Forbes, "eight hundred miles will be nothing at all."

This, of course, was before they meet the sea serpent.

"I don't admire the appearance of that river very much," remarked the colonel. "It comes through the cliff as though shot by a cannon. No wonder, though, when you think of the terrible pressure from above."

"We will make up for lost time by rapid traveling, then," said Forbes.

"Ah, you think so?" cried Sir Arthur. "Bless me, I hope we will. I have an engagement to dine with Lord Balsover at the Hotel Bombay at Aden on the 10th at six o'clock in the evening. He touches there on his way to India, and I can't disappoint him, you know."

As River of Darkness is too good a title to be so squandered, James Grady employed it in 1991 and Rennie Airth, in 1999. Both titles are metaphoric, a topic of Chapter 30. Grady's tales is about a has-been CIA agent. Airth's work is about a has-been Scotland Yard detective. As "Grady" is suspiciously close to "Graydon," maybe the latter is still writing.

Zane Grey

Some may uphold Zane Grey as a literary artesian, but others would argue that his works are Boys Club fodder, just for older boys. Both Gray and Louis L'Amour churned out roughly 100 volumes, generally of the cowboy genre, but as L'Amour came no closer to underground rivers than Callaghen (1972), advertised to be about following an "underground river of gold," clearly metaphorical, we'll not count Louis.

Gray, on the other hand, employed a physical underground river in Desert Gold (1913).

The time was near the end of the dry season. Perhaps an underground stream flowed from the range behind down to the valley floor, and at this point came near to the surface. Cameron had heard of such desert miracles.

He was just in time to see the last of the water. It seemed to sink as in quicksand. The shape of the hole had changed. The tremendous force of the blast in the adjoining field had obstructed or diverted the underground stream of water.

Suddenly he again heard the dull roar of falling water. It seemed to have cleared itself of muffled vibrations. Yaqui mounted a little ridge and halted. The next instant Gale stood above a bottomless cleft into which a white stream leaped. His astounded gaze swept backward along this narrow swift stream to its end in a dark, round, boiling pool. It was a huge spring, a bubbling well, the outcropping of an underground river coming down from the vast plateau above.

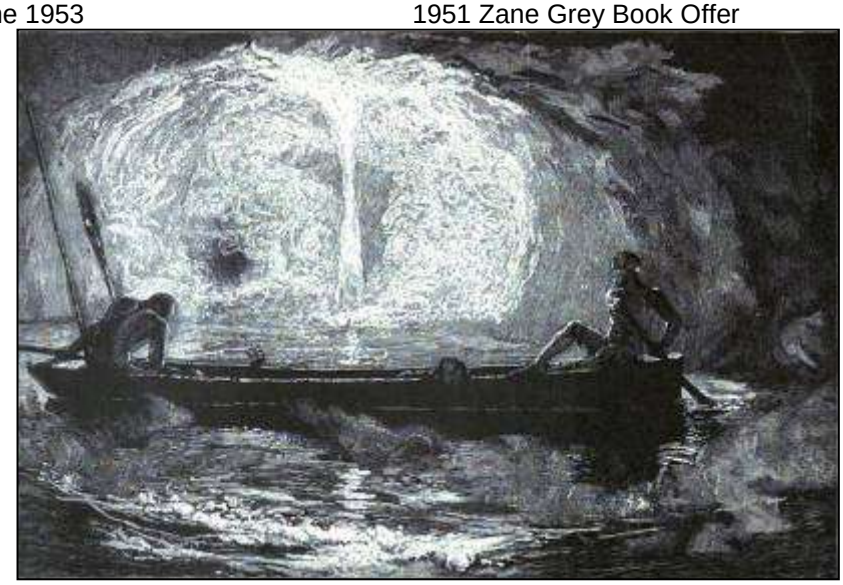
Following are the pertinent panels from Desert Gold's comic book version. We could have thus saved Gray for Chapter 25, Underground Rivers in the Comics, but that would truly infuriate Gray devotees. In deference to Gray's hard-cover credentials, we include an advertisement for his complete works.

"Desert Gold"
Zane Grey Comics # 467
May-June 1953

1951 Zane Grey Book Offer

H. Rider Haggard

Haggard's sequel to King Solomon's Mines (1885), Allan Quatermain, Further Adventures and Discoveries (1887) tells of a white race in Africa, a cross between Zoroastrian Persians and Druidic Celts. The travelers reach this country through an underground river which conducts them past a jet of flame and into to the country of living sacrifices.



By the river's edge was a little shore formed of round fragments of rock washed into this shape by the constant action of water, and giving the place the appearance of being strewn with thousands of fossil cannon balls. Evidently when the water of the underground river is high there is no beach at all, or very little.

Our river that was, Sir Henry said, a literal realization of the wild vision of the poet.

Haggard's endnote, "Where Alph the sacred river ran through caverns measureless to man down to a sunless sea," identifies the poet as Samuel Coleridge. As for the "sunless sea," we will further visit its shores in Chapter 31, Down to a Sunless Sea.

Indeed Haggard's plots are violent and racist and his language, stilted, but he doesn't take his readership as uncultured. His Stygian line,

And when all's said and done an underground river will make a very appropriate burying-place.'

In the "Authorities," Haggard mentions,

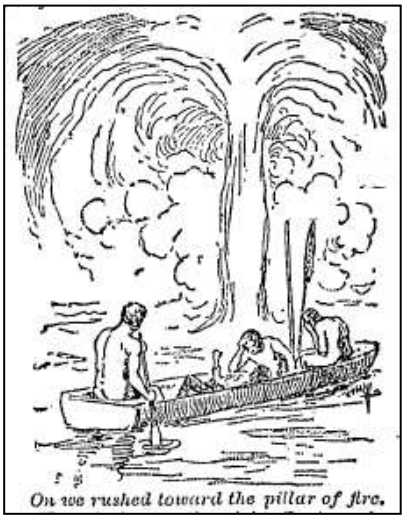
There is an underground river in "Peter Wilkins," but at the time of writing the foregoing pages I had not read that quaint but entertaining work.

Which leads us to the underground river of **Robert Paltock**'s Life and Adventures of Peter Wilkins (1751), a tale of an English castaway and a remote race of humans, a Gulliver's Travels meets Robinson Crusoe.

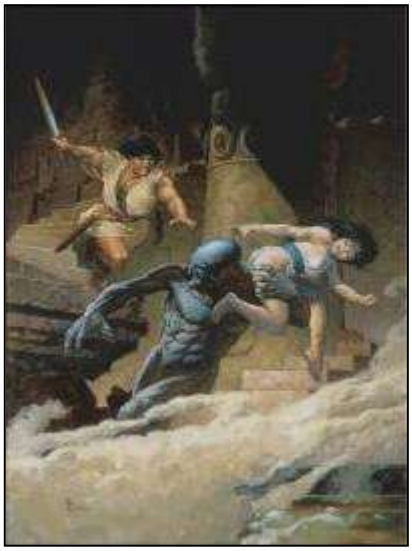
I soon found myself in an eddy; and the boat drawing forward beyond all my power to resist it, I was quickly sucked under a low arch, where, if I had not fallen flat in my boat, having barely light enough to see my danger, I had undoubtedly been crushed to pieces or driven overboard. At length, finding the perturbation of the water abate, and as if by degrees I came into a smoother stream, I took courage just to lift up my affrighted head; but guess, if you can, the horror which seized me, on finding myself in the blackest of darkness, unable to perceive the smallest glimmer of light.

However, as my boat seemed to glide easily, I roused myself and struck a light; but if I had my terrors before, what must I have now! I was quite stupefied at the tremendous view of an immense arch over my head, to which I could see no bounds; the stream itself, as I judged, was about thirty yards broad, but in some places wider, in some narrower. It was well for me I happened to have a tinder-box, or, though I had escaped hitherto, I must have at lust perished; for in the narrower parts of the stream, where it ran swiftest, there were frequently such crags stood out from the rock, by reason of the turnings and windings, and such sets of the current against them, as, could I not have seen to manage my boat, which I took great care to keep in the middle of the stream, must have thrown me on them, to my inevitable destruction.

The Quatermain saga was serialized in numerous newspapers, an illustration from the Alton [Iowa] Democrat, March 24, 1888, to the right.



Robert E. Howard



Robert Howard lived a life perhaps as tortured as that of Poe, Howard's end being self-inflicted by a .380 Colt automatic, not drugs and alcohol, however. Poe was 40. Howard was but 30. Much of Howard's output was serialized in Weird Tales.

We could save Howard's contributions for Chapter 25, Underground Rivers in the Comics, but his impact in that venue was a result of his pulp fiction, his most lasting character being Conan the Barbarian, pictured to the right saving a lass from the bubbling stream of slime.

For a sample of Howard's underground river prose, three tales suffice.

The Lost Race (1927),

> *The cave debouched into a cavern so vast as to be almost incredible. The mighty walls swept* up *into a great arched roof that vanished in the darkness. A level floor lay between, and through it flowed a river; an underground river. From under one wall it flowed to vanish silently under the other. An arched stone bridge, seemingly of natural make, spanned the current.*
>
> *All around the walls of the great cavern, which was roughly circular, were smaller caves, and before each glowed a fire. Higher up were other caves, regularly arranged, tier on tier. Surely human men could not have built such a city.*

The Treasure of Tartary (1933),

> *I have but to pull that, and the treasure falls into the subterranean river which runs below this palace, to be lost forever to the sight of men.*

Jewels of Gwahlur (1935), a Conan tale,

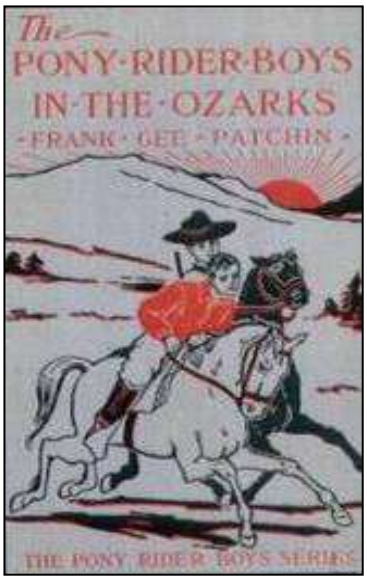
> *I've always known there was a subterranean river flowing away from the lake where the people of the Puntish highlands throw their dead. That river runs under this palace. They have ladders hung over the water where they can hang and fish for the corpses that come floating through.*

Not a pleasant scene, but Boys Clubs can handle it.

Frank Gee Patchin'

We've Frank Gee Patchin's 12-volume Pony Rider Boys series. In The Pony Rider Boys in the Ozarks, or The Secret of Ruby Mountain (1924), the lads ride not their ponies, but a rail car, into a mine.

"Not necessary," said Mr. Phipps. "It is seldom that anyone has occasion to go through this tunnel -- practically never unless something happens to a car in here. There are lights along that may be turned on if necessary, but it would be a needless expense to keep them going all the time."



"What's that loud noise?" asked Tad.

His ears had caught a booming roar that was a new note in the terrifying sounds of the underworld through which they were traveling.

The boys started uneasily.

"It's water," shouted the guide. "A cataract in an underground water course. These courses have cut channels all through the limestone rocks in the Ozark Uplift."

This somewhat calmed the nerves of the lads, though not wholly so. Faster and faster rolled the car and louder and louder grew the roar of the cataract.

What, we wonder, awaits the Pony Rider Boys within Ruby Mountain?

Luis Senarens

Jack Wright was the Edisonade hero of the 121-volume Victorian dime novel series written by Luis Senarens, the "American Jules Verne." A few Jack Wright stories were also credited to **Francis W. Doughty**.

Senarens also popularized the Frank Reade dime novel series, having taken the reins from Harry Enton, the pseudonym of Harold Cohen. Who wrote what gets a bit confusing.

Senarens took Reade's exploits to Antarctica, Australia, Central America, Central Asia, the jungles of Africa, inside the hollow earth and even the edge of space. Reade inventions included electric locomotives, one-person battery-powered electric flying suits, "electric cannons" (pneumatic machine guns), an instant camera, motorcycle-like bicycle cars, armed and armored all-terrain omnibuses, chariot-like "electric phaetons" and yachts that could travel underwater.

Jules Verne's influence in apparent in Senarens' titles, the ones about underground waters listed below.

Frank Reade, Jr., Exploring an Underground River with his Submarine Boat (1892)
Six Weeks in the Great Whirlpool (1893)
100 Miles Below the Surface of the Sea (1894)
Lost in the Great Undertow (1894)
The Underground Sea (1894)
Over the South Pole (1895)
1,000 Fathoms Deep (1895)
7,000 Miles Underground (1895)
50,000 Leagues Under the Sea (1895)
The Black Whirlpool (1895)
Lost in the Polar Circle (1896)
For Six Weeks Buried in a Deep Sea Cave (1894)
Wrecked at the Pole, or Jack Wright's Daring Adventures in the Frozen Sea (1896)

Reade slaughters Indians and Africans by the thousands and loots whatever's not nailed down. Irish, Afro-American, Jews and Mexicans are all met with ridicule. Senarens was a low point of American popular fiction.

Alpheus Hyatt Verrill

Verrill enjoyed callings other than pulp fiction, one as natural history editor of Webster's International Dictionary, another as inventor of the autochrome process of natural-color photography. Of Verrill's more than 100 fictional works, we've the four-volume Boy Adventurers series, and with a given name as Arcadian as "Alpheus," the author of course had his Boy Adventurers discover underground rivers.

In The Boy Adventurers in the Land of the Monkey Men (1923), Fred, Harry, and Dr. Woodward, visiting British Guiana in search of a radium deposit, are taken captive by bush negroes. On escaping they find themselves in a valley inhabited by black-skinned, flat-footed, broad-faced, mop-haired giants. The king of the giants, however, is treacherous, and it is only by luck that the explorers survive his schemes. Woodward teaches the savages how to make rude stone tools and weapons. Making their escape through an underground river, they continue on their search for radium.

Verrill, we come to discover, wasn't only a writer of fiction. In Rivers and Their Mysteries (1922), Verrill takes on the role of educator.

> *In many parts of the world where limestone is the country rock we find rivers and streams issuing from apparently solid hills, flowing for long distances and then suddenly disappearing as though swallowed up by the earth. In such localities, too, rivers will at times appear where no river has been before and after flowing for a variable length of time they will all at once dry up and disappear. But there is nothing mysterious about this for such rivers do not really flow from nowhere nor do they cease, but are merely underground rivers which flow above ground for a portion of their course or which, swollen by floods or other causes, find an outlet from their underground channels and flow across the land until the excess water has been drained off and they again resume their original course.*
>
> *If it is merely a flood which has caused it to overflow its underground banks, the new stream will dwindle away and disappear as soon as the surplus water has been drained off and the subterranean river falls to its ordinary size. In many places streams of this character appear regularly every spring, for mysterious and strange as they may seem they are in reality no more remarkable or abnormal than the temporary waterways which are formed by ordinary rivers when the water overflows the banks during freshets. In some places all of the streams are underground, while in other districts there are both subterranean and surface rivers, for one stream may find a fissure through which to drop and form an underground river while another may not, or again, a river may be so large that the greater portion of its water remains above ground although much of it flows through underground channels.*

According to Theodore Roosevelt, "It was my friend Verrill here, who really put the West Indies on the map." Perhaps this is why so many Americans are ill-informed about these lands.

It's difficult to reconcile the author's geological proficiency with his fictional creations, but it may be a case of knowing what sells the most books.

Elliot Whitney

Boys Clubs loved hunting, even if they didn't actually do it. From The Rogue Elephant (1913) by Whitney,

> *This lake, it seems, is fed by underground springs -- hot springs, that spout up and fall like fountains on the water; its outlet is also by an underground river, so that the lake lies, sweltering in the sun and surrounded by desert and jungle and marsh, where no people live.*

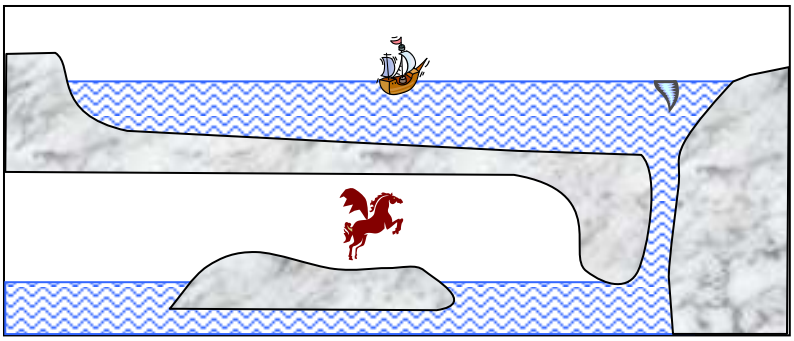
CHAPTER 22
BOYS CLUB SINGLES

In this chapter we'll meet Boys Club authors who didn't capitalize on serialization. In most cases, we'll introduce them chronologically.

In **Robert Paltock**'s The Life and Adventures of Peter Wilkins (1751), young Peter manages to steal a ship together with other English waifs and strays, but unfortunately, none of them can navigate it, and they eventually get lost. Eventually, he begins to explore in a ship's boat, and is swept by a current into a vast underground cavern. He sets up house on a small island in Robinson Crusoe style, investigating and adapting the local flora and fauna. He keeps hearing voices, which he stoutly dismisses as those of birds, until one day he finds a beautiful girl unconscious outside his hut.

> *Says I, "Quilly, how your cooks dress their victuals. I have eaten many things boiled, and otherwise dressed hot, but have seen no rivers, or water, since I came into this country, except for drinking, or washing my hands, and I don't know where that comes from. And another thing," says I, "surprises me, though I see no sun as we have."*

We can see why a Boys Club would like this volume in their library.



In Icosameron (1788) by **Giacomo Casanova**, shipwrecked siblings are dragged by currents to an underwater crevice and then through froth until they emerge on an island floating at the earth's center. The fauna of is similar to that of Europe except for the flying horses.

Robert E. Landor, The Fountain of Arethusa (1848) contains an account of a journey through a physical world in the center of the earth illuminated by its own sun. We won't belabor the likely influence of John Cleves Symmes.

> *A few minutes only were sufficient to exchange all this splendor for such solitude as pleased me even better. By an easy flexure, the river ran half round some elevated land covered with the shadiest trees, and then lost its way among an infinity of small verdant islands. Even they who were long familiar with this labyrinth, could hardly have determined what was the water's breadth, or where its shore! Leaving the midstream, we floated over pools and shallows which appeared, in some parts, to have been paved with chrysolites and amethysts, in other parts, to have been filled with flowers like our parterres.*

As for the real Fountain of Arethusa, we must wait until Chapter 29, Et In Arcadia Ego.

The title, "Waldon, the Half-Breed" by **William H. Bushnell**, Flag of Our Union, October 21, 1865, wouldn't pass muster by today's cultural standards, but as adventure, it lacked little.

Suddenly his feet slipped from under him, and his hand aching with the recent terrible struggle, alone rested on the slimy, mossy rock. To retain his hold was impossible. Slowly but surely he slipped down, down, but whither he dared not think. In a moment he was clutching at the intangible air alone, and with a cry of despair ringing from his lips, he fell into a yawning pit, a dark subterranean stream.


THE FLAG OF OUR UNION.

AN ELEGANT, MORAL AND REFINED

Miscellaneous Family Journal,

devoted to polite literature, wit and humor, prose and poetic gems, and original tales, written expressly for the paper. In politics, and on all sectarian questions, it is strictly neutral; therefore making it emphatically,

A PAPER FOR THE MILLION,

AND A WELCOME VISITOR TO THE HOME CIRCLE.

The Flag had seen better days, publishing Edward Alan Poe seven times in 1849.

Edward Bulwer-Lytton, The Coming Race (1871) tells in turgid prose of an American's descent into a deep mine, at the bottom of which is a broad road lit by gas lamps. The road leads into an underworld of "lakes and rivulets which seemed to have been curved into artificial banks; some of pure water, others that shone like pools of naphtha." Unfortunately, Lytton's underworld also contains descendants from the deluge who plan to emerge and conquer the surface world.

George Owen's The Leech Club, or Mysteries of the Catskills (1874) draws upon the readers' knowledge of Greek lore.

Finally they reached a narrow defile bounded on each side by a precipice. From this defile flowed a stream of water, beside which there was barely room to enter. This they knew from the description given by the old mountaineer, was the ravine they were seeking. Climbing from boulder to boulder, wet with the spray of the brawling stream, they make their way into the defile.

"Ah! Horace! Verily we have entered the infernal regions. I felt, when we were passing through the defile, climbing, slipping, and sometimes wading through the steam, that we were really crossing the river Styx, and I thought of calling the ferryman Charon to our aid."

"Indeed," said Horace, "if we don't meet that Stygian boatman or some of his crew here, we need not seek them elsewhere, but may be content till they come for us of their own accord."

In "Davy Crockett on the Track, or The Cave of the Counterfeiters," by **Frank Carroll**, Saturday Evening Post, January 31, 1874, young Ken Gordon is captured by the counterfeiters.

A sensation of fear ran through the mind of the interloper on finding himself discovered, and by this dangerous man. The good-natured, mocking tone of the other was of little assurance, for he knew him to be odd and cruel, a man of that temperament that can commit murder with a smile on his face and a jest on the tongue

Gordon, however, was too well aware of the company he was in, and had too much command over his feelings, to permit and sense of fear to display itself. He was in the lions den and must face the danger with a lion's boldness.

As literature should be instructive, however, the adventure is interspersed with informative passages.

The many caverns of the west, among them the giant of underground excavations, the great Mammoth Cave, are supposed to have been formed by the action of water.

Subterranean streams and rivers now run through them, following, probably, natural crevices in the rock, along whose course they have dissolved and fretted away the softer portions of the stone, excavating, in one place immense halls, in others, where the rock has proved harder, narrow apertures.

Boys Club members enjoyed knowing such things.

"Among Bushwhackers," an unattributed feature in the May 30, 1881, Aberdeen Daily News employs Poe-like imagery.

Then I was slowly lowered down, down, down, through the blackness. So slow was my descent that I seemed to be suspended for hours and to sink miles into the heart of the earth. The pain of the slender cord cutting into my flesh was well-nigh intolerable, and I bear the evidence of this today; with each moment the moaning, gurgling and groaning from the unknown depths into which I was sinking, became more distinct and horrible.

Suddenly, those above let go of the rope, and with a yell of despair I dropped, I do not know how far, into the water that closed above my head. As I rose to the surface choking and gasping for breath, I felt I was being swept forward by a powerful current, and as I again sank my feet touched the bottom. A moment later I stood in water up to my shoulders and again breathed freely. For some time I was confused beyond the power of thought by the hollow roar of the black waters rushing through those awful caverns. All surrounding space seemed filled with snarling, formless monsters cautiously advancing and making ready to spring at me. Even now I often awake at night with the horror of that moment strong upon me. It was so unendurable that I resolved to end it. It was with great difficulty that I maintained my footing. I could not do so much longer. Why should I attempt to? There was absolutely no hope of escape. I tried to pray, "Oh, Jesus, receive my soul." Then my muscles relaxed, and I was swept away by the rushing torrent.

At the other end of the writing spectrum, an excerpt from The Four Canadian Highwaymen, or The Robbers of Markham Swamp (1886) by **Joseph Edmund Collins** reminds us of the rule: An author may quote conversations phonetically, but should otherwise employ standard spelling.

The clay into which the roots of the trees had fastened themselves was quite solid, and was held fast in the thick tangle of roots. So for many years you could hear the river floween

beneath the ground with a subdued gurgleen sound. Hunters avoided the wood, for some careless persons had come here and fallen through the holes into the rusheen tide. Their bodies were afterwards found floateen in Silent Lake. One day my grandfather and two of his men came to see the treacherous underground river; and they moved cautiously down the stream till they came where it sank into a hole in the ground, that looked like a huge sluice-way.

My grandfather looked at the strange sight for a time, and then at the great bridge of trees and boulders that lay across the original course of the river. They wondered why he gazed at all so earnestly; and why his eyes grew so bright. Then he slapped the capteen, who was yet a boy, upon the back, and said,

"Just the very place we want. Here we will have a quiet castle of our own, where no limb of the law can find us.'"

It is not uncommon for Boys Club, we observe, to suspend the rules of spelling.

In the World Below (1897) by **Fred Thorpe** features a Subterranean Boring Car, its outer shell fitted with revolving cutting edges, its inner core, cabin and stationary. In a planned bore from the Amazon to China, the machine runs out of control and the passengers find themselves swimming in the water of an inner earth. The vegetation is odd and the force of gravity is weak. The explorers are about to be speared by blue-skinned natives when they are rescued by a white man who'd fallen into the inner world from the Andes. The Subterranean Boring Car is their only chance for escape, but it's submerged and blocking the drainage of the inner world. As the waters rise, the explorers wisely build a raft. The fortuitous appearance of a white savior isn't an uncommon happening in such novels. In the World Below was written within memory of Henry Stanley's, "Doctor Livingstone, I presume?"

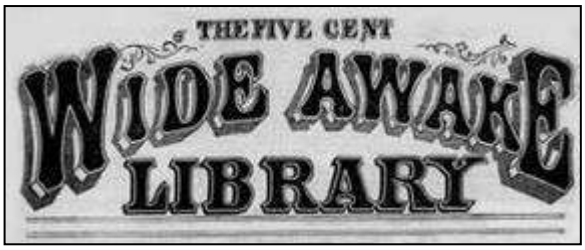
In **Charles W. Beale**'s The Secret of the Earth (1899), Guthrie and Torrence Attlebridge, co-inventors of the airplane, enter the earth's interior where they find roofless houses and a city of white and gold, a paradise that was man's first home. As the Wright Brother's success at Kitty Hawk wasn't until 1904, the Attlebridges would seem to deserve aeronautical recognition. As they were acting as agents of an inner-terrestrial benefactor, however, we tend to minimize their accomplishment.

James De Mille's A Strange Manuscript Found in a Copper Cylinder (1888) is couched in the style (if not plot plagiarism) of Poe's Arthur Gordon Pym. Adam, the hero, is swept into a channel that leads into a chasm into the depths of the earth.

The darkness grew so intolerable that I longed for something to dispel it, if only for a moment. I struck a match. The air was still, and the flame flashed out, lighting up the boat and showing the black water around me. This made me eager to see more. I loaded both barrels of the rifle, keeping my pistol for another purpose, and then fired one of them. There was a tremendous report, that rang in my ears like a hundred thunder-volleys, and rolled and reverberated far along, and died away in endless echoes. The flash lighted up the scene for an instant, and for an instant only; like the sudden lightning, it revealed all around. I saw a wide expanse of water, black as ink -- a Stygian pool; but no rocks were visible, and it seemed as though I had been carried into a subterranean sea.

Mamelons & Ungava, A Legend of the Saguenay (1890) by **W.H.H. Murray** tells of subterranean Atlantilian army of the dead.

> *So the two boats went through the lovely lakes, floating slowly down the flowing rivers without hap or hazard, until they came to the last portage, whose gloomy tide flows out of death and into bright life at Mamelons.*



We like "The Skeleton Island, or A Cruise in an Underground River" by **Roger Starbuck** in The Five Cent Wide Awake Library, Issue 1054 (1891), not as much for the story, as for the magazine name.

From its name, Golden Days for Boys and Girls wasn't exclusively for Boys Clubs, though our example has that ring.

"The Mutiny on Board of the Sea Eagle, or the Adventures of a Homeless Boy" by **Ralph Hamilton**, November 12, 1892,

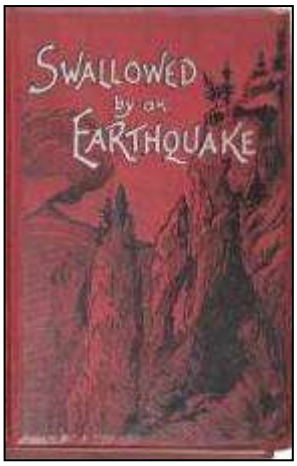
> *The entrance to this odd underground water-way was not more than four feet in height by six wide, but he unhesitatingly entered the narrow channel, bent upon seeing what there was of it and where it led to.*
>
> *Drawing a long breath of surprise and satisfaction, he ceased rowing, and, as the boat came to a stand-still on the glassy surface of this subterranean sea, he uttered an exclamation of wonder, and looked around him in a maze of doubt and admiration.*

In **Ingersoll Lockwood**'s satirical Trump's Marvelous Underground Journey (1893), an opening in the earth conveys Trump into the interior where he meets the Transparent Folk and the Rattlebrains.

Note the ease of fishing on the glassy river.

> *From now on Lord Bulger and I made ourselves perfectly at home among the Mikkamenkies. One of the royal barges was placed at our disposal, and when we grew tired of walking about and gazing at the wonders of this beautiful city of the underworld, we stepped aboard our barge and were rowed hither and thither on the glassy river; and if I had not seen it myself I never would have believed that any kind of shellfish could ever be taught to be so obliging as to swim to the surface and offer one of their huge claws for our dinner, politely dropping it in our hand the moment we had laid hold of it.*

Swallowed by an Earthquake (1894) by **E. Douglas Fawcett** was marketed as a "New Story of Romance and Adventure for Boys." From the book,



> *Never before had a voyage such as ours been ventured. Three hundred feet below the valley of the Scherno we were threading a subterranean watercourse that led no one knew where.*

The review in the Journal of Education 16, 1894, notes the centrality of the underground river setting.

> *Various writers have made use of underground passages and subterranean rivers for extricating their heroes and heroines from apparently hopeless positions, but Mr. Fawcett introduces us to an underground world, lighted by an aurora borealis, still peopled by the sauria of the Mesozoic time, and also by savages of the stone age, who converse chiefly in clicks, and worship the fire-god... It is a pity that a false note is so often struck by the two young men of the party. Naturally, they could not help being much more modern than their entourage, but they need not have been slangy. A more serious, or even tragic, demeanor would have harmonized better with the story... It is not an easy book to illustrate, but two of the pictures -- the underground river, and the lake of the Aurora -- have come out very well.*

The mentioned illustrations,

The Marble City Being the Strange Adventures of Three Boys (1895) was **R.D. Chetwode**'s warning to Boys Clubs regarding the horrors of socialism. Bob, Jack and Harry -- Boys Club heroes prefer such unencumbered names -- set out for Australia, but are captured by black cannibals. Brown-skinned cannibals rescue them, but in turn sell them to yellow-skinned barbarians who practice socialism. The Great High Priest, however, turns out to be an Englishman who was captured as a child helps them escape by the secret underground river.

The Fortress of Yadasara, a Narrative Prepared from the Manuscript of Clinton Verrall, Esq. (1899) by **Percy Brebner** is another romantic lost-race adventure taken from discovered writings. While hiking in the Caucasus, the Victorian-era hero falls into a hidden land populated by the

descendent of the last Crusade. We'll skip the central part of the story, just mentioning that -- as is often the case in such situations -- escape to the outside world is by, yes, an underground river.

The serialized "The Cave of Avarice" by **Clinton Ross**, April 7, 1898, Salt Lace Herald, featured a subterranean treasure trove.

To the cave of the underground river I had the casks carried. Then I had a wall built 20 rods from the caves entrance and I walled the treasure there against the roar of the stream that sees no light.

If the illustration looks vaguely familiar, it's more or less the same as the one in Deering's The Border Boys Across the Frontier in the previous chapter, only from the front, not the back.

A Mystery of the Pacific (1899) by **William H. Smeaton** deals with Romans and Atlantilians dwelling under the South Pacific. A bit of the dialog about the subterranean river passing inland.

"What is that?"

"It is a mysterious underground river, dark and deep, which seems to flow underneath the entire range of mountains. I believe it enters the ranges away to the west, in the heart of a mountainous, impenetrable tract of country covered with dense forest. But for miles and miles this river flows underground. It must go somewhere."

"Has it ever been traced to its mouth, or at least to where it leaves the mountains?"

"Never. At least I have never heard of anyone who followed it up so far, that returned to tell his experiences," was the somewhat alarming remark of Icilius.

The river seemed to flow through subterranean valleys and plains, through narrow gorges and beneath the frowning face of sheer impending cliffs. A dull semi-twilight prevailed, amidst which we could discern objects at a great distance both before and behind us. Gems of value almost incalculable sparkled here and there, and by their sheen, even in the dull light, lent their quota to the illumination of the gloom.

Now and again we would pass on the left-hand bank the faces of gigantic figures sculptured in the rock. Also mysterious blocks of masonry, showing that mankind had been there before us.

In "His Enemy's Daughter," Michigan Farmer, April 14, 1900, **Ernest Glanville**'s subterranean stream leads the hero onward.

He continued along the passage for some twenty yards, when it terminated in a flight of steps descending at a steep slope into the black well, out of which came the noise of running water. He hesitated here for some time, but finally, plucking up courage, went down, till he stood upon the edge of the underground stream. This he found flowed swiftly along a trough, some three feet in width, hewn out of solid rock. The path followed the stream for a few yards, then suddenly the darkness grew less, and he stood on a sort of gallery above a great underground cavern or chamber, the floor lined with white sand, which reflected a thin stream of light pouring through a crack in the roof. Stepping across the stream to the narrow lip or rock beyond he looked down into the chamber, whose floor was about ten feet below. Then he walked along this natural gallery the whole length of the cave which extended thirty paces, when the stream disappeared into a small opening.

Josiah Flintabbatey Flonatin, the distinctively-named hero of **J.E. Preston Muddock**'s The Sunless City (1905), chronicles a descent.

> *Flin occupied himself with carefully writing up his diary and examining his instruments. He felt very well satisfied, for so far success had attended his venture, and the theory he had advanced at the meeting had now become actual fact, and he was sailing beneath the surface of a subterranean river.*
>
> *Before him rushed the river which might have been taken for the fabled Styx, and the gloomy caverns the abode of the grim ferryman, Charon... He knew that the rushing river led somewhere, and wherever it led to he was willing to go.*

H. Henry Rhodes, Where Men Have Walked, A Story of the Lucayos (1909) begins in a cave.

> *Cautiously I brought my boat nearer the entrance, and I wondered why I had not seen the arch before. But the water was lower now, the tide was out and left clear to view what had before passed as a rock projecting from the ocean's depths. I stepped out on the broad, stone threshold, and gazed around. The water looked black and dismal and bottomless. It was still, not a ripple, for the ocean had no influence here. It could beat its waves against the outside, but could not molest the weird quiet of the waters within, that, in their depths, mirrored the sword-like rocks that hung from the ceiling.*
>
> *A peculiar gurgling sound attracted my attention, and I looked a few feet away from where I stood, to the right, and saw that the waters were disturbed slightly as though a little rivulet made its way over the rocks, down, down the depths below, where it fanned an underground stream.*
>
> *Near the center of the cave, a fountain played, formed by a little stream that bubbled up, sparkling and rippling awhile, for observation, seemingly, then gurgled down into the inner recesses or the earth. A crystal cup rested invitingly near on a ledge of rock, and I advanced to drink. As I drank, the same cooling liquid that had been my salvation when I lay neath the shelter of the rocks, cooled my dry, parched tongue... Could this streamlet, only showing itself for a moment, rippling over the stones for the space at a foot or two, be the same stream that, travelling through the bowels of the earth, became heated almost to boiling, and formed the fabled river that led to hell?*

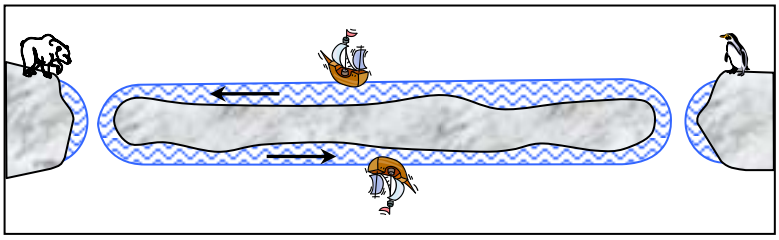
"The fabled river that lead to hell." By its temperature, it must be the River Pyriphlegethon.

Willis George Emerson's The Smoky God, or a Voyage to the Inner World (1908) capitalized on Symmes' hollow-earth. Olaf and father are caught in a great polar maelstrom fails (a singularity we know from Chapter 16) which sweeps them 10 miles downward. Their compass fails (the other singularity) and the two mariners discover that the seawater is now fresh. How the water can pass around the verge, but not the salt, isn't explained.

For two years the two live with the hollow earth inhabitants whose capital is surrounded by four rivers taking their source from an artesian fountain.

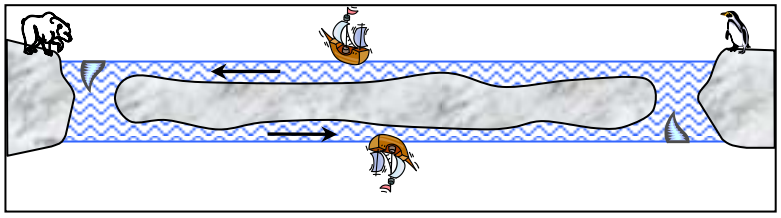
When time comes to bid adieus, Olaf and father head south, as the wind constantly blows from the north. The first intimation of their approach to an exit is an island inhabited by 3-meter penguins. The compass again behaves erratically as they ascend the curvature of the opening and the two Norwegians find themselves among the Antarctic ice.

This is the Symmes model (Chapter 15, Hollow Earth Geophysics). Dual polar passageways nicely maintain Plato's balance of nature and from the perspective of mass balance, the scheme is elegant.



Keeping the water on the respective surfaces defies science, but we'll not belabor the issue.

Other authors describe the passages as vortices, the topic of Chapter 16. Unlike an arced descent around a Symmes verge, however, the chance of surviving such a maelstrom would be nil. Poe's MS. Found in a Bottle got the fatal part right



Hydrologic information from the The Smoky God,

> *Some of the rivers "within," Olaf Jansen claims, are larger than our Mississippi and Amazon Rivers combined, in point of volume of water carried; indeed their greatness is occasioned by their width and depth rather than their length, and it is at the mouths of these mighty rivers, as they flow northward and southward along the inside surface of the earth, that mammoth icebergs are found, some of them fifteen and twenty miles wide and from forty to one hundred miles in length.*

At 2,000 square miles, this inner-side iceberg exceeds the largest ever recorded on the outside (off Antarctica) by one-third. The outer-world record holder extended out of the water to almost the height of the Washington Monument.

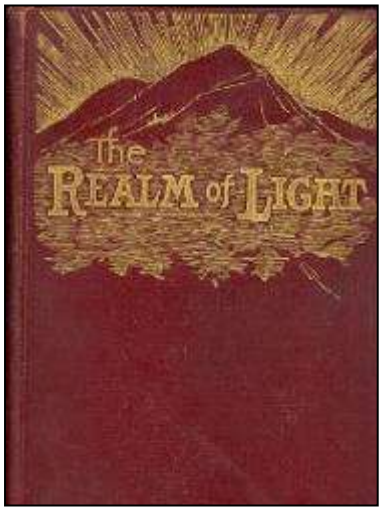
> *In this garden four rivers have their source in a mighty artesian fountain. They divide and flow in four directions. This place is called by the inhabitants the "navel of the earth," or the beginning, "the cradle of the human race." The names of the rivers are the Euphrates, the Pison, the Gihon, and the Hiddekel.*

The Euphrates, Pison, Gihon and Hiddekel are the Edenic Rivers of Life, Chapter 4.

Sheridan Frank's "The Young Marooner, or An American Robinson Crusoe," Brave and Bold, December 26, 1908, freely lifts from other plots.

Sixteen year-old Tom Scott leaves home and becomes a sailor on a whaling ship. Hanging on to a cable tied to a harpoon buried in a whale, Tom ends up riding atop the whale and being chased by a ravenous giant squid. He passes out and wakes up on the shore of an island inhabited by Joco, a Friday-like character. Tom and Joco discover a mysterious well leading to an underground river which tunnels to an adjacent island. There, they save princess Waupango from cannibals, but her people try to kill the heroes. Tom and Joco escape, and with a powerful explosive destroy the tunnel.

In searching for a lost white race in West Africa, explorers in **Frank Hatfield**'s The Realm of Light (1908) embark upon a subterranean river which whirls them to the land of Zoeia, a fantasy civilization -- like many of the literary era -- brimming with scientific marvels. Only once in seven years do the subterranean waters subside enough to negotiate the passage, which, even then, is no easy sail.



> *There was no sound save the occasional rasp of a timber against the rocks, no light, but little sense of time. We lay mutely awaiting the inevitable. What would the next moment bring? Should we suddenly feel the sharp, cold fangs of the rock-roof on our upturned faces, and the rush of water into our mouths and nostrils ere we gasped and died in an embrace as deadly as the "Iron Maiden's?" Or should we be smothered in the stifling atmosphere that each moment grew denser?*
>
> *To lie motionless, helpless, hopeless, on a frail craft in a dark, deep vault rapidly filling with seething water, and await the unpunctual coming of a horrid death, who can define that?*
>
> *The current of my thoughts was broken by Hum.*
>
> *"Mr. Hatfield," he said, as quietly as by the campfire, "have you noticed that the density of the air is no longer increasing."*
>
> *"No, my thoughts have been elsewhere."*
>
> *"Well, I have. I am convinced that this shaft, or whatever it is, communicates with the open air. If so, there is ground for hope."*

The noted increase in air pressure and "There is ground for hope" -- era's celebration of science.

Emma L. Orcutt's The Divine Seal (1909) involves lycanthropy, the Arctic, a hollow world with Atlantilian survivors, suspended animation and a baffling cosmology.

> *We knew the crater was not deep; that some time a winding stairway had been made, and that landings, built of wood, or hewn out of the rock, had served as resting places. We also were aware that at the bottom there was a stream of water; its source and mouth had never been*

found; at least none of the living inhabitants of Heclades had explored the river and there were no records referring to it that seemed reliable... I knew that volcanic eruptions and earthquakes had occurred since then and I believed this stream had an outlet in the known world.

Our electric lantern and "dome light" enabled us to see a long distance ahead; we glided down that underground current with no anxiety as to our safety, but with a great deal of curiosity as to the terminus of our trip.

As with many Boys Club books, the literary verdict wasn't positive.

But it fails to grip a responsive imagination in the reader, and all its wonders fall to the ground with a dull thud -- New York Times Saturday Review of Books, March 12, 1910

In The Great War Syndicate (1882) by **Frank R. Stockton**, the American War Syndicate fights the British with a "motor bomb" (a rocket fired from a gun), "crabs" (a submarine that snags the propeller of enemy ships) and "repellers" (spring-loaded armor that throws incoming artillery back from where they came). After defeating the Brits, the Syndicate falls into an underground river and must deal with dwarf Indians.

The Adventures of Captain Horn (1910) by the same author presented its hero a puzzle.

As he and Ralph stood there, stupefied and staring, they saw, by the dim light which came through the opening on the other side of the cavern, a great empty rocky basin. The bottom of this, some fifteen or twenty feet below them, wet and shining, with pools of water here and there, was plainly visible in the space between them and the open cleft, but farther on all was dark. There was every reason to suppose, however, that all the water had gone from the lake. Why or how this had happened, they did not even ask themselves. They simply stood and stared.

In their search for water, game, or fellow-beings, no one had climbed these desolate rocks, apparently dry and barren. But still the captain was puzzled as to the way the water had gone out of the lake. He did not believe that it had flowed through the ravine below. There were no signs that there had been a flood down there. Little vines and plants were growing in chinks of the rocks close to the water. And, moreover, had a vast deluge rushed out almost beneath the opening which lighted the cave, it must have been heard by some of the party. He concluded, therefore, that the water had escaped through a subterranean channel below the rocks from which he looked down.

Edith Nesbit's The Magic City (1910) is simply credited to E. Nesbit, as Boys Club boys might not appreciate a lady author. An unhappy 10-year-old escapes into a magical city he has built out of books, chessmen, candlesticks and other household items.

He listened. And he heard a dull echoing roar that got louder and louder. And he looked. The light of the lamps shone ahead on the dark gleaming water, and then quite suddenly it did not shine on the water because there was no longer any water for it to shine on. Only great empty black darkness. A great hole, ahead, into which the stream poured itself. And now they were at the edge of the gulf. The Lightning Loose gave a shudder and a bound and hung for what seemed a long moment on the edge of the precipice down which the underground river was pouring itself in a smooth sleek stream, rather like poured treacle, over what felt like the edge of everything solid.

The moment ended, and the little yacht, with Philip and Lucy and the parrot and the two dogs, plunged headlong over the edge into the dark unknown abyss below.

"It's all right, Lu," said Philip in that moment. "I'll take care of you."

And then there was silence in the cavern--only the rushing sound of the great waterfall echoed in the rocky arch.

And all the time the yacht was speeding along the underground stream, beneath the vast arch of the underground cavern.

'The worst of it is we may be going ever so far away from where we want to get to,' said Philip, when Max had undertaken the steering again.

"All roads," remarked the parrot," lead to Somnolentia. And besides the ship is travelling due north -- at least so the ship's compass states, and I have no reason as yet for doubting its word."

"Hullo!" cried more than one voice, and the ship shot out of the dark cavern into a sheet of water that lay spread under a white dome. The stream that had brought them there seemed to run across one side of this pool. Max, directed by the parrot, steered the ship into smooth water, where she lay at rest at last in the very middle of this great underground lake.

In Darkness and Dawn (1914), **George Allan England** makes use of the whirlpool, by then a standard ploy.

From the warmth of the sea and the immense quantities of vapor that filled the abyss, they concluded that it must be at a tremendous depth in the earth -- perhaps as far down as Stern's extreme guess of five hundred miles -- and also that it must be of very large extent.

Beatrice had noted also that the water was salt. This led them to the conclusion that in some way or other, perhaps intermittently, the oceans on the surface were supplying the subterranean sea.

"If I'm not much mistaken," judged the engineer, "that tremendous maelstrom near the site of New Haven -- the cataract that almost got us, just after we started out -- has something very vital to do with this situation."

"In that case, and if there's a way for water to come down, why mayn't there be a way for us to climb up? Who knows?"

King of the Khyber Rifles (1916) by **Talbot Mundy** is "the most picturesque romance of the decade," according to its press, although Boys Clubs would have been more taken by the adventure.

There was only one wild scream that went echoing and re-echoing to the roof. There was scarcely a splash, and no extra ripple at all. No heads came up again to gasp. No fingers clutched at the surface. The fearful speed of the river sucked them under, to grind and churn and pound them through the long caverns underground and hurl them at last over the great cataract toward the middle of the world.

Rex Stout, Under the Andes (1914) tells of brothers and Desiree Le Mire, the most desirable woman in the world, who daringly enter a cave that takes them deep below the Andes.

"But where are we? What happened? My head is dizzy -- I don't know --"

I gripped his hand.

"'Tis hardly an every-day occurrence to ride an underground river several miles under the Andes. Above us a mountain four miles high, beneath us a bottomless lake, round us darkness. Not a very cheerful prospect, Hal; but, thank Heaven, we take it together!

"Keep your nerve. As for a way out -- at the rate that stream descends it must have carried us thousands of feet beneath the mountain. There is probably a mile of solid rock between us and the sunshine. You felt the strength of that current; you might as well try to swim up Niagara."

We dragged ourselves somehow ever onward. We found water; the mountain was honeycombed with underground streams; but no food. More than once we were tempted to

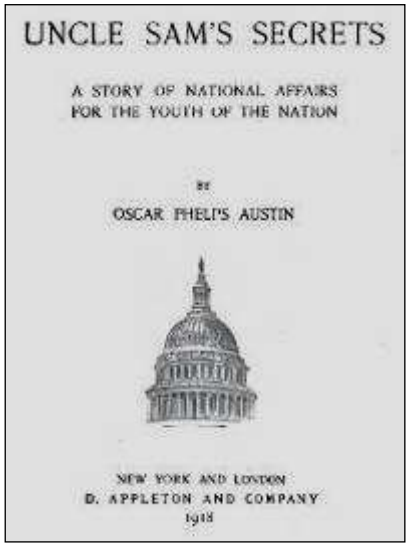
trust ourselves to one of those rushing torrents, but what reason we had left told us that our little remaining strength was unequal to the task of keeping our heads above the surface. And yet the thought was sweet -- to allow ourselves to be peacefully swept into oblivion.

Nature is not yet ready for man in those wild regions. Huge upheavals and convulsions are of continual occurrence; underground streams are known which rise in the eastern Cordillera and emerge on the side of the Pacific slope. And air circulates through these passages as well as water.

I lay on a narrow ledge of rock at the entrance to a huge cavern. Not two feet below rushed the stream which had carried me; it came down through an opening in the wall at a sharp angle with tremendous velocity, and must have hurled me like a cork from its foaming surface. Below, it emptied into a lake which nearly filled the cavern, some hundreds of yards in diameter. Rough boulders and narrow ledges surrounded it on every side.

Amidst such fiction we'll insert a couple of works written to edify Boys Club members. Pick, Shovel and Pluck: Further Experiences "With Men Who Do Things" (1914) by **Alexander Russell Bond** provided the Boys Club with appropriate role models

"Fighting an Underground Stream" concerns subway excavation, as what boy wouldn't like to dig in the earth with steam shovels? A near disaster enlivens the episode, but all escape and the work progresses.



Uncle Sam's Secrets: A Story of National Affairs for the Youth of the Nation (1918) provides author **Oscar Phelps** Austin the opportunity to explain many things of importance, America's gold standard and the workings of a postal railway car being two. As for underground rivers,

"It seems to me," said the professor, as they bade adieu to the bats, "that I hear the sound of running water; perhaps we shall encounter an underground river. Such things are not uncommon in caves."

He was right. A few minutes' walk brought the members of the party to a rapidly flowing stream, which issued from an opening in the side of the cavern, flowed along the passageway for some distance, gradually widening until it covered the whole floor, and then with an abrupt turn disappeared through the side of the cavern.

"Dear me," said Mr. Canby, "we shall not be able to go farther."

"Wait a bit," said the professor. "I must see about the strength of the stones which project over the water. I cannot consent to your taking any risks, for I consider myself responsible for your

safety. The water in this river is evidently deep, and, should anybody fall into it, he would be swept underground in an instant and lost."

"Where does the water go?" said Mr. Canby.

"Probably it flows into the Ohio or some of its tributaries at some unknown point; perhaps it comes into it under the surface of the water, or else at some obscure spot where its reappearance on the surface of the earth has not been observed."

This part of the cave," said he, seating himself as calmly as though he were in his chair in the schoolroom, "was probably formed in part by the washing and friction of gravel and sand poured over it by the water coming through that opening above us. We are now under a portion of the land which was covered by the great lake caused by the huge ice dam formed across the Ohio River during the glacial period in North America."

The professor is incorrect regarding the genesis of the cavern, as abrasion can occur only in a channel already large and steep enough to have high velocities. Like all karst rivers, this one was by dissolution.

Everett McNeil, The Lost Nation (1918) features Aztecs, Toltecs, ape-men and subterranean monsters.

"Now," and Ith turned quickly to Professor Kendal, "Exitl calls and we must hasten. Look not down and follow me without fear, though I appear to be walking on air. From this point a narrow bridge hangs suspended from the ceiling of the cavern, far above the horrors below, and passes over the river of burning brimstone, even to the Cavern of the Great Jaws of Death."

H.P Lovecraft's short story, The Beast in the Cave (1918), tells of a man lost from his tour group and stalked by a wild beast in the bowels of Mammoth Cave, a place we will visit in Chapter 55, Then, Madam, You Should Go and See the Great Cave in Kentucky.

No Boys Club member would admit to being scared, even by Lovecraft's "The Festival" in Weird Tales, January 1925.

And then, because that nightmare's position barred me from the stone staircase down which we had come, I flung myself into the oily underground river that bubbled somewhere to the caves of the sea; flung myself into that putrescent juice of earth's inner horrors before the madness of my screams could bring down upon me all the charnel legions these pest-gulfs might conceal.

Abraham G. Merritt, The Moon Pool (1919) features a South Sea escape from reptilians.

Whence came the stream, I marveled, forgetting for the moment, as we passed on again, all else. Were we closer to the surface of earth than I had thought, or was this some mighty flood falling through an opening in sea floor, Heaven alone knew how many miles above us, losing itself in deeper abysses beyond these?

"The Flying Legion," All-Story, November 15, 1919, tells of the Master (a soldier of fortune), the mysterious masked Alden (a female in disguise) and the Legionaries who enter the hidden city Ruba al Khali, discover a pyramid of solid gold and in fighting their way out, leap into an underground river which delivers them to a perilous desert.

In **Ella M. Scrymsour**'s The Perfect World, A Romance of Strange People & Strange Places (1922), features purple-skinned one-horned descendants of the Korahites, swallowed by the earth for rebelling against Moses.

> *Tirelessly he worked, until success met his efforts and he had made a hole big enough to crawl through, and from whence came the sound of rushing waters.*
>
> *He lifted his lantern above his head in his endeavor to discover where he was, and its feeble rays shone upon a swiftly flowing, subterranean river that disappeared through a tunnel on either side. The place he was in was very small and had no outlet except by way of the water.*
>
> *The river was narrow, perhaps four feet wide at the most, but with a current so strong that Alan, good swimmer though he was, would not have dared to have trusted himself in its cruel-looking depths. Mechanically he dropped a lump of coal into the water. There was a slight splash -- but no sound came to tell him that it had reached the bottom.*
>
> *He looked at the water curiously, and dabbled his fingers in the brackish fluid. Suddenly a pain in his hand made him draw it out quickly, and by the light of the lantern he saw it was covered with blood. As he wiped it clean he saw the impression of two teeth on his first and third, fingers. Slowly his lips moved and he murmured, "There is animal life in this river then-I wonder where it leads-can there be humanity near too?"*

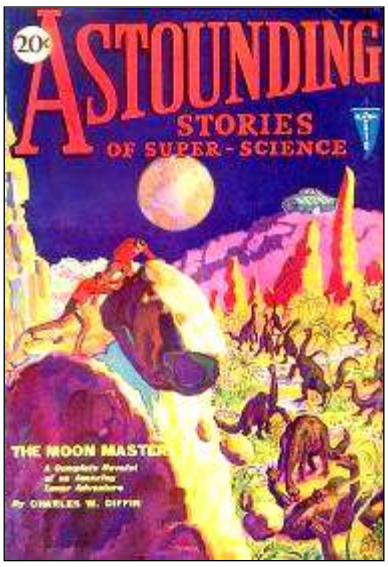
Soviet geologist and geographer, explorer, and indefatigable popularizer of scientific knowledge, **Vladimir Obruchev** wrote Plutonia in 1924. A comet knocks a hole in the earth's shell, permitting access into an underground world of rivers, lakes, volcanoes and strange vegetation, a world with its own sun -- Pluto, a world inhabited by monstrous animals and primitive people.

Edward M. Forster's 12,000-word The Machine Stops (1928) describes a subterranean world in which almost all humans have lost the ability to live on the surface. Each individual lives in isolation, with all bodily and spiritual needs met by the omnipotent, global Machine. The population uses a "speaking apparatus" and the "cinematophote" (television) to conduct their only activity, the sharing knowledge.

The people forget that they, the , created the Machine and treat it as a mystical entity having needs that supersede their own. Those ting subordinate to threatened with expulsion.

Eventually, defects begin to appear in the Machine. Humankind at first accepts the deteriorations as the whim of the Machine, but as the knowledge of how to repair the Machine has been lost, the Machine apocalyptically collapses, bringing civilization with it.

Tom Curry's "Giants of the Ray" in Astounding Stories of Super-Science, June 1930, concerns Super Science, but the underground river is just worldly big one.

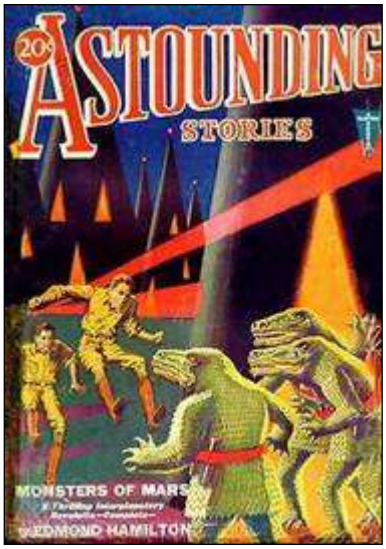


Madly the Three raced for their lives up the shaft of the radium mine, for behind them poured a stream of hideous monsters -- Giants of the Ray!

The mine spread out now, and began a steeper descent. The air was poor, and it was hard to breathe through the mask. Maget, his heart thumping mightily, listened to the roaring within the depths of the mine.

Now the ground seemed to drop away before them. Maget could hear the running of water, the underground river, and every now and then there came an immense splash, as if some great whale had thrown itself about in the water.

"Four Miles Within," Astounding Stories, April 1931, by **Anthony Gilmore** is saga of terror.



They were standing on a narrow ledge that overhung an underground river. A fetid smell of age-old, lifeless water rose from it. Dimly, at least fifty feet across, they could see the other side, shrouded in vague shadows. The inky stream beneath did not seem to move at all, but remained smooth and hard and thick-looking.

They could not go around it. The ledge was only a few feet wide, and blocked at each side.

"Got to cross!" Phil said tersely.

Quade, sickly-faced, stared down. "There -- there might be other things in that water!" he gasped. "Monsters!"

"Sure," agreed Phil contemptuously. "You'd better stay here." He turned to the others. "I'll see how deep it is," he said, and without the faintest hesitation dove flatly in.

Oily ripples washed back, and they saw his head poke through, sputtering. "Not deep," he said. "Chest-high. Come on."

He reached for Sue, helped her down, and did the same for her father. Holding each by the hand, Sue's head barely above the water, he started across. They had not gone more than twenty feet when they heard Quade, left on the bank, give a hoarse yell of fear and dive into the water. Their dread pursuer had caught up with them.

"Blond Goddess" was a lightening-paced adventure story by **Herbert Jensen** serialized in daily newspapers in the mid-1930s. We'll extract from the passage in which Frank Grahame, the

explorer, may not escape a flooding Yucatan valley via an underground river to the coast. We'll classify it as a single work, as it's just one adventure chopped up.

Despite himself, Frank's teeth begin to chatter. He had estimated eight to ten hours immersion would his resistance bear it.

Then suddenly the phosphorescent glow disappeared. The water seemed quicker; then apparently the current became a scarcely perceived flow.

He touched the side-wall. His senses had not deceived him. The current had indeed diminished.

As he splashed forward to assist with the effort of downstream progress, he began to be aware that ahead of him there showed a light that was not the greenish yellow of phosphorous.

He could not let himself believe that the grayish dimness that suffused the blackness ahead of him was the end of the cavern. His disappointment, he knew, would be too keen. The clumsy life belt impeded his progress; yet he dared not dispense with it lest some weakness overcome him, or some mishap occur.

A vagrant eddy caught him and hurried him forward. He was whirled dizzyingly for an instant. He bumped against a buttress of rock projecting into the channel. The stream made a twist to the left; then to the right.

Sudden realization swept him. The underground river discharged here at sea level; but also it plunged into the hidden chasm that could have no outlet except in the floor under that glittering, turquoise sea ahead.

The breath gasped in his lungs. Deeper the suction pulled him. He was spun about in the inflexible grip of a whirlpool.

Gasping for a last despairing breath, he was shot down a great tunnel. A crashing and roaring sound filled his ears. His body was hammered and flailed against the rough sides of this terrible aqueduct. His lungs were on fire -- no, they were bursting.

S. Fowler Wright's The Hidden Tribe (1938) concerns the fortunes of a tribe which has isolated itself for over two thousand years in an oasis, watered by a subterranean river in the midst of the vast barrenness of the Libyan dessert. They are ruled by a race of kings who have continued the ancient Egyptian custom of marrying their sisters, but at the time of this story the destruction of all but one of the royal race renders this custom impossible. As a consequence, an English lass whose "aeroplane" has crashed in the desert finds herself in unwelcome competition with an American girl who has been kidnapped from a Cairo train for the dubious honor of sharing the throne.

"There is a river here?" Leonard asked, in a natural surprise. "There is a stream that flows underground."

The fault of strata, the consequent outcrop of rocks of different solidity, the presence of subterranean water -- it was all no more than the Western Sahara illustrates a hundred times on a smaller scale, where green oases have resulted, and men have sunk wells to find that abundant water will rise so long as it be kept dear of the choking sand.

But this misconception did not alter the importance of the fact that there was a method of contact with the outer world which was known and used. And the channel of this contact was clearly indicated as being the subterranean river. But on the essential point of where and how access had been obtained to it in the far Egyptian desert, Helen Vincent had nothing helpful to say.

Somewhere, in the 20,000 square miles of that monstrous and repellent wilderness, there must be access to the subterranean river. But this was a point on which Miss Vincent could give no guidance at all.

And, after all, it is better to go to rest on a goat-skin couch than to spend the night clambering in the black bowels of earth, afraid at every moment to be faced by a sudden light and a circle of lifted spears; or to be launched on a subterranean river, perhaps with no light at all (and how would the place of landing be found under such conditions as that?), and with little food, and dreading that, at any moment, the water might rise, or the cavern roof come down, so that they would bump against it in the dreadful dark, and be scraped off, or choked by the flood as it filled up to the roof above.

Quoting from the table of contents of **Alaric J. Roberts**' New Trade Winds for the Seven Seas (1942), in the third episode, "Atlantis and Lemuria of the Deep,"

A dramatic shipwreck scene takes place, and the survivors escape to Crater Island, where they discover a geological rift causing and underground passage into the gigantic "subtitudes" of the earth's interior.

We have the pro-forma exploration party for such ventures -- the young and adventurous accompanied by the pedantic professor. A snippet of the explorers' banter,

"Then one day as we were exploring the lower depths of these endless byways, we were astonished by the discovery of an underground river that must have been several thousand feet beneath the surface. The entire tunnel as far as we could see was covered with a thin growth of luminous substance that radiated light."

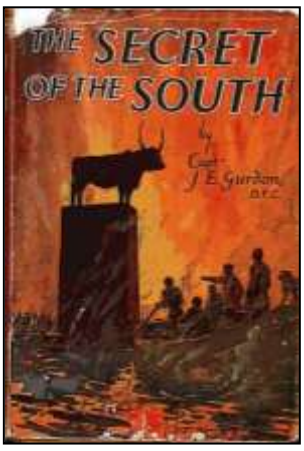
"That's certainly is a coincidence," said the professor. "I have a friend on the Pacific Coast by the name of Walter Dee, who has written a biography of his life called 'Into the Bowels of the Earth.' He has given an account of his actual experiences beneath the surface of the earth in a gigantic rift, similar to this one, which extends thousands of feet into the ground... They intersected a traverse fault, too, at that tremendous subtitude, and there they discovered an underground river of ocean water. The heat grew so intense at that depth that they were unable to continue their explorations. Comparing Jean's subterranean experiences in France and Mr. Dee's on the Pacific Coast, with our situation here, we may conclude that we, too, may find an underground river further down this corridor."

"Our minds must be turned alike," answered Jean jovially, "for during the past week you have astonished me with many deductions that I thought were original with me."

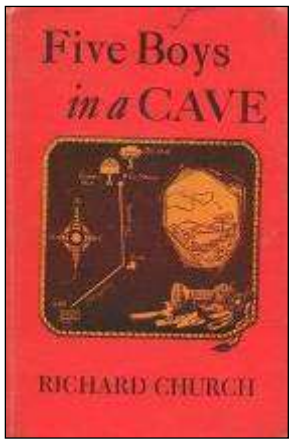
"Great minds run in the same underground river," added Gerald humorously.

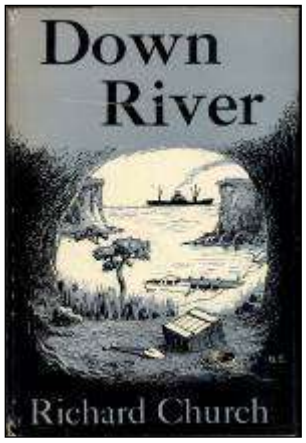
We'll pick up upon the "underground rivers" metaphor in Chapter 30, but this passage would be one of the very few in English literature combining literal and symbolic employment.

In **J.E. Gurdon**'s The Secret of the South (1950), explorers from the upper world discover a lost white race, the Polarians, battling the Neanderthal-like Anthropians beneath the Antarctic icecap. Note the cover's ominous watery setting.



In **Richard Church**'s Five Boys in a Cave (1951), young John Walters discovers the entrance to the limestone cave and invites four buddies to explore with him. They find their way out along a subterranean river. In the sequel Down River (1958), John Walters and the Tomahawk Club set out to explore another underground river, meet a gang of rival boy explorers and foil smugglers hauling contraband to a waiting vessel.





Secret of Stygian River (1951) by **Elbert M. Hoppenstedt** is set in a Kentucky cavern having an underground river. Spelunker Martin Gillis discovers a map and coded message which seems to point to silver bars hidden before the Revolutionary War. Martin's discovery saves the old Gillis farm from destruction in the path of a new highway.

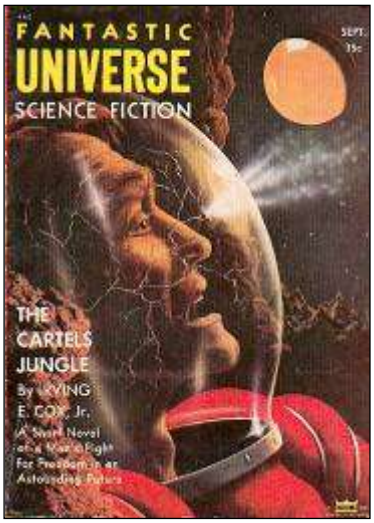
We'll visit the cave which likely inspired this setting in Chapter 55, Then, Madam, You Should Go and See the Great Cave in Kentucky.

The cover of Dan Carter and the Great Carved Face (1952) by **Mildred A. Wirt** shows a Scout Leader, a Boy Scout, and Dan in Cub regalia, hip-deep in an underground stream.

More heroic than the plot is the female author, affixing her true name to the Cub Scout series.

The Mystery of the Piper's Ghost (1954) by **Zillah Macdonald** involves a mysterious bagpiper rising out of a Nova Scotia lake. Our boys suspect that this relates to a secret gold mine and become lost in the tunnels.

Emerging, a la Sinbad, from a cave river into a strange world is a standard ploy in Boys Club fiction. In the American-Czech hybrid film Journey to the Beginning of Time (1955), four boys row into a cave in New York's Central Park and emerge into a prehistoric world. After their boat is crushed by a dinosaur, they travel yet further back in time on a makeshift raft and themselves begin to become primitive. In mythology fashion, they at last return to the sea. , The film was serialized into 5-minute chapters for US television.



A Hollow-Earth passage via Brazil has long been speculated (Chapter 15, Hollow Earth Geophysics), something which may have been of use to the Nazis. Consider "Operation Earthworm," Fantastic Universe, September 1955, by **Joe Archibald**

"For the last seventy years, all we have thought about was outer space... I am announcin' for the benefit of the press and everybody from here to Mars and Jupiter and back that I intend to explore inner space! I have already got the project underway...

The Magnificent Mole is built mostly of titanium, a metal which is only about half as heavy as steel and twice as rugged. It is not quite as big in diameter as the auger, for if it was any Martian moron knows we would scrape our sides away before we got down three miles...

Whir-r-r-r-r-r-r-r-r-r-o-o-om! The Mole shudders like a citizen looking at his income tax bite and then starts boring. There is a big bright light all around us, changing color every second, then there is a sound like all the pneumatic drills in all the universe is biting through a thousand four-inch layers of titanium plate...

I look at the instrument panel again and see we are close to being seven thousand miles down, and all at once the gauges show we are out of energy. I look out the port and see a fish staring in at me, and a crab with eyes like two poached eggs swimming in ketchup.

Then we are going through dirt again and all of a sudden we come out of it and I see a city below us all lit up and the buildings are made of stuff that looks like jade run through with streaks of black...

Encountering a nefarious subterranean dweller,

"Come, schwine," the creep says. "I will show you something... I am Agrodyte Hitler, grandson of the Liberator."

We walk up a long flight of steps and come to a cadaver memorial and on the front there are big letters and numerals in what looks like bloodstone that says: ADOLPH HITLER, 1981.

"He escaped in a submarine, bringing three of Nazi Germany's smartest scientists with him. He brought plans showing us he could split the atom. He brought working models." The creep laughs mockingly. "We have certain elements down here also. Puranium, better than your uranium. And pitchblende Plus Nine. It will power our fleet of submarines that will conquer

Earth... We will leave through the underground river that our benefactor found three miles below the surface of the ocean near Brazil. It spirals down through this earth and empties into Lake Schicklegruber eighty miles from here."

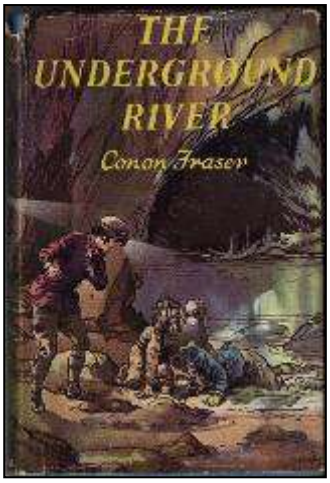
He looks at me, and then goes on: "We will proceed to the lock that will raise us to the underground river and cruise along its course for a few hundred miles. It is the treat I should accord such distinguished visitors from the outside of Earth, nein?"

The skipper of the Subterro sub pulls a switch and there is a noise like three contented cats purring. The metal fish slides along the surface of the underground lake and comes to a hole in a big rock ledge.

We see all this through a monitor which registers the scenery outside the sub within a radius of three miles. The sub slides into the side of the rock, and then is lifted up to the underground river that winds and winds upward like a corkscrew to the outlet under Brazil.

Drawn by the mystery revealed through holes cut into the pages of The Darkness of the Night (1956), **Bruno Munari** leads the reader through the darkness, into the meadow and then into a mysterious cave where an underground river flows and walls tell stories.

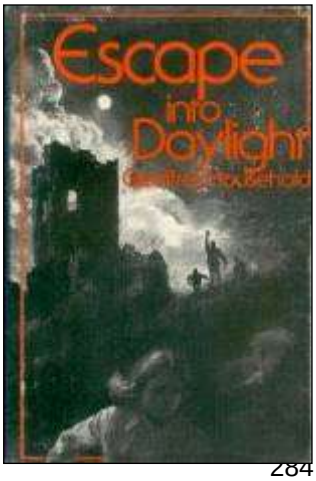
Conon Fraser's The Underground River (1959) is set in the Mendip district of Somerset, home to Wookey Cave (Chapter 56, The Tourist Trade Worldwide). That's an underground lake in the center.

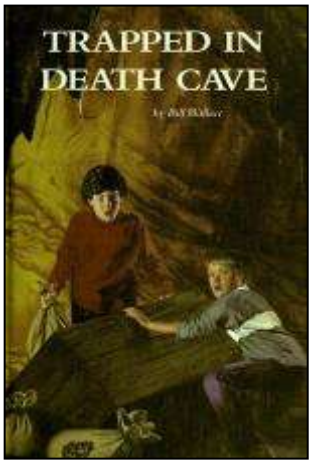


Trevayne (1973) by **Robert Ludlum** was published under the pseudonym Jonathan Ryder, probably to preserve the author's reputation, but it does contain a nice passage.

Yet now, as he stared down at the Genessee notebooks piled beside the folder newspaper, he found himself strangely reluctant to plunge back into the work he'd set aside three days ago. He'd traveled to and from his River Styx. Like Charon, he'd carried the souls of the dead across the turbulent waters, and now he needed rest, peace. He had to get out of the lower world for a while.

In Escape into Daylight (1976) by **Geoffrey Household**, Carrie and Mike are kidnapped and imprisoned in a dark, damp dungeon beneath a ruined abbey. The only way out is through twisted passages and an underground river.





Trapped in Death Cave (1984) by **Bill Wallace** qualifies as Boys Club literature by virtue of being in the Weekly Reader "Just for Boys" series.

> *They were in the big cavern. The trough that Brian had followed into the cave was filled with water. Like a river, it wound and twisted its way through the big room.*

James P. Blaylock's The Digging Leviathan (1984) mechanical "subterranean prospector" was inspired by Edgar Rice Burroughs' At the Earth's Core. The Subterranean Car we encountered in Fred Thorpe's In the World Below, able to drill through the earth completely, was a more powerful machine of excavation, however.

The subterranean prospector is enough to navigate sewers connected to an underground river from there to an underground sea stretching from the Pacific Ocean to the Inland Empire where Chinese junks ply their illicit trade and enormous creatures from past ages yet survive.

Note the cover. It's what any Boys Club would love to build in their No-Girls-Allowed Invention Shop.

The Hour of the Gate (1984) by **Alan Dean Foster** scores low for plot, but above-average for style. Defending against monstrous insectoids, Jon-Tom and his otter companion embark on an underground river to the spider-silk city of the wary Weavers and their horrifically attractive arachnid queen.

"How far into the mountain does the river go?"

"Nobody knows," said Bribbens. "Leagues, maybe weeks worth. Maybe only a few hours."

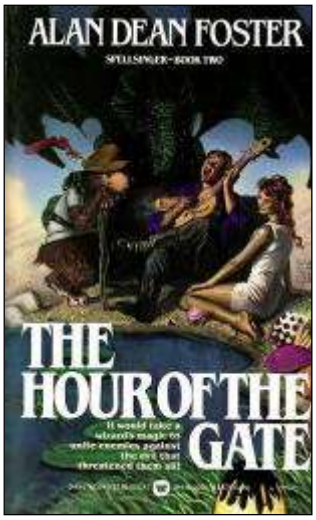
"Where does it end, do you suppose? In an underground lake?"

"Helldrink," said the boatman.

"And what's Helldrink, Senor Ranac?"

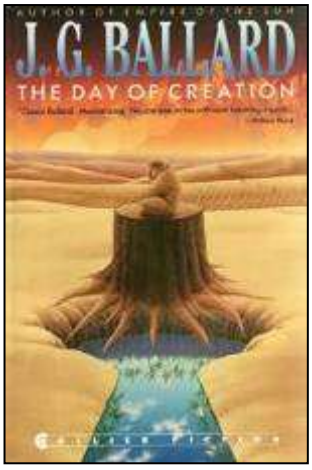
"A rumor. A story. An amalgam of all the rears of every creature that navigated the waters in times of trouble, during bad storms or in leaking ships, in four harbor or under the lash of a drunken captain. I've spent my life on me water and in it. It would be worth the trip to me if we should find it, even if it would mean my death. It's where all true sailors should end up."

It was odd, Jon-Tom mused as they drifted onward, to be moving downstream and yet towards mountains. Rivers ran out of hills.



In **J.G. Ballard**'s The Day of Creation (1987), a stretch of African desert is transformed by an underground river accidentally brought to the surface by a mentally-deteriorating English physician. The doctor, who identifies himself with the river, embarks on a stolen ferry, journeying towards its source in a voyage that echoes Joseph Conrad and Herman Melville.

Well, okay, perhaps it doesn't echo Conrad and Melville, but would like to.

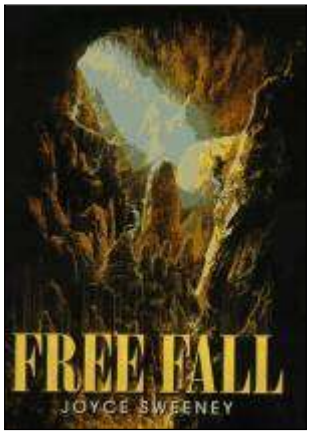


Graham Marks' Subterranean Sea -- Stingray (1992),

What mysteries lie beneath the earth's crust? A team of scientists call upon Stingray's crew to investigate. Trapped in the unchartered waters of a vast subterranean sea, Troy Tempest must find an escape route before their oxygen runs out.

Indiana Jones and the Unicorn's Legacy (1992) by **Rob MacGregor** employs the dive-into-the-underground-river escape familiar to Boys clubs, but it's not Indy's who gets away. As a graduate student in France, Junes goes on a dig and discovers a flooded cave containing Ice Age paintings and clay animals. The nefarious Roland Walcott tries to steal the glory, but disappears into an underground river during a struggle and is presumed dead. He isn't.

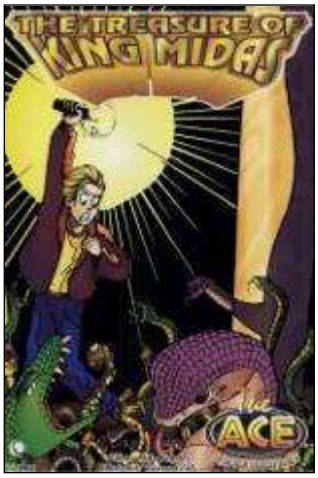
Free Fall (1996) by **Joyce Sweeney** is about four boys who go cave exploring. Finding an opening in the cave ceiling, one of them attempts to scale the wall, but falls and breaks his leg. They finally escape by swimming underwater.



Many of **Clive Cussler**'s adventure novels find action underground. Inca Gold (1994) takes readers on a wild ride on an underground river in search of treasure.

In Free Fall (1996) by **Joyce Sweeney**, our boys find a cave, go exploring, get lost and discover an opening in the ceiling. Attempting to scale the wall, one falls and breaks his leg. They finally escape by swimming underwater. Male bonding.

The Treasure of King Midas (1999) by Mike Kingsley

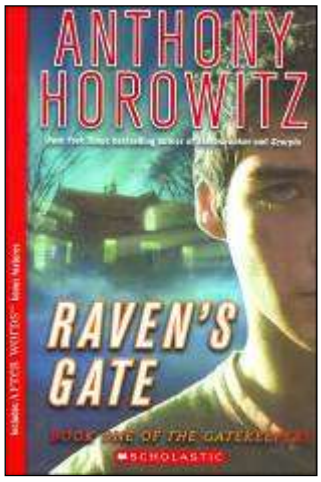


> *Brian was standing on a narrow ledge like a wharf. Just beyond them, floating on what looked like an underground river, was a small flat bottomed boat. What could it mean?*
>
> *"AEEEGGGGHHHH!"*
>
> *"What is it?"*
>
> *"A man. Right there."*
>
> *It was a human figure, dressed in a long black cloak, holding a sickle. The other hand was stretched out toward them.*

And a bit later,

> *Where they had come down from the mountain above, through the maze, down to the underground river to the boat cave, there was nothing but a wall of rubble. Carbunkle had done his job too well.*

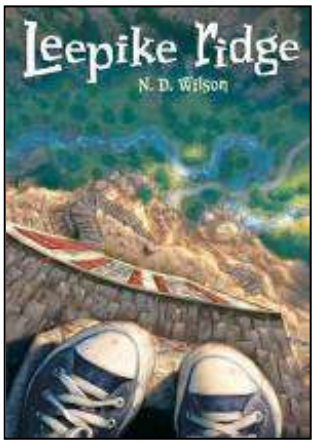
Raven's Gate (2005) by **Anthony Horowitz** includes the standard escape-via-underground-river sequence when Matt and Marsh flee Omega One by jumping into such a river under the building.



More interestingly in a later discussion regarding a nuclear reactor, an underground river use we'd not realized.

Richard Cole:	*Why did you build it in the middle of a wood?*
Sir Michael Marsh:	*Well, it had to be somewhere out of the way. And there's an underground river that runs through the wood. That was the main reason. A nuclear power station requires a constant supply of water, you see.*

In Leepike Ridge (2007) by **Nathan Wilson**, 11-year-old Tom is dragged deep underground by a swift river, finds himself trapped in a world of labyrinthine tunnels, freezing subterranean rapids and relentless darkness. He pulls himself onto an island, but as there is no food, he's compelled to try his luck in the river again. He ends up in the net of someone trapped for years inside the mountain.



In The Secret of the Tarascan Ruins (2007), one of the bilingual Palo Alto Adventures by **Beverly Blount de Pérez Palma**, Carlos discovers the secret of the underground river by venturing into a waterfall tunnel.

The secret-territory-behind-the waterfall device is somewhat common in adventure fiction, e.g. the Ithilien Rangers' hideout behind such a waterfall in the 2002 movie adaption of Tolkien's Lord of the Rings, The Two Towers.

The Odyssey (2007) by **Elena Dorothy Bowman** has little in common with Homer's original. From the first chapter,

> *When the dam above the town was built, it changed the course of a river flowing underground, and up to now had never been a problem. People knew it was there and had once inundated their neighborhood, but most days never gave it a thought. Now, however, once the dam was breached the huge flood of raging water rushing through the town was instrumental in rerouted* [sic] *the underground river back to its original course and in so doing was responsible for the creation of a large sinkhole to emerge in the back lot of the land belonging to the Knights.*

What is in common with Homer's world are the underground river and -- as we will see in Chapter 41, the sinkhole.

And there's Fallout (2007) by suspense-master **Tom Clancy** and **David Michaels**.

> *Now Fisher heard something else: the gurgling rush of water.*
>
> *A river. An underground river.*
>
> *He loosened his grip slightly and let himself drop toward the ground until he could see the bumper. The truck's headlights were still on, casting a white glare along the cave walls.*

This by the acclaimed Tom Clancy? On further inspection of Fallout's cover, we realize that Clancy contributed the idea and Michaels did the writing.

But let's not leave the Boys Club before recognizing that an active club did more that read tales of daring. Consider "More about Pickett's Cave" from the April 30, 1881, issue of Scientific

American.

> *"The Boys' Exploring Association," to whose diligence this discovery is due, is an organization of young mountaineers living in the vicinity of Pikes Peak, whose laudable purpose it is to combine the enjoyment of camping out with the study of biology, geology, and mineralogy, amid the hills and valleys of that remarkable region.*
>
> *The presence of extensive beds of ocher indicated that the subterranean stream flowed from the granite mountains above, fringing the decomposed materials of the feldspathic rocks in the form of these ferruginous clays, which are so hard and compact as to take a fine polish.*

The boys saw the falsity of the prevailing opinion -- based on the beach-like roundness of cave pebbles -- that the cavern was once ocean washed, in view that its karst genesis could have only happened since the region's elevation.

> *The swirling of a subterranean stream could round the fragments of granite into pebbles as readily as the wash of waves.*

Boys Club enjoy exercises in deduction.

CHAPTER 23
BOYS' LIFE

The most durable Boys Club serial is, of course, Boys' Life, the more-than-a-century publication of the biggest Boys Club of them all, the Boy Scouts of America. We've selected 19 issues to illustrate the broad spectrum of ways in which underground rivers are employed in literature written for youth.

June 1915

"The Moonshiners in the Jungle"

Were it not for an occasional glimpse of the stars through the leafy roof over the creek, we might easily have imagined ourselves moving down some mysterious subterranean stream.

We'll see underground river allusions employed to evoke a sense of drama and about everything else in Chapter 30, The Underground River as Metaphor.

August 1919

"Boy Scouts in the Wilderness"

Diving deeply as possible and swimming down with all their strength and speed they shot past the rock and the bottom and into the dim, green depths of the shaft below. As they turned to come up in the clear water they caught a glimpse of what seemed to be a cave opening into the side of the shaft. There was a dare-devil streak in Will's make-up and without stopping to count the cost, he shot into this slanting opening believing that the cave led up into the heart of the mountain above the level of the pool... If the opening reached the air above, the boy's breath would just last long enough to bring them up...

Not in accord with Boy Scout Manual regarding safety.

April 1920

"The Cave of the Golden Dragon"

Something more than an hour afterward they were standing in the great cave of the golden dragons... Besides finding conclusive evidence that it was the headquarters of the opium smugglers, they had also come upon a number of ingenious modern improvements, such as the electric dynamo Larry suspected...

"Fu-chong was responsible for those, of course," observed Captain Curtis. "No doubt he discovered the place and adapted it top his purpose. I'm inclined to think, though, that as a whole it existed when the monastery up there was in its prime. That bronze trap letting down into the underground river is old as the hills. So are those golden dragons, aren't they?"

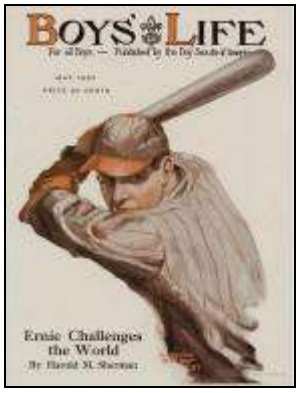
Pulp fiction of the era, reference to an underground river adding to the mystery.

March 1923

"In the Quarry Pit"

The floor of the quarry had disappeared, and he could see nothing save only the sullen black water. He glanced at his watch -- it was a quarter past two, just, and Bob made a hasty calculation. His last shots had opened a seam in the rock; the quarry was filling from some spring or some underground river, and at the rate it was coming -- for the quarry floor was uneven, and he stood upon the highest point -- it would be ten feet deep my morning.

Preposterous portrayal of an underground river vented to the surface by a stray bullet.



May 1927

"The Secret of Sprit Lake"

They locked up the cabin and, entering the canoe, headed down the lake.

"Wonder what makes it so regular?" pondered Huston, as the cone-like peak came into view. "It's shaped just like a dish of ice-cream poked out of one of those nickel things that aren't ever big enough."

Tex laughed. "If I could tell you that I'd be drawin' good money in one o' these here colleges," he returned. "Some say that thousands of years ago this was a volcano and the island might have been the peak, sunk down sort of. The lake must be fed by springs or some kind of an underground river, for it hasn't any inlet or outlet, and the water level always stays the same.

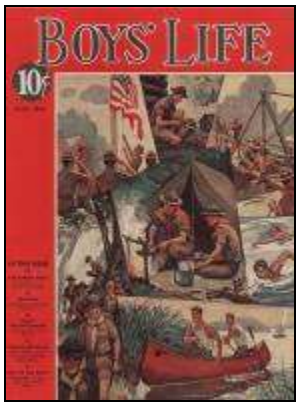
Sprit Lake has the appearance of Oregon's Crater Lake, but the latter's hydrogeology isn't particularly subterranean.

April 1930

"Mississippi Miles"

The sound of a rushing current as distinctly to be heard. They went ahead, with renewed caution, careful where they set their feet, using their elbows to brake themselves as they went slowly down the rough stairway hewn in the rock... The noise of the steam became louder, though it sounded somewhat muffled. The cause for this became plain when they halted at length on the brink of a great split that ran sheer across their path, stretching far on either side. Deep down in this black abyss ran the subterranean stream. The gap averaged ten feet in width. Into it they must have inevitably plunged had they lost footing. Miles shuddered as he realized how nearly Wild Bill had come to ending his life.

In subsequent chapters we'll encounter numerous references to the sounds of subterranean streams.



June 1938

"Porky, the Outboarder"

"My partner's right," endorsed Mr. Jordan. "Don't you boys put too much line out and the muskallonges won't bother you. You've got to fish deep for babies like that. They say they come into Cedar Lake from the Great Lakes, through an underground river and that's why you can't find bottom here in some places."

Chapter 85, Beneath the Great Lakes, will have more to say regarding such fish.

September 1941

"Golden Peril"

"Looks pretty dark inside," Peter said, taking out a candle. "What I don't understand is, where's the lake? Ought to be one, according to the map. A pretty big one, too. 300 yards by 500."

"And 20 fathoms, that's 120 feet, down," Steve added. "Must be underground, if at all."

"Under water, too," Peter pointed to a large circle on the map. "See how it extends beyond the shore. Seems screwy to me. Still, I've heard of underground rivers. Maybe there could be a lake down there, fed by subterranean streams. With a rock roof above where it spreads out under the bed of the ocean."

Cross-section reminiscent of Kirchner, Chapter 8.

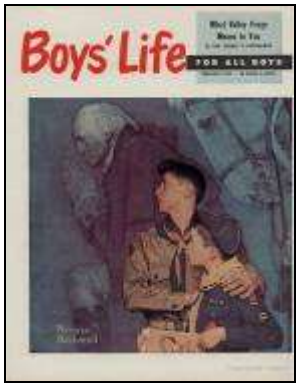
August 1948

"Scout Cavemen"

We boarded a sightseeing boat and paddles across a dammed-up lake and into the cave mouth, which was as big as a railroad tunnel. A few hundred yards upstream we found a group of patrolmen seining the underground river for the lost cave owner. They advised us to go back.

After another thousand yards we reached the head of the river, a small pond in the corner of the biggest room we ever found under the earth.

An account of Explorer Post 2031's excursion to Case Cave in northwestern Georgia. Accurate description of a karst cavern.



February 1950

"Saulteaux's Lobstick"

"He's Grey Hawk," Conant interpreted. "Says his father wants to get the buffalo-killers lost. Or delay 'em till they are caught. So he's taken' them to the Nyarling -- the Underground River. Which they canna' follow because part of its way it does flow underground through the salty bed rock.

More adventure fiction, but accurate in the description of desert rivers that persist below the stream bed.

September 1950

"Death Valley Adventure"

The others gathered to hear the park naturalist, L. Floyd Keller, tell a story of how Bad Water got its name from a man who made a mistake.

He was a map-maker, and he found the place many years ago -- a small pool of water standing in a depression of the salt flats. The salt there is 1800 feet deep, but the water, fed by an underground river, runs to a depth of only a few inches. The map-maker tasted it, made a wry face and reported to his bureau in Washington that it was bad water.

Another bona fide report of a Scout outing, the "underground river reference" meaning "spring."