

BELFER CENTER PAPER

The Collapse of Civilizations

Malcolm H. Wiener



HARVARD Kennedy School
BELFER CENTER
for Science and International Affairs

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SEPTEMBER 2018



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The Roman Aqueduct of Segovia, located in the city of Segovia, Spain.
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About the Author

Malcolm H. Wiener is an Aegean prehistorian who has written extensively on the Eastern Mediterranean world in the Bronze Age. His many published papers span the emergence, florescence, and collapse of the first complex societies of the western world in Minoan Crete and Mycenaean Greece, their relationship to the civilizations of the Near East and Egypt, the absolute chronology of the ancient world (science, texts, and interconnections via objects), warfare in the ancient world, the acquisition of copper and tin for bronze tools and weapons, and the interaction of climate change, mass migrations, pandemics, warfare, and human agency in the collapse of civilizations. His awards include the honorary doctorates of the Universities of Sheffield, Tübingen, Athens, Cincinnati, University College London, Dickinson College, and the University of Arizona, the Gold Cross of the Order of Honor (Greece), and the Ring of Honour of the German Academy in Mainz. Mr. Wiener is a Fellow of the American Academy of Arts and Sciences and the Society of Antiquaries in London, a Corresponding Member of the Royal Swedish Academy, the Austrian Archaeological Institute, the Austrian Academy of Science, the Deutsches Archäologisches Institut, and the Academy of Athens, holds the rank of Chevalier in the Ordre des Arts et des Lettres of France, and is an Honorary Director of the Greek Archaeological Society. He is the founder of the Institute for Aegean Prehistory and the Malcolm Wiener Laboratory for Archaeological Science at the American School of Classical Studies at Athens, and a recipient of the Archaeological Institute of America Bandelier Award for Public Service to Archaeology and the Athens Prize of the American School of Classical Studies at Athens.

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Cover Image

The Roman Aqueduct of Segovia, located in the city of Segovia, Spain.
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Introduction

Current dramatic breakthroughs in archaeological science provide persuasive new insights about the collapse of past civilizations. Winston Churchill once remarked “The longer you can look back, the farther you can look forward.” Armed with DNA analysis of the movements of human populations, animals, and pathogens; strontium isotope analysis documenting the movements of people over the course of individual lifetimes; analyses of past climates through beryllium as well as oxygen isotope analysis, together with the drilling of deep lake, sea, glacier, and cove cores, and the study of annual growth of tree rings, among other scientific advances, we can look back upon the history of humankind as never before. Five causes of collapse appear paramount: major episodes of climate change, crises-induced mass migrations, pandemics, dramatic advances in methods of warfare and transport, and human failings in crises including societal lack of resilience and the madness, incompetence, cultic focus, or ignorance of rulers.

Climate Change Collapses

We begin with the hot topic of climate change. Around 13,000 to 12,700 BC, the ice sheets that had covered parts of Europe, northern Asia, and North America down through New York City retreated, opening these areas to human occupation. The ice returned c. 11,000 BC, during the period known as the Younger Dryas, but by 9750 BC had largely retreated again to its approximate current configuration. The period c. 10,000 to 9500 BC saw the origins of civilization in the Near East, with the appearance of cult centers with significant structures such as the recently discovered site of Göbekli Tepe in southern Turkey, followed by cereal cultivation and animal husbandry, which spread gradually from the Near East to Europe between about 9000 and 6500 BC. Recent scientific progress has disclosed, for example, that Lake Van, the largest lake in Turkey, was essentially dry until about 8,000 BC, when the appearance of moist conditions facilitated the spread of agriculture.¹ We should also note, however, that the Neolithic lifestyle may also have led to the origin and spread of diseases, due to contact between animals and humans and greater numbers of people in small, confined spaces.

Around 6200 BC, changes in rainfall patterns (for which a periodic change in the earth's orbit has been suggested as a possible cause) led, inter alia, to the contraction of the savannah in North Africa, forcing humans to move to the banks of the Nile for water.² A further period of cold, indicated by evidence gathered from Greenland ice cores, may have spurred rapid dispersal of migrants along the comparatively warm shores of the Mediterranean between about 5,750 and 5,450 BC.³ Indeed, all five of the known great migrations out of Africa appear to correspond with climate events. Improving climate c. 4600 to 4000 BC spurred Neolithic dispersal from western Asia, and was followed during the fourth millennium BC by the emergence of the first complex civilizations between the Tigris and the Euphrates Rivers in Mesopotamia and in the Indus River valley.

The First Historical Megadrought

We come now to the first identifiable climate-related collapse of civilizations, encompassing at least all of West Asia and the Mediterranean world between 2300 and 2000 BC. For this major climate event we have both abundant scientific evidence, thanks in part to recent dramatic advances in archaeological tools, and also textual references, including personal responses to the disaster. During these years rainfall declined sharply throughout the area, playing a major role in the collapse of many complex societies. Scientific evidence for the megadrought comes from the analysis of marine and lake sediments, cave and glacier cores, and datable tree rings. The megadrought, which caused or intensified major movements and migrations, some violent in nature, was accompanied by drastic changes in methods of warfare and transport, most notably the introduction of bronze weapons and sailing vessels, which may have carried not only invaders but also pathogens to which there was no local resistance. Of course severe food shortages appeared at different times in different places, depending on local conditions, food storage capabilities, societal resilience, and whether major advances in methods of transport and warfare preceded or followed the onset or culmination of famine.⁴

In Egypt, there is direct textual evidence of a climate event during the First Intermediate Period, c. 2200 to 2050 BC, when the Nile flow sharply diminished, resulting in famine. The Egyptian Old Kingdom, the age of the pyramids, dissolved. The tomb of a southern Egyptian provincial governor of c. 2100 BC contains an inscription carved into the rock describing the resulting starvation, dislocation of people, and breakdown of order. Another text reads: “The river of Egypt is empty, men cross over the river on foot.”⁵ The waters of the Nile are fed by rainstorms carried by southwest winds from the Atlantic from June to September and by monsoons sweeping north from the Indian Ocean, which bring smaller amounts of rain from February to March.⁶ Various bodies of geological evidence indicate that these water sources were severely diminished for roughly two centuries. Egypt began its recovery c. 2050 BC, when the Nile floods returned and the Egyptian Middle Kingdom, with its grand temples, palaces, and sculpture, arose.



Farther north, the Akkadian Empire covering much of the Near East collapsed by about 2150 BC,⁷ and its successor, the Third Dynasty of Ur, lasted only about a century c. 2100 to 2000 BC. The challenge posed by a changing climate was first noted in the Upper Khabur region of northernmost Syria, where archaeological sites contain a massive dust level lacking signs of significant human occupation between about 2225 and 2050 BC. At the site of Tell Brak, an unfinished, abandoned fortress containing bricks stamped with the name of Naram-Sin, who reigned c. 2231 to 2176 BC, provides additional evidence for dating the event. The nearby major site of Tell Leilan and its surrounding satellite communities were abandoned and covered in dust. Further west, several major sites, including Ebla, were destroyed in fires, abandoned, or greatly reduced in size.⁸ While some sites adjacent to the Tigris and Euphrates Rivers or to karst-fed springs grew in size, areas dependent on rainfall agriculture were generally largely deserted. No doubt states and sites under climate stress differed in their societal resilience and adaptive capacities, with some losing population at a later date or more gradually.

Texts from Mesopotamia describe the migration of peoples from the west and north, complaining of the absence of rain. After what may have been an attack or attacks by neighboring polities, the once-great capital city at Ur was overrun by people from the north seeking food and pasturage. Walls were built in eastern Syria and in Iraq between the Tigris and Euphrates Rivers, known respectively as the Très Long Mur and the Repeller of the Amorites

(a people speaking a Northwest Semitic dialect), but the walls failed to halt the migrants. A text of the succeeding Assyrian Empire speaks of the “17 Amorite kings who lived in tents” during the interregnum.⁹ Societal collapse almost always reflects a combination of factors. For example, food shortages may gravely weaken a polity, with conquest by a neighboring society providing the fatal blow. The challenge posed by deteriorating climactic conditions during this period appears to have been a common link, however, making previously strong societies far more vulnerable.

Around 2200 BC, sites in Cilicia in southwestern Turkey and in the central Taurus mountain range were abandoned, including the major trading center at Kültepe/Karum Kaneš. In Canaan, a decrease in rainfall resulting in the creation of the wadis or ravines still visible today has been suggested as the cause of the precipitous decline in the number of inhabited sites. West of the Jordan River and the Dead Sea, not a single site has been found that survived the collapse, whereas a few sites survived in the stream-fed northern Levant. It should be noted, however, that radiocarbon measurements suggest that the end of urban culture in the southern and central Levant may have occurred earlier, c. 2500 BC. If the destructions now tentatively dated c. 2500 BC were non-climate related, then the failure to resume a major urban existence for half a millennium, including the period 2250 to 2050 BC, was surely due in part to the climate event. In Cyprus, the Philia culture of the Early Bronze Age also disintegrated c. 2300 to 2200 BC. The arc of destruction included the great site of Troy at the outlet from the Dardanelles to the Aegean Sea, where the massive walls fell into ruin c. 2200 BC. The far less imposing occupation which followed contained evidence of six destruction levels. The inhabited area of Troy shrank drastically, all evidence of external contacts disappeared, and the smaller sites surrounding Troy were abandoned. During this process, signs of stress on barley crops appeared. Faunal remains indicate an altered diet containing a significant percentage of deer and other non-domesticates, with cattle, sheep, and goats almost totally absent.¹⁰

The collapse of civilizations at this time includes Greece, where the incipient complex society of what is known as the Early Bronze II period in the Peloponnese, marked by large buildings such as the House of the Tiles at Lerna (named for the innovative use of roof tiles in its architecture) and

the Rundbau at Tiryns, both with evidence of administration in the form of seal impressions and of contacts with sites in Anatolia and elsewhere, disappeared. Both sites were reinhabited by people who lived in far simpler structures lacking any evidence of record-keeping. Similar reversions can be noted at other sites in Greece, including Zygouries, Thebes, Manika, Poliochni, and especially at the large site of Kolonna on the island of Aegina. Helike on the Gulf of Corinth is destroyed early in EH III.¹¹ The wave of destructions accompanied a radical decrease in general in the number of occupied sites in the Peloponnese.¹² The dramatic differences in the types of cooking pottery before and after the destructions signal a change in the method of food preparation and perhaps of diet as well, indicating a change in population resulting from migrations, including the arrival of people from north-central Greece.

In the Cycladic islands, many sites were abandoned or destroyed during this period. The culture marked by the well-known Cycladic marble figurines, which inspired works by Picasso, Brancusi, and Moore, among others, disappeared by 2000 BC. Some Cycladic islands, such as Kea, were simply deserted for centuries, while on others, fortifications were built on hilltops, only to suffer violent destructions. At the fortified citadels of Panormos on Naxos and at Kastri on Syros, the end was surely warlike. The evidence from Naxos includes the burnt entrance gate, sling-stones, and a bronze spearhead found in the debris.¹³ Weapons made of bronze now appear in significant numbers in the Mediterranean region, a reminder that analysis of episodes of climate-induced migrations must also take into account any concurrent major changes in military technology, whether of weapons or of means of transport such as the first appearance of horses or of sailing vessels capable of raiding.

While oared longboats are depicted on stone carvings in the Cyclades beginning c. 4000 BC, the earliest depiction in the Aegean of a ship under sail appears on a Minoan Cretan seal of c. 2000 BC.¹⁴ An Egyptian text from c. 2300 BC shortly before the collapse of the Old Kingdom contains a description of the earliest recorded amphibious assault. The pharaoh of Egypt had received a report that pirates located in the vicinity of Gaza in modern Palestine had seized an Egyptian ship returning from Byblos with its cargo of the prized cedars of Lebanon. The pharaoh directed that

troops be placed on ships to attack the pirate lair, thereby inventing the Marine Corps. Sailing vessels may have brought not only raiders equipped with bronze weapons, but also pathogens from distant lands to which local inhabitants had no immunity. Dating Bronze Age invasions closely may be difficult in some cases, and the possible appearance of devastating pathogens significantly more so. Accordingly it is possible that in some cases well-armed attackers or pathogens appeared before the full brunt of the deteriorating climate was felt, with the climate event providing the coup de grâce,¹⁵ or that the climate-induced famine weakened the population prior to the plague. *Yersinia pestis* infections have been identified as early as the Late Neolithic period around 3000–2500 BC in Eurasia. Actual bubonic plague genomes have recently been identified in the Samara region of modern Russia c. 1800 BC, suggesting a possible appearance close to the time of the climate collapse of 2200–2050 BC.¹⁶

The arc of upheaval extended to the central and western Mediterranean. The imposing megalithic temple culture of Malta, the relatively advanced Copper Age cultures of Sardinia and Languedoc in southern France, and the metallurgical culture of Spain exemplified by the major copper-producing sites of Rio Tinto and Los Millares which flourished from about 3000 to 2000 BC also came to an end, followed by the apparent arrival of newcomers with much less imposing architecture. In the case of Malta, the immigrants obviously came by sea.¹⁷ Of course the effects of episodes of climate change are not uniform across the Mediterranean. Precipitation on the windward side of a mountain may differ greatly from the leeward side, a phenomenon which may be relevant in connection with the relative prosperity of Achaea compared to other areas of the Peloponnese in the 12th century BC.

The collapse or major diminution of cultures may open opportunities for others. Between about 2300 and 2000 BC the Balkan Cetina Culture, with its distinctive tumulus burials, bronze daggers, archery set, and ornately impressed pottery, expanded over both coasts of the Adriatic Sea, including a site under the much later Altar of Zeus at Olympia, and on into the central Mediterranean, including Malta. Mariners sailed westward from the Peloponnese as well, bringing pottery and other aspects of Early Helladic III culture to Sicily and Malta.¹⁸ In England, the period of monumental

building at Stonehenge and Avebury in Wiltshire comes to an end around 2300 BC. DNA and strontium isotope analyses suggest an influx of people between 2500 and 2000 BC from the direction of the Netherlands, bearing Beaker pottery.

Returning east, the Indus Valley civilization, with its great centers at Harappa and Mohenjo-Daro, was initially spared the full effects of drought by the mighty Indus River and its tributaries, but collapsed by 1700 BC with its great sites abandoned. There is some evidence for the role of climate change in the process, but the subject requires additional investigation. Areas in the west of China may also have been affected by extended drought, as suggested by the conspicuous spike in the Dongge Cave (southern China) stalagmite record at 2160 ± 10 BC,¹⁹ while areas to the east suffered destructive rains, perhaps the result of the bifurcation of the Indian Ocean monsoons. In any event, the Longshan Culture of the third millennium BC in China disappeared.

The Climate Recovery and Flourishing Societies of the Middle and Late Bronze Age

Beginning around 2050 BC, a period of generally good climate lasting almost a millennium enabled the rise of powerful and prosperous states from Egypt to Assyria to Anatolia to Crete and later mainland Greece. Egypt was reunited at the beginning of the period into what is known as the Middle Kingdom. The grand palaces, magnificent tombs, and remarkable depictions of the human body in sculpture (the last particularly during the 12th Dynasty c. 1985–1775 BC) still arouse awe today.

The Near East during this period enjoyed the benefits of expanding trade, and in particular the Assyrian trading colony network which stretched from northern Iraq to northern Syria and central Turkey. One of its great centers was located at Kültepe Karum-Kanesh in Turkey, where the local ruler lived on a hill above a large lower town of Assyrian merchants. A

robust system of caravanserais stretching from Assyria to much of Anatolia provided rest stops along the route. By 1600 BC the Hittite Empire appeared in central Turkey. By c. 1300 BC it reached the shores of the Mediterranean and controlled parts of Canaan.

The beginning of the Middle Bronze Age in the Aegean Sea c. 2000 BC saw the origin of the first Minoan palatial states on Crete. By c. 1600 BC Knossos with its famed “Palace of Minos” excavated initially by Sir Arthur Evans had established its rule over Crete and in all likelihood over many of the Cycladic islands, the islands of the eastern Aegean, and the site of Miletus, the entrepôt of the River Meander, in Turkey. A prime purpose of what has been called the Minoan thalassocracy, or seaborne empire, was surely to obtain through trade the tin and copper, constituents of the bronze of the Bronze Age, which Crete lacked internally. Bronze was essential to be able to produce the great swords and daggers employed by Minoan troops and the great saws used to construct the palaces and grand villas of the Neopalatial period in Crete, c. 1600–1200 BC. The period 2000–1200 BC saw the appearance of the first scripts in Crete. The conquest of Crete c. 1440 BC by the Mycenaean civilization of mainland Greece saw the introduction on Crete of a script known as Linear B, depicting an early form of the Greek language.

The Return of Dry Climate and Famine, Migrations, Outbreaks of Plague, Improved Weapons, and the Collapse of Civilizations

At the end of the Bronze Age c. 1200 to 1050 BC, the return of adverse climate appears to have been a significant factor in the collapse of the Egyptian New Kingdom, the Hittite Empire, and the palatial culture of Mycenaean Greece. Pollen records indicate that the dry period covered a large area stretching at least from northern Turkey to the Nile Delta. In Egypt and Anatolia, there is abundant textual evidence for famine and plague, covering most of the century-and-a-half preceding the collapse. The Hittites devoted major resources to storing vast amounts of grain in

many large silos, but nevertheless suffered devastating food shortages at the end of the Bronze Age. A Hittite letter from late in the reign of Emperor Tudhaliya IV (c. 1248 to 1220 BC) begs for 450 tons of grain to be sent from Ugarit in northern Syria to the port of Ura in southwest Turkey for transfer to the Hittite capital at Hattuşa/Boğazköy, over 500 km away in the Anatolian mountains, where starvation is reported.²⁰ In the end, it appears that the colossal, massively walled Hittite capital may have been simply abandoned c. 1200 BC, perhaps for want of food.

In Mycenaean Greece, the collapse was marked by loss of bureaucratic literacy with the disappearance of the Linear B script, and of the engineering, technical, and logistical abilities previously employed to construct massive hydraulic works, defensive fortifications, palaces, and imposing beehive-shaped tombs made of ashlar blocks. A year ago, new high-resolution oxygen and carbon isotope data from Mavri Trypa Cave near the Palace of Nestor at Pylos were published,²¹ showing a period of dryness around the time of the destruction of the palace c. 1200 BC and for a short time thereafter. This may help explain why the Palace of Nestor along with sites throughout Messenia and Laconia remained almost entirely unoccupied for some time after the destructions, unlike sites such as Mycenae, Tiryns, or Thebes. Acquiring adequate supplies of grain was surely a matter of prime importance in Mycenaean Greece as well as Anatolia, as indicated by the massive drainage works in the Kopais Basin, constructed between 1330 and 1300 BC in the same era as the first texts mentioning grain shortages in Anatolia and the Near East. The destruction of these great hydraulic works²² along with the nearby sites of Thebes, Orchomenos, and Gla, c. 1225 BC, perhaps as a result of warfare between Mycenaean states, was likely a major factor in the collapse of Mycenaean palatial civilization.

Famine, apart from its direct effects, can also damage social cohesion, with state structures based on divine kingship and priestly rule particularly vulnerable in the event of perceived divine disfavor. Conversely, some societies will feel lesser effects, whether because of relatively favorable climate circumstances, locations apart from the route of migrating masses or invading armies, or as a result of greater societal resilience. Climate-induced famine may call forth and impel a number of infectious agents, while other diseases appear indifferent to the nutritional status of their

victims.²³ (It is worth noting that in addition to famine contributing to the virulence of plagues, the reverse can also occur—for example, pathogens caused the great 19th century potato famine in Ireland.)

Vectors of collapse other than climate-induced famine were clearly present in the collapse of civilization at the end of the Bronze Age culminating in the 13th and 12th century BC. In the last quarter of the 14th century BC, two Hittite emperors in succession died of the plague.²⁴ In 1312 BC their successor Mursili II requested that representations of plague-combatting deities from neighboring cultures be brought to the Hittite capital, implying that the relevant Hittite deities had failed in their duty. Texts also describe the earliest recorded instance of biological warfare, with the Hittites and their coastal neighbors, the Arzawans of western Anatolia, each attempting to send infected rams behind enemy lines.²⁵ There is also abundant evidence of warfare in general in the Near East and Greece in the late 13th century BC, and of continuing pirate raids throughout the eastern Mediterranean, accompanied by some movement of people from the Aegean to Cyprus and Canaan by sea, and from Anatolia to the northern Levant by land. The period also saw the appearance of a new and deadly weapon, the Naue II type sword, plus a complete new military kit, consisting of javelins, round shields, metal greaves, and infantryman corselets.²⁶ The new military equipment may have come with mercenary troops from Italy and possibly the Balkans, along with crude cooking pots very different from Mycenaean pottery. Mercenaries may of course present problems on their own. Moreover, the eastern Mediterranean at the end of the Bronze Age contained a web of interdependent states exchanging essential commodities, where a failure in one part of a complex yet fragile interconnected system could severely impact the whole.

The Greek and Phoenician Colonization of the Mediterranean in Search of Land, Followed by the Roman Warming

The climate improved by c. 800 BC and remained relatively benign in general through the Classical and Hellenistic periods in Greece, with the possible exception of a period of famine in the late 8th and 7th centuries BC contributing to the era of Greek colonization eastward toward Turkey and westward toward Italy, plus two colonies in Africa. This was also the period Phoenician expansion to the western Mediterranean, Carthage in particular. A period of particularly temperate climate, known as the Roman Warming (a.k.a. the Roman Climate Optimum), began about 200 BC and continued until c. AD 150, thus encompassing the heights of the Roman Republic and Roman Empire. There followed a transitional period of unsettled but not extremely severe weather c. AD 150 to 450. Roman rulers paid close attention to food supplies during this period, seeking to institutionalize resilience. The extant segments of the ancient aqueducts and granaries inspire wonder today. The emperor Septimius Severus, who ruled between AD 193 and 211, took provisioning the city of Rome so seriously that at his death there was enough grain stored to feed its one million inhabitants for seven years. This feat was accomplished in part by the deployment of a flotilla of deep-hulled ships which brought grain from Egypt.²⁷ During the Roman Climate Optimum the Roman Empire reached its peak, encompassing an area from the cold north of England to the sands of Egypt, erecting remarkable works of architecture and engineering, and imposing a common system of laws, weights, coinage, and language. The connectivity of the Roman Empire, and especially the sheer numbers of ships then traversing the Mediterranean, as well as sailing from the Indian Ocean to the Red Sea ports built by the Empire, however, also brought the Romans into unfortunate contact with new frontiers of disease. In AD 165, an event known as the Antonine Plague, probably caused by smallpox, swept the Roman world. In AD 249 came another plague of unknown cause, together with a period of drought, adding to the problems presented by the continually increasing costs of providing armies, fleets for naval battles and transport, highways, aqueducts, granaries, and

sanitation systems, resulting in the onset of political disintegration, leading to what has been termed the “first fall” of the Roman Empire.²⁸ As with earlier stages in the history of Rome, we find examples of deadly internal strife, the madness of rulers, and the role of chance in the fortunes of war, as in the case of Rome’s narrow escape from destruction by the forces of the Carthaginian commander Hannibal in the Second Punic War between 223 and 205 BC. All the factors stated have played major roles in the collapse or survival of civilizations.

The End of the Western Roman Empire

This major decline from AD 250 to 270 was once again due to the combined effects of climate change, famine, migration, and an advance in transport plus warfare followed by pandemic. A drastic slackening of the movement of the Atlantic air mass across Europe and beyond produced a major drought, resulting in what has been called a “dust bowl” in Central Asia.²⁹ The crisis in turn led to the invasions of the nomadic pastoralists from Central Asia and Eastern Europe known as the Huns, who employed new cavalry tactics using horses able to endure hard riding, cold, and hunger, and a new weapon, the composite reflex bow, hard to manufacture and use, but deadly in action. The Huns have aptly been described as “armed climate refugees on horseback.”³⁰ At this point disease intervened to save the Roman Empire’s defenders, for the Huns, and in particular their horses, were felled by malaria-carrying mosquitoes, unknown in the cooler regions to the east and north.³¹ Again we encounter the deadly combination of climate change, famine-induced migrations, pandemic, and new methods of warfare and transport. The weather-spurred migration of the Huns pressed against the Gothic tribes to the west and north, who in response moved south into the Roman Empire. After more than a century of recurring battles, interspersed with alliances and reciprocal betrayals often accompanied by slaughter, Rome itself fell to a Gothic assault in AD 410. The history of the interactions between the Goths and the Romans provides a prime example of the role of folly in the collapse of civilizations. The Roman Empire, which had proven adept at subduing or

integrating (via grants of citizenship among other measures) other Italic peoples speaking various languages including the Etruscans, Greek city-states, nations around the Mediterranean from Anatolia and Egypt to the Magreb and Spain, plus Britain to the northwest, failed in the end against the Goths.

The Role of Climate and Plague in the Collapse of the Roman Empire

While the Western Roman Empire collapsed by the beginning of the 5th century AD, the Byzantine Eastern Roman Empire revived until the dramatic events of the Late Antique Little Ice Age of AD 536 to 680. The frigid climate of the period was due in part to a series of volcanic eruptions in early AD 536, AD 539–540, and AD 547, a cluster of eruptions unmatched in the last 3000 years.³² Aerosols from these eruptions partly obscured the sun. AD 536, the year of the first eruption, was known as the year without sun, and 539–540 may have been even worse. The 530s and 540s were the coldest decade since the Ice Age.³³ The significantly stunted tree rings at AD 550 signal a year of particular frigidity. At the time of the volcanic eruptions, the sun itself may have entered a periodic cycle during which it radiated less heat toward the earth.³⁴ The decline of solar output is now measurable for the first time via analyses of beryllium isotopes. It is worth noting that the years AD 550–600 mark a period of reduced rainfall and societal collapse at the great center of Teotihuacan in Mexico as well.

Famine induced by the highly unsettled weather of the 6th century AD contributed to the deadly impact of the Justinianic Plague of AD 541 to 543, which worked its way across the Roman Empire in three years, causing an estimated 30 million deaths, or about one-half the entire population. The Byzantine Greek historian Procopius reports that the plague originated in Pelusium in northeastern Egypt and then spread throughout the Empire via maritime and land transport routes, with the result that “the whole human race came near to being annihilated.”³⁵ With regard to Rome itself, Procopius states that by AD 547 the population had declined from one

million people to five hundred.³⁶ While he may have exaggerated the extent of the decline, it was surely drastic in any event. The enormous seaborne commerce of the 1st century AD all but disappeared by the mid-6th to early 7th centuries, and all of Italy reverted to a prehistoric condition not seen since before the Etruscans, with signs of recovery only emerging in a new medieval guise in the 11th century.

The Eastern Roman Empire under Justinian and Theodora displayed great resilience in the face of the increasing cold and other challenges during the years AD 527 to 541. It made peace with Persia, recaptured large areas of the Roman Empire in the west, built grand structures including the imposing Hagia Sophia in Constantinople, and enacted the famous codification of Roman law whose effects are still felt today. In the end, however, the Eastern Empire, weakened by the frigid weather, succumbed to the Plague of Justinian.³⁷ Adverse climate, mass migrations, and disease, interacting with human agency in the form of mad rulers and internal strife (plus the occasional role of chance in the outcome of battles) combined to destroy the Roman Empire, with plague the final fatal stroke.

Two-hundred forty-one years after the publication of Edward Gibbon's *The History of the Decline and Fall of the Roman Empire*, the best-seller of its day, the subject retains its fascination while undergoing reconsideration via a torrent of new and ongoing scientific research

The Curse of Benign Weather

In the 10th century, a period of general warming known as the Medieval Warm Period began. This period includes the special and counter-intuitive case of benign weather playing a major role in the destruction of cultures. Examination of tree rings of Siberian pines in central Mongolia provides evidence for a period of sustained rainfall and unusually mild weather between AD 1211 and 1225, which coincides precisely with the conquests of the Mongols under Genghis Khan, accompanied by widespread destruction and slaughter. Pastures suddenly rich after a preceding drought provided fodder for the herds of war horses which enabled the Mongol

armies to conquer lands from China to Hungary. In short, the unusually mild climate produced the grasspower that provided the critical horsepower, plus the necessary fodder for the camels, yaks, cattle, and sheep accompanying the invaders.³⁸ Warrior peoples move and seek to conquer not only when they must, but also when they can.

The Little Ice Age

The succeeding Little Ice Age of c. AD 1300 to 1750 produced prolonged freezing winters and colder, damper summers in much of Europe, the Near East, and China as well, with famines common. Cold weather accompanied by famine reappears in Scandinavia around AD 1300, with land abandoned and marked population decline.³⁹ We still seek evidence as to whether lack of nourishment diminished resilience to the massive epidemic which followed. By mid-century, the expansion of sea travel in the Mediterranean, which marked the beginning of the early Renaissance in Italy, brought with it the great plague known as the Black Death of 1347–51, which spread through Europe. Estimates of the death toll range from about one-quarter to one-half of the total population of Europe, depending on the area. A widely though not universally accepted reconstruction of events holds that the epidemic, caused by bubonic plague as we now know from DNA analysis, originated in China and decimated the Mongol army besieging a Genoese trading port in the Crimea. The Mongols catapulted plague-infested corpses into the town. From here Genoese ships carried the plague to Mediterranean ports, including of course those of Greece and Italy. The medieval Book of Hours, the first text read across Europe by people at every level of literacy, illustrates (in every sense) the great fears of humankind via prayers to forestall death, plague, warfare, and crop-destroying weather.⁴⁰ The subsequent onset in Ottoman territories of a period of cold and drought, beginning around AD 1400 and continuing through the 16th century and into the 17th, was accompanied by regional abandonment and conflict in parts of the Ottoman Empire as well. Waves of bubonic plague during this period affected both the Ottomans and their enemies.⁴¹ The early 16th century also saw the conquest and collapse of the Aztec and Inca Empires of Mexico and Peru, brought about by Europeans utilizing new

methods of warfare (horses and firearms) and transport (horses and sailing vessels) but above all bringing pathogens to which Native Americans had no resistance, resulting eventually in the death of an estimated 90% of the indigenous population.

At the culmination of the Little Ice Age, Dutch paintings of the 17th century AD show the canals and ponds of the Netherlands frozen over, with locals engaged in various activities on ice. Marked population decline is documented in France, where about 15% of the population died of starvation between 1692 and 1694, and in Germany, England, the Netherlands, Denmark, Finland, Poland, Estonia, Castile, and Catalonia. Smallpox, plague, typhus, and measles attacked many already weakened by starvation. During the Little Ice Age, Europeans were also frequently at war, with the Thirty Years' War of 1618 to 1648 taking an enormous toll in lives. Overall, population may have been reduced by a third or more.⁴² The decline in temperatures and populations coincides in time with the virtual absence of sunspot activity known as the Maunder Minimum between AD 1645 and 1715. Recent research suggests that variations in solar activity may have a profound influence on climate.

Conversely, warming climate beginning in the latter half of the 18th century was accompanied by population increase. The increase in population was halted one more time, however, not by adverse climate but by war and epidemic, in this case World War I and the influenza pandemic of 1918, which took the lives of somewhere between 50 million and 100 million people around the globe. The broad history of epidemics was stated 40 years ago by William McNeill in his classic work, *Plagues and Peoples*, as follows: agriculture brought us into close contact with domesticated animals; the growth of cities provided the dense population in which germs could circulate; and improvements in transport led to a convergence of disease pools.⁴³

Clear and Present Dangers Today

Our examination of the major examples of the collapse of civilizations past shows clearly that major episodes of climate change have had profound impacts upon cultural continuity, and that the interactions between climate change, famines, migrations, pandemics, and major innovations in the means of transport and warfare are critical in understanding the collapse of past civilizations.

The prime movers of collapse throughout history all present risks for today. The cumulative stock of carbon emissions over the past century has increased the risk of destructive climate change in the future. Many areas of the world remain vulnerable to famine, particularly those most exposed to climate risk and war. We are now grappling with the effects of massive forced migrations in many places, particularly from the war-torn Middle East to Europe, from persecution in Myanmar, and from famine and tribal warfare in Africa.

The risk of pandemics is ever present, as shown by the appearance in recent years of HIV, Ebola, Lassa, West Nile, Nipah, SARS, MERS, and the Zika virus, the transmission of which is fostered by the democratization of air travel. The Gates Foundation has estimated that if an influenza pandemic like that of 1918 erupted today, about 33 million people would die within the first six months. Unlike in past centuries, there is today the non-trivial risk of a deliberate bio-terror attack. One bioterrorist carrying a cocktail of deadly pathogens might cause a pandemic killing many millions. The drastic reduction in funding for the Centers for Disease Control and Prevention in the current budget seems clearly ill-advised.

Major changes in methods of warfare, whose effects we noted in connection with the use of bronze weapons, cavalry, war chariots, and sailing vessels during the Bronze Age, continue today. Key developments include the prospect of weaponized pathogens as noted, whether in the hands of states, terrorist groups, or deranged individuals; electronic warfare including cyber attacks using digital weapons, which pose threats to critical power grids, information and communication networks, medical records

and hospitals, financial systems, all personal records, and electronic voting; delivery of devastating cargoes of various types by drones; each menace compounded by advances in artificial intelligence. The internet provides a new conduit, with the prospect of future enhancement via 3-D printing, for making available deadly instructions, including recipes for biological pathogens. All are clear and present dangers. Finally, the ongoing struggle between human failings including the madness, incompetence, or ignorance of rulers and their supporters versus societal resilience in the face of adversity is clearly evident today, together with the potential major impact of chance events, also present throughout history.

In the words of Churchill: “Study history, study history. In history lies all the secrets of statecraft.” Continuing study of the collapse of past civilizations, as well as instances of survival under stress, aided by the recent dramatic breakthroughs in archaeological science described, will provide insights useful for the future.

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