Yale-New Haven Teachers Institute®

Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2024 Volume II: Dynamic Earth, Foundation and Fate of Industrial Society

Natural and Human Histories: Using Geology to Study the Roman Past

Curriculum Unit 24.02.02, published September 2024
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Introduction

On a summer afternoon in the Roman port of Misenum in 79 AD, Plinia Marcella first observed a cloud "of unusual size and shape" to her brother Pliny the Elder.[1] The strange cloud was in fact the ash plume of the infamous eruption of Mount Vesuvius. Pliny the Younger, writing years after the eruption that would take his uncle's life, described "vast sheets of flame and columns of fire" as homes and settlements burned into the night, and by morning, the smoke and ash darkened the day into "blackest and thickest of nights."[2] The eruption of Vesuvius would destroy the towns Herculaneum and Pompeii, and yet would also provide for future generations one of the most complete collections of Roman architecture and artifacts. While Vesuvius's eruption is perhaps one of the most notable, and explosive, geological events of the Roman world, the intersection of environment, history, and geology is a worthy and compelling object of study. Consider the city of Rome itself, famous for its "seven hills," although the city's growth over the centuries meant that the hills in its limits would become more numerous. The Palatine hill, one of the oldest and most central in the city, bears both mythical and historical importance. It was here, in the Lupercal cave, that a wolf raised Romulus and Remus, the mythical founders of Rome. According to the Roman historian Livy, Romulus's "first work was to fortify the Palatine hill where he had been brought up."[3] Setting aside for a moment the mythical nature of the hill, consider its practical importance: it allows for a defensible position, one near a source of fresh water, the Tiber River, which likewise permitted easy access to the Mediterranean. The geological history of the Palatine Hill, however, dates millions of years before humans would even step foot in Italy, with the bedrock of the hill dating from the Pliocene Epoch. Researchers have found that "the original topography of the hill and surrounding areas is completely lost because of the anthropic reworking during the last 3000 years."[4] Just as the earth itself is a driving and shaping force of history, humanity also shapes, changes, and alters the earth.

In this unit, students will study this complex interplay between geology and history across the Roman Empire. The unit will commence with an analysis of Rome itself, introducing students to the concepts of how geographical features such as hills and rivers and continents form, and likewise how an ancient society might have lived with and adapt to those features created millions of years in the past. The class will then proceed to a series of case studies, centered on different locations in Roman Europe. The first case study will focus on

the cities of Pompeii and Herculaneum, where students will learn the volcanic forces that caused the devastating eruption, the effect of the eruption on the landscape and the people who lived there, as well as the tools of archaeological exploration that the eruption provided to future generations. From Pompeii, students will travel to London, to explore how geography affected the Roman conquest of Britain and the establishment of London. Finally, we will examine Roman mining settlements along the Rio Tinto, as students consider how the need for ore can dictate settlement in difficult places. Each case study will present unique historical and scientific questions for students to evaluate, building the cross-disciplinary skills that are central to this unit's aim and themes.

Study of these three places will not necessarily be focused on just one specific city but will broadly look at the region. Likewise, while the unit focuses mostly on the time of the Romans, students will be asked to both look towards the following eras of history in these places as well as dive deep into their geologic pasts. How did London change, and address problems of growth such as sewage and clean water? How do we preserve the ruins of Pompeii? How can we mine resources responsibly and sustainably, to avoid the plight of Rio Tinto? Because this unit takes place as part of the broader segment of a seventh-grade social studies curriculum focused on Europe, the expansive variety found in our case studies allows students to learn about the climate, geography, and history of a variety of locations across the continent, with analytical lenses at the intersection of geology and history.

For a final project, students will be tasked with implementing the knowledge and skills to a location of their choice in the Roman Empire. They will have to consider the landscape, geological and geographic features, and how people affected and were affected by those features. This provides students with choice, while also enabling them to exercise their skills as researchers of both history and science.

For the case studies and the final project, students will encounter a variety of sources, both primary and secondary. While the brunt of material will consist of traditional social studies reading, each case study will be accompanied by both lessons and readings focused on the geological processes that make each of the three regions of study unique. Students will develop the essential skills that involve reading, analyzing, and interpreting texts, data, and material across disciplines. This unit is being developed for social studies classrooms and curricula, but I hope that teachers of history, science, and English Language Arts will all be able to implement this unit in their classrooms, making changes in emphasis as needed.

Part 1: Unifying Themes and Purpose

The essential question that will drive the unit, and that students will answer in their final project, is "how did geological forces affect patterns of life, settlement, and society across the Roman Empire?" The second essential question is the first's inverse: how did the Romans shape and adapt the natural world to their will? These questions illuminate the central themes of the unit: the natural history of planet Earth is essential to our understanding of its recorded human history; skilled historians must be able to access knowledge and skills from across disciplines. By understanding historical and geological concepts in tandem, we can meet the diverse and complex challenges of both our present and future.

The historiographical impulse of this unit was taken from historians of the American West. In these histories, the physical landscape is essential to the study historical patterns of settlement and expansion. In his

monograph on the Colorado Coalfield War of the 1910s, historian Thomas G. Andrews begins his exploration of one of deadliest labor conflicts in American history with the formation of the coal deposits, writing that the discovery of coal in Colorado was "possible only because of events that had taken place at the time the Rocky Mountains were first formed, long before human life evolved.[5] " The geological processes that brought coal to Colorado shapes the human story that follows long after it. While the section on Earth history here is brief, only four pages, its very inclusion stresses the importance of the links between natural and human histories. The story of the colonization and exploitation of the American West is bound to humans encountering a specific set of natural features, in a unique coincidence and convergence between the forces of plate tectonics and human evolution, The mineral and material riches of the West brought hundreds of thousands of settlers, from gold in California, oil in Texas, and fertile lands and logging in the Pacific Northwest. We can see similar patterns in Roman history, as the expansion of the Republic and then Empire brought legions across the span of Europe and into Asia. People ascribe profound meanings as vast as they are varied to our planet, from seeing beauty in a waterfall to ascribing divinity to mountains, volcanos, and caves. The resources humans have harnessed, and will continue to harness, from the planet were all millions of years in the making, until people ascribed meaning to it, whether it was economic or metaphysical. One of the pillars of geography is unfolding how humans adapt to, and change, the environment, but often left out of these stories is how that environment came to be in the first place.

Due to the nature of our education system, where students take classes dedicated to a single subject, they are subconsciously taught to believe that learning and knowledge can fit into neat and tidy categories: mathematics, history, science, English, foreign languages. Students have largely become accustomed to this, rarely expecting to see science in the history course. Among the issues of this compartmentalization of learning is the troublesome notion that one is more inclined to STEM fields or to the Humanities, potentially scaring students away from deeply learning and engaging with a topic, because they are "just not a math person." This mindset hinders students from thinking about a problem with multiple perspectives. At higher degrees of academia, a specialized set of skills makes sense; one cannot expect every expert in a subject to also be an expert in three other fields. Our students are not yet at the point where need to specialize, nor should they. Applying a cross-disciplinary approach to learning enables students to think critically and creatively about a topic, strengthening the learning they are doing in their other classes. Research demonstrates that cross-curricular pedagogy enhances student learning. Education scholar Jonathan Savage writes that a cross curricular approach "is characterised by sensitivity towards, and a synthesis of, knowledge, skills and understandings from various subject areas. These inform an enriched pedagogy that promotes an approach to learning which embraces and explores this wider sensitivity through various methods."[6] In the 21st century world of ideas, strong problem solvers must see that multiple methods can be used to resolve issues that are becoming increasingly varied and complex. Academia is responding to this need as well. Historian W.V. Harris notes that "the subject matter of history has widened still further in recent decades to include problems that have also been, and continue to be, the objects of widespread scientific attention."[7] To address these problems, historians need to use the skills and methods of scientists, and scientists equally need the skills and methods of historians. Harris goes on to write that "scholars still write books about the ancient environment that are essentially digest of what Greek and Roman writers *said* about the environment… but if we want to know what the environment in antiquity was actually like, and why it developed as it did, we turn to scientific archaeology, to geology, and so on."[8] Of course, good students of history should rely on primary sources, as for example, Pliny's writings on Pompeii were crucial for our understanding what came to be known as *Plinian* eruptions. On the other hand, the best kinds of history do not limit themselves to a constant reinterpretation of the same texts. The way ancient writers might have perceived natural and geological phenomena might differ from our contemporary scientific understandings,

and we can still use those to best make sense of the natural world of the past. Geography and geology already have many natural overlaps, and this unit aims to use methods from both of those fields to enhance student understandings of the worlds of our past. In the geologic timescale, where years are counted in the millions, human history is but a small fraction of our planet's history; however, those forces and processes shape the world as the Romans, and ourselves, encountered it.

In addition to the demonstrably strong effects of a cross-curricular approach on student learning, thinking across disciplines likewise allows students to apply lessons learned from history to modern problems using many approaches. While this unit is not strictly focused on environmental history, geology and environmental sciences have many crucial and important overlaps to the study of both geography and history. At its core, as J. Donald Hughes defines it in *The Mediterranean*: *An Environmental History,* "environmental history is the study of the interaction between human societies and the natural environment through time."[9] This allows us to understand how the Earth system is shaped by human actions. Through the study of environmental history, as it will be incorporated into this unit, students will understand the problems that the people of the Ancient World faced: finding and protecting stable sources of potable water, ensuring the transportation of goods and peoples, mining the natural resources that the planet has to offer. As Hughes writes, "the impact of ancient cities on the natural environment, the land and its resources, air and water, and animal and plant populations – produced problems prefiguring many of those familiar in modern settings"[10] All these issues are applicable to the challenges that humans face today, magnified by industrialization and globalization. In their simplest forms the challenge is the same: how do we meet their needs for minerals, water, and energy? What changes, of course, is the context and details. By seeing how ancient people answered that question, their successes and failures, both in human costs and environmental, students will have another set of knowledge that can be used to find solutions today.

This unit's primary thematic aim is in *methodology,* rather than just content. The unit has been designed for a seventh-grade world cultures and geography course, but the methods used here, that is, using geology and science as tools to understand the past, are intended to be used across a variety of social studies curricula. As the study of Ancient Rome is part of the seventh-grade curriculum in New Haven and given the Roman Empire's spread throughout much of the European continent, studying Rome naturally takes students across the wide spanning geography of the region. Case studies are the best tools to achieve the thematic purpose, because we can look at several unique phenomena that are present in one place but not in another (or that might be present in all locations.) The next part of this unit focuses specifically on the intertwining of geology and history in Ancient Rome, but teachers should focus on the ways that students will student history and science concurrently in this unit. For example, a similar World History or Geography course could apply this to the great African Empires of Aksum and Mali, or to any of the ruling dynasties of China from the Qin to the Qing. A United States history course might examine the geological features across the nation's vast territory, considering how both Native peoples and settlers interacted with the land in the colonial period, or how agricultural patterns led to the Dust Bowl, or even a contemporary look at the hydrological issues facing much of the American West. This process does demand a significant amount of preparation and research, and overcoming the mindset that there is a hard divide between the humanities and the sciences. Hopefully this unit might serve as a potential roadmap for employing cross-content skills in our study of history and geography.

Part 2: The Natural and Human History of the Roman World

Rome – The Eternal City

Students will begin their exploration of the intersection of geology, geography, and history with the city of Rome itself. This analysis will focus extensively on the most ancient period of Roman history, the semi-mythical period of the Roman Kingdom. The key question in exploring this location will be "what enabled Rome to become the seat of a continent spanning empire?" As Historian Mary Boatwright phrases it, "Rome's location was a favorable one" thanks to plentiful supplies of clean water, seven hills pressed next to the Tiber River that allowed for easy defense in times of crisis, fertile soils, and the closest point inland from the Mediterranean Sea where the Tiber could be forded.[11] During the period of the Roman Kingdom, the Latins expand the influence of the city to Ostia, translated literally to mouth, for both its access to the Mediterranean sea, as well as substantial salt pans, an essential component to preserving food in the ancient world. Rome's geography and landscape permitted the city to eventually establish dominion over the rest of the Italian peninsula, and later much of Europe.

Understanding Rome's geographic advantages requires that students and teachers understand the geological factors which brought about Rome's existence. Through the process of plate tectonics, the African and Eurasian plates collided together forming the backbone of the Italian peninsula's Apennine Mountain range, and then separated to form the Mediterranean Sea. The Apennines, once submerged, reveal its nautical origins in its lithography, where limestone forms because of the collection of the calcium of seashells and corals. As this process occurred, the Italian Peninsula separated from the whole of mainland Europe, leaving behind as evidence the islands of Corsica and Sardinia. Geologists Grant Heiken, Renato Funicelli, and Donatella de Rita write that "the complex collisions and extension (pulling apart) of the Earth's crust in this region lasted from about 20 million to 2 million years ago, [while] at the same time, the Italian Peninsula began to rotate counterclockwise, opening basins to form what is now the Tyrrhenian Sea."[12] In part due to Italy's proximity to major fault lines, the peninsula was host to a substantial amount of both seismic and volcanic activity. Evidence of these volcanos can be found in calderas close to Rome itself, as well as the substantial deposits of tuff, a rock composed of volcanic ash which has lithified into solid material.[13] Almost since the city's founding, Romans made use of tuff, quarrying it extensively as the building blocks for the city's built environment. These examples show directly how natural history has shaped human history. Looking more closely at Rome's geology, the city sits on a flood plain of the Tiber River, formed through both tectonic and volcanic processes. The Field of Mars, a large open area where Roman armies would gather and prepare outside of the ancient city's walls, would frequently flood when the river overflowed. The field served a dual purpose: its natural one, protecting the city from the river's might; and it's military one, as the mustering ground for the Roman legion. Throughout the unit, students will understand how Rome's power and might adapted to the natural world. The city's proximity to the Mediterranean was an obvious advantage, but Rome was primarily a land power, especially in its early years as it united the Italian peninsula under its rule. Essential to the Roman project of power was roadbuilding, and even here we can see a crucial connection to natural history. Efficient road building goes around mountains and tries to follow flat terrain as much as possible. Heiken et al. explain that two of the most important roads of Ancient Rome, one crossing the Apennines and the other extending out into the heel of Italy's boot, the "Via Flaminia and the Via Appia follow routes along valleys formed by erosion along major faults."[14] Through understanding these connections, students will be able to analyze decisively the effects that geology has on the growth and development of human civilizations.

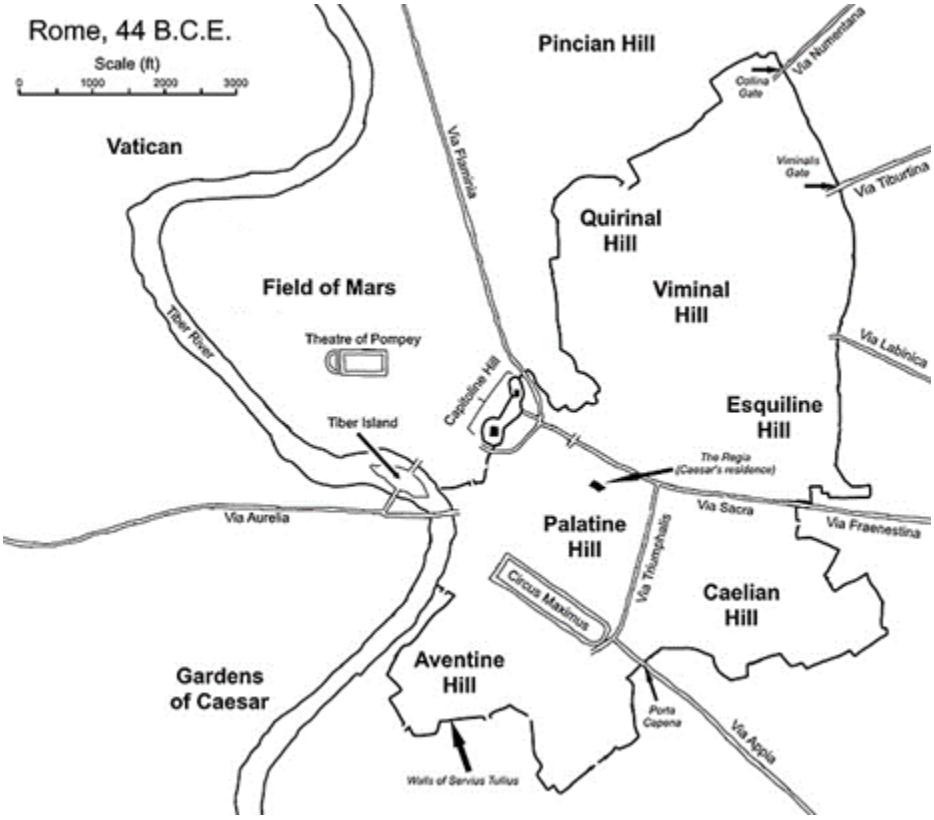

Figure 1 – Map of Ancient Rome[15]

Looking forward to the present day, over 3000 continuous human habitation years has had a demonstrable impact on the geology of the city. Rome's plethora of ancient ruins, most buried underground, are archaeological treasures. But the city's storied past, on average at least 20m below the current city, has made modern Rome a sinkhole capital of Europe. Since Rome sits on a flood-plain, situated on the Monte Vaticano formation, a loose collection of sedimentary deposits, on top of millennia of construction, excavation, and quarrying, have put modern Romans at risk of sinkholes. Factoring in changes in climate due to climate change increases the risk of flooding, and thus the likelihood of a sinkhole, along with tens of thousands of vehicles driving the city's streets, means that Rome from 2010 to 2017 saw an average of 90 sinkholes a year.[16] A combination of geological and human factors has created the present reality of the city.

Pompeii and Herculaneum – Preserved Moments of Disaster

Ancient Rome bore witness to one of the most well-known moments in geological history, the eruption of Mount Vesuvius. History remembers the names of Pompeii and Herculaneum for their connection to the deadly eruption, as otherwise they would have likely been a footnote in the historical record. This disaster gave contemporary historians an unprecedented examination into daily Roman life, something often lost in written sources, with buildings, artifacts, graffiti, and even the last poses of the victims preserved. The term "volcano" comes from the Romans, as their term for the mountain on an island of the Mediterranean which seemed to billow as the chimney of Vulcan, the god of the forge.[17] The gods, heroes of myth, were reflected in the world. Underneath the Palatine Hill, perhaps the heart of power in the city, in the Lupercal cave, the she-wolf weaned Romulus and Remus. So too did Romans see a sort of divine power to the volcano, one they would certainly encounter explosively on an afternoon in August of 79 CE.

The amazing degree of preservation at Pompeii and Herculaneum is due to the type of eruption that

devastated the two towns. Most rock that exists in the earth is in fact solid; but magma, or liquified rock, does form under a special set of circumstances, depending on factors such as chemical composition, pressure, and tectonic forces.[18] As discussed in the previous section, the Italian peninsula contains active extensional faults, where the Earth system is more likely to produce liquid rock, and consequently, volcanos. Because magma is lighter than the surrounding solid rock underground, it moves up through a chamber in Earth's crust to reach the surface, eventually erupting from a vent. Vesuvius is a stratovolcano, meaning that its mountainous cone shape has formed due to centuries of eruptions, as solid layers of volcanic rock and ash are piled on top of each other. The eruption of Vesuvius was so violently explosive due to a variety of factors, including the buildup of gases present in the magma under extremely high pressures. The viscous nature of the magma meant that the gases could not escape until reaching the earth's surface, resulting in a tremendous and destructive blast. Geologists term the specific type of eruption seen in 79 CE as either Plinian, after one of its observers, or Vesuvian, after the volcano itself. The eruption is characterized by a large explosive plume of ash, rock, and gases to heights potentially over 20 km into the atmosphere. Additionally, this type of eruption also includes a swift moving pyroclastic flow, a current of hot tephra (volcanic matter, not necessarily lava) that encased many of the victims in its path.[19]

Figure 2 - J.M.W. Turner's stunning interpretation of Vesuvius in Eruption[20]

While Pliny's description survived, the actual towns of Pompeii and Herculaneum were lost to the historical record and were only rediscovered in the 18th century. What archaeologists discovered over a millennium later buried under the ash was almost a direct step back in time. The towns were comparatively wealthy, with many of the Roman elite building villas to take advantage of the pleasant coast and fertile soils.[21] The number of artifacts and data available for historians to use is staggering. Penelope Allison[22] goes so far as to record the nature of the rooms in Pompeiian households, the nature of the artifacts found in those homes, considered alongside primary sources from Latin authors. The archaeological record preserved by Vesuvius's eruption reveals more about daily life for Romans than almost any other source. Graffiti strews the walls, such as those found in the basilica connected directly to the public forum: "I am amazed you haven't fallen down O wall / loaded as you are with all this scrawl."[23] Some graffiti is the ancient equivalent of the scratchings on the bathroom walls of a bar, equally as crude then as it is today, so care should be taken if examining these texts

with students. The miracle is that they survived at all. Most stunning, and terrifying, are the plaster casts made of some of the corpses found scattered throughout the city. During excavations in the 19th century, archaeologists discovered that many of the bodies were posed, with little decay, exactly as they were on the day they died. Using plaster of Paris, the bodies have retained these positions, making the tragedy of the natural disaster feel real and present two thousand years later. With many online resources, artifacts, and images available, Pompeii is an excellent way to have students study material culture and the actual lived experiences of Romans. At the same time, we also build an understanding of the geological processes that brought ruin.

Vesuvius is still an active volcano, and last erupted in 1944. While no other eruptions have been as deadly as the one of 79, the Italian Peninsula still has several active volcanos. Naples, the city closest to Vesuvius, has been affected by its eruptions in the past, and other volcanos pose a very real, and potentially disastrous, danger today. Comparing the present-day population of Naples, numbering almost a million people, to the populations of Pompeii and Herculaneum, about 20,000 people, it is clear the mortality of another such explosive eruption would be far greater. Fortunately, modern science has a far better range of tools to study and understand volcanos. Despite the two thousand years that have since passed, Vesuvius is one of the best studied historical volcanic eruptions, given both the lasting historical and geologic interest that it has, and will likely continue, to generate. As researchers led by Domenico Doronzo concluded, research on Vesuvius "can be applied to many explosive volcanos worldwide, particularly when inhabited areas are directly exposed to eruption impact… as modern architecture could take advantage from what happened in 79 CE."[24] Contemporary research on volcanos can hopefully mitigate the disastrous effects of an eruption so close to a densely populated area. The story of Pompei presents such a rich and deeply interconnected historical and geologic tapestry. This section displays what a tremendous, and indeed devastating, impact the Earth system can have on human history.

London – The Edges of the Roman Frontier

The next stop in our journey across the Roman world takes us to one of the furthest corners of Europe. With our study of Rome, we considered the earlier history of the Roman Kingdom and Republic, while Pompeii and Herculaneum offer glimpses into the early Empire. To understand the Roman project in London, students and teachers must also consider in its larger context the Roman project of Empire. Julius Caesar was the first Roman to take his legions across the English Channel in 55 BCE, writing in boastful third person that "Caesar thought it would be of great service to him if he only entered the island, and saw into the character of the people, and got knowledge of their localities, harbors, and landing-places."[25] In his time, Britain was the furthest frontier of the known world, with an interior that would promise riches. Caesar is perhaps downplaying the reasons for his sojourn into Britain, as the conqueror of Gall did not emerge from that island as the victor. While Caesar could not conquer Britain, he did set precedent for Roman involvement in the British Isles. A little under a century later, with the transition of Rome from Republic to Empire, the Emperor Claudius would try to establish dominion over Britain again. Claudius dispatched four Roman legions led by general Aulus Plautius, and Rome would maintain a (mostly) permanent foothold in the south of Great Britain for over 300 years. With Plautius's eventual defeat of the Britons, their riches were ripe for plunder by the new conquerors. Roman geographic knowledge of Britain before the invasion was limited; Julius Caesar reported tin, iron, and other mineral riches, land ripe for cultivation, a climate more moderate than Gaul. Interestingly, Caesar does note that its more northerly status results in less daylight. Historian Peter Salway writes that the Romans regarded Britain as "a land of natural abundance and that by AD 47, the exploitation of Britain's mineral resources—one of the chief objectives of victory—had begun (the silver-bearing lead of the Mendips was being

mined under state control by this date)"[26] Deposits of natural resources, good soil, and moderate climates are all shaped by geological factors, and imperial dominance is rooted in the quest for material riches. London, a city with a location that was both strategically and economically advantageous, would serve as the seat of the Roman government of Britain, and would itself be the home of an even larger empire over a thousand years later.

Julius Caesar first noted the importance of a location, though not named as London, fits its description. He writes of a place "about eighty miles on the Thames from the sea" where the "river can be forded in one place only and that with difficulty. [27] According to Caesar, the Thames, and this crossing, were both a territorial boundary as well as an important strategic location, as it was here that Caesar fought the Britons under the leadership of the general Cassivellaunus in 55. Caesar and his legionaries saw the tactical advantage of the Thames as an artery to the North Sea. It is unsurprising that the Thames also marked tribal boundaries, as rivers, mountains, and other natural features often define political borders, After the conquest of Britain under Claudius, the Romans established London as the provincial capital. The original Roman *colonia* of Colchester would be destroyed during the revolt by Queen Boudica, but as Roman historian Tacitus writes, while "not distinguished by the title of colony, [London] was none the less a busy centre, chiefly through its crowd of merchants and stores."[28] Londinium suffered the same destruction as Colchester did during the revolt, with Tacitus describing one resident witnessing a dreadful omen "in the estuary of the Thames…a vision of the ruined colony."[29] That this vision of doom comes in the river speaks to its strategic role in the success and failures of armies. Halting Boudica's fording of the river was the city's salvation, failing its destruction. The Roman General Suetonius was unable to muster his forces in defense of the city, and instead retreated, defeating the Queen after she had burned the Roman settlement. The defeat of Boudica gave the Romans a path to take control over the southern portion of Britain, although the Empire would never advance past the wall that the Emperor Hadrian built 70 years later. It is worth noting that many of the Roman colonies were intended as permanent settlements, not merely military outposts or locations to extract and ship off resources (although there was certainly much of that across the Empire). Peter Salway writes, "Rome was unlike most modern empires in that it gradually extended its citizenship to those it absorbed."[30] The Romans saw the city as an anchor to the Romanticization of the British Isles. The archaeological and documentary evidence speaks to both the military and commercial origins of London as a seat of power. The similarities between the locations of Rome and London on inland rivers with navigable access to the ocean are not surprising, as river fords and crossings have key tactical and economic advantages. Historian Lacey Wallace writes that in London the "choice of landscape characteristics, location within existing tribal-political territories, town planning and infrastructure, and planned industrial, commercial, and domestic organization are all significant reflections of how they conceived of the idea of a town, and its significance and purpose to their daily lives."[31] It was the Thames that made London a viable site for settlement and ensured its future. Connections to commercial avenues, freshwater, accessible crossings, access to the North Sea via the Thames, strategic advantages, and available deposits of clay and stone all factored into the choice of London as a seat of power.

Geology will be the key to understanding not only the origins of Roman London, but likewise its rapid growth, and at the heart of our geologic exploration of the city is the Thames. During the last glacial period, roughly 20,000 years ago, lower sea levels meant that the English Channel was not submerged. The Thames connected with other Major European rivers, including the Rhine. The recession of glaciers raised global sea levels, flooding the English Channel, and by about 5000 BCE, the Thames had been fully severed from the European mainland. Just as the Thames can carry ships out to sea, it also deposits large deposits of sediments like sand, clay, and silt along its course, giving definition to the terrain. The British Isles are relatively stable

tectonically in contrast to the geologically chaotic Mediterranean. Sedimentary deposits are key to interpreting the city's lithography. The same chalk that defines the stunning cliffs of Dover can be found beneath surface deposits across the greater London area, allowing access to underground water. The London Clay, a marine sedimentary rock, largely defines the rock formations throughout the city, along with alluvial deposits of sand and silt on the banks of the river. As described by the British Geological Survey, "the original Roman settlement of Londinium was sited on dry sand and gravel deposits close to the River Thames, with readily available water supplies from riverside springs. As the city grew, the abundant water supplies from the major Chalk groundwater aquifer supported the rapid population growth. A ready supply of locally worked aggregate and brick clay deposits aided the infrastructure development." Water, close access to the river, quarrying, and clay for brick all make London a favorable site for a town, in addition to the Romans' political and military considerations. [32]

The Thames, while a boon to the Roman settlers of Londinium, has presented substantial challenges to Londoners in the millennia since its founding. Greater London is part of the Thames floodplain, so during times of exceptionally high tides or rainfall, the area is vulnerable to potentially deadly and destructive rainfall. As the city's population grew, the Thames would also become increasingly polluted, with at times the smell of human waste choking the city's inhabitants. These issues would lead to the creation of innovative (for the 19th century) sewage and drainage systems, but the Industrial Revolution also brought factories and further pollution into the river. Industrialization also brought the burning of fossils fuels and the gradual warming of the planet. The consequences of a changing climate can be seen today, as floods, drought, and potential scarcity of potable water remain present day issues.[33] In the 1980s, London officials constructed the Thames Barrier, a system designed to prevent flooding in the city much as Romans had used dikes to stem tidal waters. Now forty years old, the Barrier is being used more and more. At the same time, London is also facing the possibilities of drought. Winter is usually the rainy season in Britain, but the levels of rainfall are increasingly falling short of meeting the needs for water in the summer. Rising air temperatures means water evaporates quicker, while human demand simultaneously rises.

Rio Tinto – Mineral Wealth and Abundance

Our final case study location is the Roman mines of Rio Tinto, located in the Huelva province of Andalucia, noted for their significant deposits of iron, copper, and silver. Resource extraction has occurred here since before the times of the Romans and continues today, and the modern-day town of Minas de Rio Tinto is home to the largest open pit mine in Europe. In this case study, students will understand the impetus that brought the Romans to this part of Spain, and the geological systems that birthed such rich mineral deposits. Originally controlled by Carthage, Rome's during the Republican Era, the Iberian Peninsula fell to Rome after Carthage's defeat in the Second Punic War. The region called Andalucia today was named Baetica and was a distinct political province from its northern neighbor Hispania. While the Roman name of the mines and settlement at Rio Tinto have been lost to history, Pliny the Elder, who would perish in the eruption of Vesuvius, described in his *Natural Histories* that "nearly the whole of Spain abounds in mines of lead, iron, copper, silver, and gold… and in Baetica there is cinnabar [mercury sulfide]."[34] Our examination of London revealed that the project of Roman expansion was driven not only by political aims and the absorptions tribes into the Empire, but likewise by the desire for control over mineral wealth. Historian and archaeologist GBD Jones notes that today remnants of over "sixteen million tons of ancient slag [are]ringing the northern edge of the mining area," evidence that Rio Tinto was one of the most important and prolific mines in the Roman realm."[35] The sheer output of silver was essential to the health of its economy. When Baetica came under threats from foreign invaders in the last second century, documentary evidence showing a decline in mining at Rio Tinto

corresponded to similar declines in the circulation of silver coinage across the Empire. Rio Tinto was a key component of the circulation of goods and money across the Empire.[36]

To extract such tremendous quantities of ores, Romans employed a variety of technologically innovative, though often dangerous, methods to extract and smelt the ores. In addition to the physical act of digging out the tunnels and ensuring adequate lighting and ventilation, flooding often occurs due to both surface and ground water seeping into the lowest chambers. In the 1920s, archaeologists discovered a massive water wheel which could pump water over a height of 30 meters from the lowest levels of the mine (figure 3). The water wheel demonstrates the tremendous amount of human labor required to operate a mine of this scale, which included enslaved labor. Mining was a dangerous task in antiquity, as environmental historian Lukas Thommen writes, "lead poisoning was characteristic" of the Roman mine labor, especially the smelting process, and that the "the contaminated air deposited ever greater amounts of metals in the soils."[37] Mining towns, like the one at Rio Tinto, were never intended to one day flourish as London one day would. The dry and hilly location had little access to clean sources of water as the water of the Rio Tinto would certainly not be potable because of the extensive pollution from the mining operation (see Figure 4 below) and no convenient connections to navigable bodies of water. Rio Tinto served as a point of extraction for the benefit of the imperial project, more on the periphery of the life of the Roman citizen than London. Once the ores were mined and smelted, the challenge remained of how these exceedingly valuable resources could reach the centers of power and commerce.

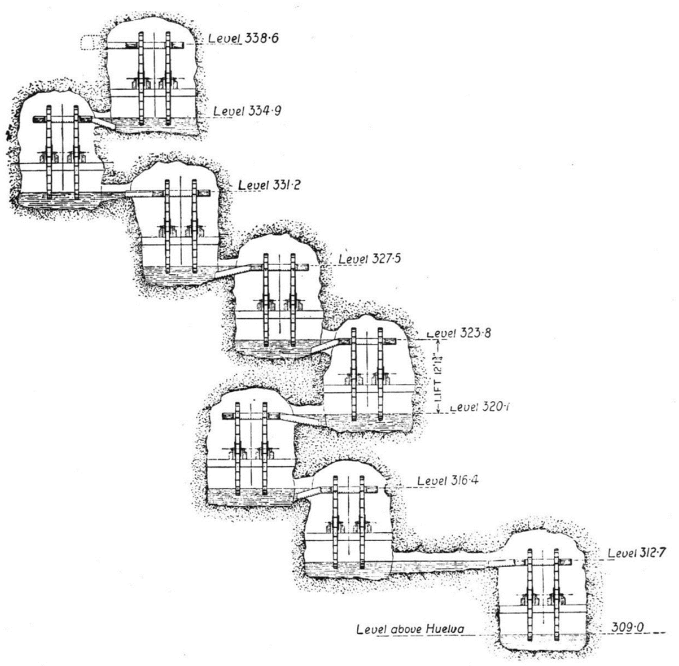

Figure 3 - The Roman Water Wheel Discovered in Rio Tinto[38]

The Roman system of roads was the answer to this challenge, a feature that was essential to Rome's expansion and connection across Europe. Historian M.C. Bishop describes that the soldiers of the Roman legion were often the ones to build the roads, from a strategic perspective. roads made movement and refurbishing supplies far easier. Likewise, legions enabled vast networks of commerce. Bishop further writes that "wherever possible, local materials would have been used…they could be obtained from most river valleys, and quarry pits can often be seen lining roads."[39] Rio Tinto contains remnants of the Roman roads

that crossed the Iberian Peninsula, and part of the Roman Empire's strength was how interconnectedness. In hilly and mountainous terrain, roadbuilding could prove treacherous and difficult, and would require digging trench roads, forming terraces, or simply rerouting to avoid too difficult terrain. As Camilla Campedelli writes "in the Southern regions of the Iberian Peninsula, we can still see the solutions adopted by Roman builders in the development and implementations of the road system in a morphologically intricate territorial context."[40] The Roman road served not only as routes of trade, but also as a form of Imperial power and control. As the saying goes, all roads lead to Rome, and vast material riches to their travelers.

Some Romans recognized the potential dangers of such intensive extractive processes. In his *Metamorphoses*, the poet Ovid writes of the mythical descent of humankind from the golden and silver ages of tranquility and harmony to the ages of bronze and iron. He writes that "not only did they demand the crops and the food the rich soil owed them, but they entered the bowels of the earth, and excavating brought up the wealth it had concealed in Stygian shade, wealth that incites men to crime. And now harmful iron appeared, and gold more harmful than iron."[41] Ovid primarily identifies the problem here as one of greed, rather than environmental destruction, but still sees something sinister in those things which are best kept beneath the earth. Food, sustenance, all come the soil, identified here as good and nourishing, while destruction and greed are found below. Pliny the Elder condemnation of mining and lust for ore even further:

> She [the earth] is continually tortured for her iron, her timber, stone, fire, corn, and is even much more subservient to our luxuries than to our mere support. What indeed she endures on her surface might be tolerated, but we penetrate also into her bowels, digging out the veins of gold and silver, and the ores of copper and lead; we also search for gems and certain small pebbles, driving our trenches to a great depth. We tear out her entrails in order to extract the gems with which we may load our fingers. How many hands are worn down that one little joint may be ornamented! If the infernal regions really existed, certainly these burrows of avarice and luxury would have penetrated into them. And truly we wonder that this same earth should have produced anything noxious! We tear out her entrails in order to extract the gems with which we may load our fingers. How many hands are worn down that one little joint may be ornamented![42]

Pliny personifies the earth here, and evoking the same bodily language that Ovid used, and while his language is likewise focused on the consequences of greed, the feeling of the damage that people do to nature feels clawing and real. For Pliny, the earth fights back, and he would indeed come to know the full power of the earth's might and capacity for harm.

Figure 4 – The Distinctive Orange Hue of the Rio Tinto[43]

Having considered the Roman practices of mining, we must now turn to the question of how the silver and copper that made Rio Tinto such an attractive place to the Romans ended up there. Jones writes that "it is thought that mineralization occurred in two stages, first when tufaceous sediments along the ridge were impregnated [by volcanic activity] with copperless pyrite. This was followed by probable fracturing and the creation of chalcopyritic, or copper bearing, veins normally occurring vertically. The ores present in the Rio Tinto area are primarily sulfide minerals." Put simply, ore deposits are largely the result of magmatic activities, and are brought to the Earth's surface through the processes of plate tectonics. Millions of years ago, as the tectonic plates came together in forming the supercontinent of Pangaea, one plate was, to put it simply, shoved under the other in a process known as subduction. Pockets of magma concentrate the metals, and the rock makes its way to the surface through either tectonic or volcanic activity (recall that volcanos and earthquakes are more likely to form along the lines of active faults).[44] Most of the metals that people consider valuable can be found in trace amounts in many rocks, but not at levels high enough to be valuable. Native metals, that is metal that is not bonded to anything chemically, can be found in smaller amounts in nature, but most valuable elements are found in ores -- rocks which contain concentrated amounts of the element, but do require a further physical or chemical concentration process for extraction. In addition to the human pollution caused by mining, and indeed, smelting, the process of heating ores at very high temperature to extract metal content, Rio Tinto is highly acidic with a pH of 1.7 to 2.5 and has notable orange hue because of the concentrations of hematite derived from the weathering of iron pyrite (see Figure 4). Particularly noteworthy, as marine biologist Sarah Bordenstein writes, is that while mining pollution has contributed to the river's extreme environment, "the presence of chemolithotrophic organisms, such as iron-oxidizing bacteria and sulfur-oxidizing bacteria, are thought to be the true culprits to the river's condition."[45] The acidic nature of the river has given rise to an ecosystem unlike few others on the planet. The collision of geology, biology, and history makes Rio Tinto a place that should spark curiosity while also allowing students multiple pathways to interpreting its significance.

The scale of the mines at Rio Tinto today far exceeds any the Romans could have ever envisioned. Across the globe, we must mine for the metals and minerals that make the chips in our phone, that line the wires that transmit energy, and that enable technologies that have become essential to how we live. The geological and

biological processes that made Rio Tinto distinctively rich in minerals, the tremendous lengths that Romans went to harness those metals, the voices of Ovid and Pliny condemning the dangers of extractive greed, all give insight into how people presently make their marks on the planet in pursuit of its resources. As students consider these perspectives, they can understand the processes that shaped our planet and how humans have shaped the planet in turn, in the pursuit of pursuing new solutions to the problems of greed and destruction that mining can have.

Part 3: Teaching Plan

This unit has been developed for a grade 7 World Culture and Geography course. This unit is intended to be taught over a period of five weeks. At the unit's conclusion, students should understand and explain how geological processes affect the human experience in the Roman Empire. They will understand plate tectonics, ore formation, Plinian volcanos, and river systems. They will be able to analyze ancient patterns of settlement, interpret and explain material culture, and explain the tools of empire and its connection to the natural world. The first week will be a general overview of the themes of the unit, with the subsequent three weeks focusing on one of the three locations discussed in this project: Pompeii, London, and Rio Tinto. The unit will conclude with a final project where, using Google Earth, primary, and secondary sources, students will complete a small portfolio that examines a location's ancient geological and historical features, with an eye to using their learning to make connections to the present day. This unit heavily relies on digital tools and resources, which can be found in the classroom resources section below, including databases of maps, house plans, virtual tours, and artifact databases. The teaching of digital skills is not explicitly addressed here, but teachers should consider what their students are skilled at already when it comes to technology, and what skills they may need to be taught. The following section is the framework for teaching this unit with sample lessons. My chief hope in writing this unit is that teachers, across contents, apply a cross disciplinary pedagogy while teaching these concepts, relying on the skills and bases of knowledge of both geology and history. As I wrote in Part 1, this approach does not have to be limited to the Roman Empire or to the ancient world. Indeed, the specific geological concepts I have chosen to focus on can likewise be interchanged, perhaps focusing on climate, mountain building, or earthquakes instead. The essential component of this unit is using case studies of specific geographic locations that employ scientific and historical methods of study to interpret humanity's complex relationship with our planet.

Weekly Plan

The following is a sample weekly plan that teachers might want to follow for this project. This is a broad overview that teachers can follow when planning lessons for this unit. Each week has a central theme and is generally focused on one specific geographic region of the Roman World. Also included in the middle column are the specific historical and geological topics that will be covered in that week's lessons. If you are a Social Studies teacher, depending on your teaching situation, you may want to collaborate with science teachers at your school. The materials provided here do address the scientific side that students will do in this unit and include moments for students to exercise the scientific method in learning about the Roman world. I do not, however, have substantial experience teaching science topics, although hopefully the readings and research presented here will likewise be useful for embracing a cross-disciplinary approach. Reinforcing skills and concepts across concepts gives students a more robust opportunity to truly learn them. Social Studies teachers may wish to prepare lectures or lessons more broadly on Roman history with each case study. I

found meaningful connections between the historical period of the expansion of the Roman Empire and the London case study, but other teachers might want to focus instead on the fall of the Roman Empire. Someone teaching about the Punic Wars may want to include the case study of Rio Tinto, given Spain's status as a Carthaginian colony that Rome gained in the Second Punic War.

Week	Unifying Theme and Content	Historical and Geological Topics	Suggested Readings and Activities
1	Introduction Studying Human and Natural History Together - Rome focus location	The Founding of Rome, Roman Kingdom, Early Republic; Plate Tectonics	Poetry from Martial Livy's renditions of founding myths Article on the sinkholes of Rome See lesson 1 below.
2	Material History and Volcanic Eruptions -Vesuvius and Pompeii	Fall of the Republic, Early Roman Empire; Volcanism	Virtual field trip of Pompeii Pliny letters and reports Online database exploration See lesson 2 and 3 below
3	Frontiers of Empires, Managing Rivers and War -London	Expansion of the Roman Empire; Waterways and rivers	Secondary Source Readings on Roman London Selections from Julius Caesar and Tacitus London Sewage Readings
4	Demands for Ore and the Roman Roads – Rio Tinto	Decline of the Roman Empire, Creation of Ore Deposits	Roman Mines at Rio Tinto Reading a Geology Map, Introduction to Google Earth
5	Final Project – Exploring Rome	Students apply their skills and learning working on their final project.	Extensive use of Google Earth and Primary Source Databases

Sample Lesson Plans and Activities

The three sample lessons provided are intended to demonstrate the cross-disciplinary approach that defines this unit. Resources that are part of the lesson plans can be found after the bibliography.

Lesson 1

This will be the introductory lesson of the unit. Working in groups, students will examine topographic maps of one of three ancient cities: Carthage, Memphis, and Athens, and explain what makes a location advantageous to settle. Students will examine a map of Ancient Rome and identify the locations' advantages. Finally, students will be asked to consider the geological forces that shaped these locations.

Objective: Students will be able to understand the settlement patterns of ancient peoples based on geological and geographic factors. Students will understand that complex geological processes that occurred millions of years ago shaped the makeup of our planet's surface.

Teaching Plan: Begin with a hook activity, asking students to think of themselves as a member of a small tribe in the ancient world, attempting to find a place to live. They need to decide what resources or factors in the landscape (i.e. access to a river, minerals, wood, etc.) will contribute to their tribe's success. Allow students no more than five minutes to complete this activity.

Bring the class together, and have students share their responses to the hook activity first with a partner, and then share out their ideas with the class. The teacher should write down on either a whiteboard or chart paper

some of the key ideas down for the class to see as the class comes to a consensus on the most important resources and factors. Then, ask students to consider how those resources or landscape features came to be. Allow five to ten for this activity.

Have students break into groups of four to five students and allow them to choose a name for their “tribe.” Using the criteria they identified, present students with a map or several maps to read and interpret. Suggested online resources for maps of the ancient world can be found in the classroom resources section below. You may want to use topographic maps that showcase features in the terrain. As a scaffold, you can use a blank map of the ancient location and add your own labels for resources or topographic features. Before having students commence their analysis, use one of the suggested cities to model your thought process of notable geographic features. The model should take no more than five minutes. Then, allow students 15 to 20 minutes of time to make their decision, having them record their thinking in the process. Bring the class together, and have students discuss their decision with the entire class. Either as an assessment, homework, or whole class activity, present a map of Ancient Rome to the class, having students identify its key features that would enable its success.

Lessons 2

This will be the first in a two-part lesson as part of the case study on Pompeii and the eruption of Mount Vesuvius. This first lesson will explore what causes a volcanic eruption, and the aspects that made the eruption in 79 so deadly.

Objective: Students will be able to describe and identify volcanic features using written and visual sources.

Teaching Plan: As a hook, have students share first in writing, and then with the whole class what they know about volcanos and eruptions. As a follow-up, ask them what this might have to do with ancient Rome. Allow five to ten minutes for students to complete this activity.

Next, have students read the two relevant letters from Pliny the Younger to Tacitus describing the events at Pompeii (Numbers 45 and 46). For this lesson, follow a close reading protocol as students read the source. Translations of this text can be easily and readily found online, though be aware that some may require explanations for difficult vocabulary. For this close reading protocol, students will read the text twice. For the first reading of the text, students will be focused on the gist or main points. This should be read aloud by the teacher. After reading the text, students write a summary of the account. It should only be two or three sentences. Students then share their summaries with the class. For the second reading of the text, students will annotate the text this time. This time, they are going to underline any description they found in the text about the volcanic eruption or its after affects. Students will complete this on their own. Once they have finished annotating, they will list all the features of the eruption that they noticed in the text on a piece of paper, and sketch one or two doodles that reflect the descriptions given in the text.

Once they have finished, students share out their findings with the class, being sure to cite the appropriate passage in the text. As students share their responses, anyone else who also noticed that detail should raise their hands. The teacher should record their responses for the class and the areas of overlap. Once this is completed, share with students the painting from Turner (Figure 2 in Part 2) and a photograph of the Mt. St. Helens eruption (or another similar Plinian eruption.) Call on two or three students to share their ideas of what they notice.

Finally, pair students off. Since students have formulated what they already know about the eruption based

upon their annotations, they will discuss with their partner a potential hypothesis on what causes a volcanic eruption like this. Remind students to use what they have learned so far about the earth system as part of this unit and in their other classes when forming hypotheses. For homework, assign a reading on volcanic eruptions to solidify student understanding.

Lesson 3

This lesson builds on the previous day's learning on the eruption of Vesuvius. Students should understand the causes and effects of volcanic eruptions. Students will focus on the archaeology of Pompeii and how the volcanic eruption preserved many buildings and artifacts. Students will use database tools to explore the city.

Objective: Students will be able to form interpretations and analyses of Roman material culture through the artifacts, art, and architecture of Pompeii.

Teaching Plan: As a hook, have students consider how they think the eruption of Vesuvius affected the people, materials, and structures of Pompeii, first by writing their answer, then sharing their responses verbally with the class. From their homework and the previous day's lesson, students should understand that Vesuvius had a strong pyroclastic surge that buried Pompeii and Herculaneum in layers of ash and pumice. This burial's effect preserved the cities almost exactly as it had been in 79 AD.

This lesson may include some images that can be intense for some students. The casts of bodies in Pompeii are haunting, but also help us see the humanity of these ancient peoples. If you do include the casts of the bodies in this lesson, be sure to tell students that this was *not* the result of the volcano, but an archaeological method used in the 19th century. Consider your student population as you make this decision, and if you do examine the casts, I recommend doing it first as class. Likewise, be aware that some of the examples of graffiti preserved can likewise be vulgar and may be inappropriate.

With that in mind, hand each student a field researchers' notebook. They will use this guide as they conduct their exploration of Pompei and its artifacts. Ask students to return to the Pliny reading and ask for students' impression of Pliny and his uncle. The text indicates that the family was relatively wealthy, having ready access to ships and a villa. Likewise, examining the present-day sight shows a proximity to the sea, all of which may be used to infer that Pompeii at least had some status as a city of wealth.

Students will be required to explore five total resources. One should be an artistic piece, one a building, one an artifact, and another the urban plan of the city. The final choice is up to the student. Depending on classroom resources, these sources can be presented virtually or physically printed and distributed. For higher level students, students can have more leeway to choose their objects for exploration. For each item, students will have to consider its purpose, use, or function, who was likely to interact with that object, and finally what it might reveal about the people of the city. If students are still struggling, complete together as a class an analysis of the city's bath, a place of communal gathering and washing whose spacious forms indicate a place not only to clean oneself, but likewise an important social gathering spot.

After students have completed all five entries in their field notebook, they should find a classmate to compare findings with, and report those findings in their notebook. As a concluding activity, students will summarize what they learned about the Roman world by examining Pompeii's material culture.

Final Project

Over the unit's duration, students will become more comfortable with using history and geology skills to analyze the ancient. Although paper copies can be created for some textual sources, this assignment should be completed digitally to take advantage of the resources available online and to use Google Earth. Students will be asked to choose one location that was once under Roman control, and complete a brief report using primary historical sources, Google Earth, and secondary readings on both history and geology. Students will first identify some key geographical and geological resources. They will identify the tectonic plate, the nearest fault, and any seismic and volcanic activity in the region. Students will examine any nearby substantial ore or mineral deposits, evaluate the region’s topography, and report its proximity to nearby sources of water. After preparing the geological report using Google Earth and associated data sets, they will then prepare a portfolio of historical materials and sources. Students will consult online databases to see the proximity of any significant roads, mines, or forts using databases listed in the classroom resources below. Students will then find one descriptive secondary source that provides a general overview, one artifact from the location or its region, and one primary source that either or came from the region. Once students have prepared these materials, they will share their collected resources with their classmates to share ideas and commentary on what they have found. The next portion of the project will be a two-paragraph response on how the geological features of their location might have influenced the lived experience of the people who lived there, focusing on one distinctive feature of its geology. They must also prepare a two-paragraph response that analyzes how the people who lived there shaped the environment. To culminate, students will provide one take away from their research and analysis that could help us better understand the complex world and problems we have today.

This will be an intensive project, and students will begin to work on their project very soon after the unit starts. Students should have their location chosen by the end of the first week. For the individual lessons within each weekly case study, we will cover one aspect of using Google Earth, accessing historical datasets, or finding primary resources. The entire final week of the unit is dedicated to time spent working on their project. Day 1 reinforces how to use Google Earth as students examine datasets of their chosen location. Day 2 is focused on finding secondary and primary sources. Day 3’s goal is to access their historical data sets online, with day 4 serving as flexible day to catch up on anything they might be behind on. By day 5, students should be prepared to share their research materials with classmates, with that day serving as a collaborative day. With their materials prepared, students will then complete the remainder of the project at home, with a final due date one to two weeks after the completion of week 5. Depending on your classroom's needs, you may want to stagger students completing one part of the project concurrently with your other classroom lessons. Alternatively, you may want to extend the time students have to complete the geological and historical research components of the project or spend additional days reviewing how to use the online tools. This project should be flexible, and students should feel that they have autonomy in selecting their research location. Teachers should anticipate helping students find places that will have a strong documentary record and may want to curate the selection of the primary and secondary sources. The project is not writing intensive, but it does demand that students be able to research effectively, so more time may be needed to help students find research materials suitable for the project's scope. Finally, for some classrooms it might be more to have this be a group project or include a presentation component. Those decisions should reflect the needs of your students and the realities of your classroom. If group work is chosen, ensure that students are engaging with both disciplines. By the completion of the project, students should show that they have mastered the goal of this unit, of analyzing the ancient world using both the tools of an historian and a geoscientist and see how this approach enables creative and complex thinking.

Readings for Students

These readings and resources accompany many of the lessons that students will learn over the course of the unit but can provide greater insight into the geologic and human histories of Rome.

1. Pliny the Younger – *Letters* - Includes the vivid description of Vesuvius's eruption.
2. Pliny the Elder – *Natural History* – Contains detailed descriptions of Roman geography and mining techniques.
3. Julius Caesar - *Gallic Wars* – An excellent record for Pre-Roman Britain
4. Tacticus – *Annales* – Primary source evidence for the Claudian invasion of Britain.
5. Barry Yeomen – *The Mines that Built Empires*
6. Tobias Jones – "Rome wasn't built in a day but these days it feels as if it may collapse in one" in *The Guardian*. – This article details some of the geological dangers that modern day Rome faces due to a confluence of factors including climate change, heavy automobile traffic, and hollow tunnels beneath the city of ancient Roman constructions.
7. Lara Williams – "How Is the UK at Risk of Both Floods and Drought?" in *Bloomberg* – An analysis of potential water crises in the United Kingdom.
8. Sarah Bordenstein "About Rio Tinto." Microbial Life Educational Resources, Carleton College - https://serc.carleton.edu/microbelife/topics/riotinto/index.html - An interesting explanation for why Rio Tinto is so acidic.
9. National Geographic "Plate Tectonics and Volcanic Activity" – https://education.nationalgeographic.org/resource/plate-tectonics-volcanic-activity/

Bibliography for Teachers

Andrews, Thomas G. *Killing for coal: America's Deadliest Labor War*. Cambridge, Mass: Harvard University Press, 2008. Andrews' history is an excellent insight into the American West, and his consider of the geological processes that brought coal to Colorado served as an inspiration for this unit.

Beard, Mary. *The fires of vesuvius: Pompeii lost and found*. Cambridge, Mass: Belknap Press of Harvard University Press, 2010. An excellent recounting of the archaeological finds at Pompeii, and a succinct analysis of what we can learn about Roman life from these readings.

Doronzo, Domenico M., Mauro A. Di Vito, Ilenia Arienzo, Monica Bini, Benedetta Calusi, Matteo Cerminara, Stefano Corradini, et al. "The 79 CE Eruption of Vesuvius: A Lesson from the Past and the Need of a Multidisciplinary Approach for Developments in Volcanology." *Earth-Science Reviews* 231, no. 104072 (August 2022). https://doi.org/10.1016/j.earscirev.2022.104072. While this is a denser geological text, it pushes the reader to consider what we might be able to learn from Vesuvius to better protect urban environments from volcano

El-Qady, Gad, and Claudio Margottini. *Sustainable conservation of UNESCO and other heritage sites through proactive geosciences*. Cham: Springer Geology, 2023. This book serves as a great introduction into the interdisciplinary nature of archaeology and preservation, a recurring theme throughout this unit, as modern

day challenges and problems like climate change require that we use our understanding of earth science to preserve world heritage.

Ellison, R. A., and M. A. Woods. *Geology of london: Special memoir for 1:50 000 Geological Sheets 256 (North London), 257 (romford), 270 (South London) and 271(Dartford (England and Wales)*. Halstan & Co., 2004. A more academic approach to London's geology, but the version found online has excellent resources that are still approachable.

Heiken, Grant, Renato Funiciello, and Donatella de Rita. *The seven hills of rome: A geological tour of the eternal city*. Princeton, N.J: Princeton University Press, 2007. An excellent and concise text that is well written and accessible. This was essential to building my understanding of the geology of the ancient city.

Hughes, J. Donald. *Environmental problems of the greeks and romans: Ecology in the ancient mediterranean*. Baltimore: Johns Hopkins University Press, 2014. Hughes makes his analysis relevant to modern readers, connecting the issues of the ancient past to those that we experience today with a deft historical touch.

Hughes, J. Donald. *The Mediterranean: An environmental history*. Santa Barbara: ABC-CLIO, 2005. This text has a far broader aim than the one above but it does cover crucial points in the wider history of the region. This is especially useful for teachers who want to push this unit further across history.

Jones, G.B.D. "The Roman Mines at Riotinto." *Journal of Roman Studies* 70 (November 1980): 146–65. https://doi.org/10.2307/299560. This text gives a useful overview of Riotinto, although it is clearly written for an audience of fellow scholars.

Savage, Jonathan. *Cross-curricular teaching and learning in the secondary school* London: Routledge, 2011. This text honed that pedagogical aim of this unit and serves as an introduction to a series of smaller readings on the benefits of cross-disciplinary teaching as well as providing examples of how to implement this approach. The series is divided by content area, so teachers can access the one that is most relevant to their current teaching assignment.

Thommen, Lukas. *An environmental history of Ancient Greece and Rome*. Cambridge: Cambridge University Press, 2012. Lukas's book is an excellent survey of human interaction with the environment in the ancient world. This would be an excellent source to develop your own case study for the unit.

Wallace, Lacey M. *The origin of Roman London*. Cambridge: Cambridge University Press, 2015. Lacey expertly lays out the scholarship surrounding the founding of London, its potential pre-Roman past, and an overview of the city's history from its founding and past its destruction in Boudica's revolt.

Classroom Resources

1. Google Earth – An excellent tool, and one essential for completing the final project. While the Pro version is preferred, it does need to be installed on the computer. A host of excellent KML/KMZ files, overlays for Google Earth, can be found on the internet. An example file is linked below. Google Earth is entirely free for students and teachers.
2. KML file of Ancient Roman sites -

https://mw2.google.com/mw-earth-vectordb/gallery_layers/rome/en/ancient_rome_regions.kmz these files enable usable and clickable layers in Google Earth for exploring ancient Rome.

3. Pompeii City Map - https://open.pompeiisites.org/ - Users can explore a detailed map of the excavations and can click into specific room and buildings with descriptions and catalogues of artifacts. Unfortunately, many of the listing are in Italian, though students can use this in their virtual exploration of Pompeii
4. Floor Plans of Pompeii – https://web.archive.org/web/20180807000707/http://www.stoa.org/projects/ph/home - a resource similar to the one above, but just listing floor plans. Thankfull, it is in English.
5. Pompei Virtual Tour – Open University - https://connect.open.ac.uk/history-and-the-arts/pompeii - A great interactive virtual tour of Pompeii that students can explore online.
6. Pompeii Image Gallery - https://pompeiiinpictures.com/pompeiiinpictures/pompeii.htm an excellent resource for students to see floor plans, images from the city, and artifacts.
7. Michael C. Carlos Museum Roman Art Collection - https://collections.carlos.emory.edu/collections/2442/greek-and-roman-art/objects?filter=geography%3AItaly#filters – An excellent display of digital materials and artifacts for analyzing Roman material culture.
8. Roman Primary Source - https://researchguides.csuohio.edu/HIS331/primary - Students can find a plethora of digital materials here for their final projects.
9. Oxford Index of Roman Mining and Quarrying Locations - https://oxrep.classics.ox.ac.uk/databases/mines_database/ - This database includes a list many major Roman mining and quarrying sites. Students can use this as part of their final research project.
10. Professor David Evans, the seminar leader that led to the creation of this unit, has prepared an extensive collection of international geology maps that students may wish to make use of for this project - https://drive.google.com/drive/folders/1EZLkggMQRgwnpW8PFbMpvvxgMkr-8ow3?usp=drive_link

Appendix on Implementing District Standards

This unit mostly addresses Connecticut's social studies standards, but there are certainly applications to the Common Core literacy standards and the Next Generation Science Standards used in Connecticut.

CT Social Studies Standards (CSSS)7.Inq.1.c. – Determine the kinds of sources that will be helpful in answering compelling and supporting questions, taking into consideration multiple points of views represented in the sources. – In this unit, students will be exposed to a broader set of primary and secondary sources than they may be used to in a social studies class, but will have plenty of opportunities to develop compelling and engaging questions about both history and geology.

CSSS.7.Geo.10.a. – Analyze how cultural characteristics vary among regions and shape diversity of local communities (e.g., cultural centers, diasporas, cultural universals, taboos, linguistics). – By using case studies, this unit will cover a vast swath of the ancient Roman world. Primary source readings have been included to illuminate the distinct cultural characteristics of the peoples of the Roman Empire.

CSSS.7.Geo.10.b. – Analyze how environmental characteristics vary among regions (e.g., climate, natural

disasters, waterways, mountain ranges, deserts). – Again, the adoption of the case study format used in this unit serves as an excellent gateway into the skills of comparative analysis.

CSSS.7.Eco.6.a. – Explain how changes in supply and demand have influenced the price and quantity of a good or service in a region (e.g., gold inflation related to Mansa Musa's Hajj, Dutch fur trade in North America, Rainforest logging, Cobalt mining in Democratic Republic of the Congo, global agriculture, Venezuela oil production, illegal poaching) – The analysis of the mines at Rio Tinto and its importance to Roman minting demonstrates not just the concepts of supply and demand, but likewise to the rules regarding the role of currency in the exchange of goods.

CCSS.ELA-Literacy.RH.6-8.1 – Cite specific textual evidence to support analysis of primary and secondary sources. – Students will need to use this skill frequently in analyzing the readings across the unit.

Next Generation Science Standard (NGSS) MS-ESS2-2 – Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. – Our analysis of Vesuvius and plate tectonics support the teaching of this standard, as we see how Italy came to its present shape and location in mainland Europe while likewise recognizing the dangers it posed to people.

NGSS.MS-ESS3-1 – Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. – The analysis of the ore deposits at Rio Tinto perfectly addresses this standard.

Notes

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[1] Pliny the Younger *The letters of Pliny the younger,* . Edited by F. C. T. Bosanquet. Translated by William Melmoth. *Project Gutenberg* . New York: Hinds, Noble & Eldredge, 1906, n.p.

[2] Ibid.

[3] Livy. *History of Rome*. Translated by William Masfen Roberts. *Perseus Digital Library*. London: J. M. Dent & Sons, 1905.

[4] Moscatelli, Massimiliano, Alessandro Pagliaroli, Marco Mancini, Francesco Stigliano, and Giuseppe Cavuoto. "Integrated Subsoil Model for Seismic Microzonation in the Central Archaeological Area of Rome (Italy)." *Disaster Advances* 5, no. 3 (July 2012), 12

[5] Andrews, *Killing for Coal*, 28

[6] Savage *Cross-curricular teaching and learning in the secondary school*, 8-9

[7] Harris, William V. *The ancient Mediterranean environment between science and history*. Leiden:Brill, 2013., xix

[8] Ibid., p xx

[9] Hughes, *The Mediterranean: An environmental history*., xv

[10] Hughes, *Environmental problems of the Greeks and romans: Ecology in the ancient mediterranean,* 163

[11] Boatwright, Mary Taliaferro, Richard J. A. Talbert, and Daniel J. Gargola. *A brief history of ancient rome: Politics, society, and culture*. New York: Oxford University Press, 2005, 15-16

[12] Heiken et al., *The Seven Hills of Rome*, 14

[13] Ibid., 15.

[14] Ibid., 14.

[15] Image courtesy of Wikimedia Commons user sam1370 under Creative Commons Attribution-Share Alike 4.0 International license.

[16] Jones, "Rome wasn't built in a day but these days it feels as if it may collapse in one" n.p.

[17] Marshak, Stephen. Earth: Portrait of a planet. 7th ed. New York, NY: W.W. Norton & Company, 2022., 288

[18] Ibid, 188.

[19] Ibid. 307

[20] Image is in the public domain, courtesy of the Yale Center for British Art

[21] Beard, Mary. *The fires of vesuvius: Pompeii lost and found*. 18

[22] Allison, Penelope M. Pompeian households: An analysis of the material culture. Los Angeles: University of California, 2005.

[23] Ibid., 59

[24] Doronzo et al., *The 79 CE Eruption of Vesuvius: A Lesson from the Past and the Need of a Multidisciplinary Approach for Developments in Volcanology.,* n.p.

[25] Caesar, Julius. *The Gallic Wars*. Translated by H. J. Edwards. Cambridge, Mass: Harvard University Press, 2006., n.p.

[26] Salway, Peter. *Roman Britain: A very short introduction*. Oxford: Oxford University Press, 2015., 26

[27] Ibid., 249-250, 257

[28] Tacitus, Cornelius. *Annals: Book 13-16*. Translated by John Jackson. Heinemann, 1937. n.p.

[29] Ibid.

[30] Salway, *Roman Britain,* 3

[31] Wallace. *The origin of Roman London*

[32] Ellison et al., *Geology of london: Special memoir for 1:50 000 Geological Sheets 256 (North London), 257 (romford), 270 (South London) and 271 (Dartford) (England and Wales)*.

[33] Lara Williams, *Bloomberg,* "How Is the UK at Risk of Both Floods and Drought?"

[34] Pliny the Elder. *Natural History*. Translated by John Bostock and Henry T. Riley. London: George Bell, 1898., 174

[35] Jones "The Roman Mines at Riotinto.", 157

[36] Ibid. 164

[37] Thommen., *An environmental history of Ancient Greece and Rome*, 122

[38] Image taken from Palmer, RE, *Notes on some Ancient Mine Equipment and Systems*, 1928, in the Public Domain

[39] Bishop, M. C. *The secret history of the roman roads of Britain*. Barnsley: Pen & Sword Military, 2014, 19

[40] Campedelli, Camilla. "The Impact of Roman Roads and Milestones on the Landscape of the Iberian Peninsula." Essay. In *The Impact of the Roman Empire on Landscapes*, edited by Marietta Horster and Nikolas Hachler, 111–31. Leiden: Brill, 2021., 122

[41] Ovid. *Metamorphoses*. Translated by Henry T. Riley. *Project Gutenberg* . London: George Bell & Sons, 1893., 20

[42] Pliny the Elder, *Natural History*, 93

[43] Image by Carol Stoker for NASA, image is in the public domain.

[44] Marshak, p.582

[45] Bordenstein, Sarah. "Rio Tinto, Spain" *Microbial Life - Educational Resources,* np