

Chapter 5: The Impact of archaeodisasters on human evolution and civilization

The study of hazards history has shown that cultural patterns and networks are interdependent. Moreover, the characteristics, distribution, and complexity of Earth's cultural mosaic all involve the parameter of disaster in their functional processes. Apart from influencing totally the course of human history (e.g. acute climatic episodes, epidemics and cosmic impacts), disasters have also influenced the division and control of the Earth's surface. The forces of cooperation and conflict among people, the changes that occur in the use of resources and the migration of human populations have mutually modified the natural and cultural landscapes of the past. Physical systems affect human societies and human actions modify the physical environment.

Severe climatic and environmental changes have triggered human evolution and physical factors seem to have played an important role in the *Neanderthals'* disappearance. The sudden deaths of a wide portion of ancient populations shook demographic stability and severe damages altered social equilibrium within society. The transformation of natural ecosystems (e.g. reduced or increased accessibility to resources) and geographical alterations (e.g. coastal evolution) caused changes in settlement patterns, environmental use and concepts, migrations and wars. Respectively, major environmental events (e.g. cosmic impacts or giant tsunamis) modified the face of whole areas. Other periodically expressed phenomena (e.g. El Niño and Monsoons) had long-term impacts on the socioeconomic structures of local communities worldwide, and crisis cults were always of critical importance within ancient societies.

Beyond any doubt, disaster dynamics have proven to be so powerful that they changed the course of human history. Mighty empires collapsed and vanished or were shocked irreversibly. Wide-ranging case studies have shown that natural factors triggered the fall of well organized social systems, when their normal coping mechanisms failed. Drought or flooding, epidemic diseases, tremendous volcanic eruptions, cosmic phenomena, tsunamis and earthquakes influenced the circum-Mediterranean civilizations (Saharo-Sahel cultures, Iberian, Egyptian, Hittite, Mesopotamian, Minoan & Mycenaean, Etruscan, Roman), the northwestern European, Asian (Harappan, Chinese, Oceanian) and American (Mesoamerican & Andean) civilizations.

On the other hand, the positive response to hazardous phenomena may vary considerably. During the aftermath of catastrophe or environmental changes, technological innovations are coming forth (e.g. agriculture after the Younger Dryas crisis, obsidian trade correlated to volcanic landscapes, metallurgy correlated to impact areas), new lands are discovered (e.g. evolution of the waterways and early human migrations, voyages of the Vikings to northern Seas, European expansion after the Little Ice Age), new subsistence strategies and more efficient techniques are adopted (e.g. the case of the Moche Culture in Peru). In essence, crises tend to stimulate, rather than devastate, the cultural traits of a society, for example, the emplacement of nutrient-rich volcanic tephras and alluvial soils counterbalanced the spread of malaria in marshy areas.

Choosing to provide a broad coverage of the field rather than a detailed study of specific topics, the main target of the author remains the deep understanding of disaster dynamics. By drawing attention to the potential contributions of Disaster Archaeology in the study of human evolution and civilization, additional and unexplored dimensions of past human activities, site developmental history and climatic-morphogenetic environments are disclosed. It is also worth observing that even the detailed multidisciplinary analyses, based on data from the most distant parts of the world, may contribute significantly to the interpretation of the mechanisms of archaeohazards and their relevant socio-cultural patterns.

5.1 Cosmic Impact

“Impact cratering is the most fundamental geologic process in the Solar System” (Melosh, 2011, p. 222). This activity accompanied our planet from its distant past to the recent periods of the Pleistocene and Holocene (Barrientos and Masse, 2014). Various chemical elements (i.e. C, O, N, H, S, Mg, K, Na, Cl, Ni, Ca, Fe, Mn, Sr, Ba, noble gases, trace elements), found in geological formations and sediments either as isotope fractionations, as ratios, or as concentrations of organic compounds, may speak of past bioclimatic oscillations and changes that have been associated with major disruptions in civilizations. The afore-mentioned chemical elements may be studied as proxies for solar variability, cosmic rays activity, variations in the geometry of the Earth’s orbit, seasonal and geographical distribution of incoming radiation, volcanic aerosols and past levels of greenhouse gases, or for mirroring anthropogenic activities, such as the rise of human population, deforestation and the burning of fossil fuels (e.g. Coplen, et al., 1994).

Recent experiments have uncovered evidence that a Supernova exploded near Earth about 2.8 Ma (asteroid Eltanin is the other candidate for that event). Apart from the existence of noble gases, for example Helium-3 (Amari and Ozima, 1988), radioactive iron atoms have been traced in ancient samples of deep-ocean material, being likely debris of that explosion (Ericson, et al., 1963). For the first time, sea sediments are being used in the way of a “telescope” for the detection of a serious past disaster that opened the way to the evolution of the human species, due to the climate changes occurring in Africa after that severe flux of cosmic rays. The serious damage to the ozone layer provoked, or contributed to, the Pliocene-Pleistocene boundary marine extinction. Ellis, Fields, and Schramm (1996; see also Fields and Ellis, 1999; Benitez et al, 2002) detected an unusually high level of radioactive atoms in geological strata representing the ‘gold-plated signature’ of a nearby supernova. ‘Supernova Archaeology’ was born.

Three years later, the pioneering work of Knie et al. (1999), presented the first evidence of just such a signature. The new study by Knie et al. (2004) is a high-precision assay of ancient, deep-sea material, a crust of manganese and iron deposits formed over millions of year on a rock in the deep ocean. The scientists estimated that a supernova exploded at that time, at a distance of about 120 light years from Earth. The basic method was similar to the original 1999 results, but used a different crust from a different location in the Pacific Ocean. The 28 layers containing the iron-60 atoms were isolated in a single layer 2.8-myr old, at a depth of 5.2 km. This particular crust was taken from an area a few hundred kilometres southeast of the Hawaiian Islands in 1980.

In 2002, Benitez *et al* proposed the Scorpius-Centaurus OB association, a group of young bright O and B stars, as possible destructors which could have generated 20 SN explosions during the last 11 Ma. This Plio/Pleistocene event is now considered as the main trigger mechanism for the onset of the last Ice Ages and the acceleration of Hominization.

Genome researchers have just highlighted the gene SRGAP2 duplication (amongst a total of 30 in humans) that led to hominization and to the emergence of more advanced cognitive abilities. This specific gene was apparently duplicated at least twice over the past 4 Ma, once about 3.5 Ma and again about 2.5 Ma. Furthermore, neurodevelopmental disorders, such as autism, epilepsy and schizophrenia may also be related to disruptions of the ancestral SRGAP2 (Charrier, 2012; Dennis et al., 2012; Cross-Disorder Group of the Psychiatric Genomics Consortium, 2013).

A number of radioactive isotopes are also identified as possible diagnostic tools, such as Be-10, Al-26, Cl-36, Mn-53, Fe-60, and Ni-59, as well as the longer-lived I-129, Sm-146, and Pu-244, in the cases of the 35 and 60 kyr-old Be-10 anomalies observed in the Vostok Antarctic ice cores. In fact, present techniques of high precision encourage the search for the very rare and heavy radioactive species hafnium-182 and plutonium-244, produced by the mechanism known as the 'r-process' in SN.

Moreover, the Geminga SN explosion's first event (in the constellation Gemini) took place ca in 340 Ka. Bright as the full moon, it was one of the brightest celestial sources of gamma-ray radiation. At that time, *Homo erectus* prospered in Africa, Europe and Asia. This event triggered another major Ice Age that lasted about 10 Ka. *Neanderthals* appeared and began to 'replace' *Homo erectus*. Around 37 Ka, a second Geminga shock wave reached Earth.

In parallel, R. Firestone (U.S. Department of Energy's Lawrence Berkeley National Laboratory), along with Arizona geologist Allen Vest, conducted a research, attempting to prove the theory of space-induced disasters on Pleistocene mega-fauna, according to which the debris from a supernova explosion coalesced into low-density, comet-like objects that wreaked havoc on the solar system long ago. The researchers found evidence of this impact layer in several archaeological sites throughout North America, where Clovis hunting artefacts and human-butchered mammoths have been unearthed. They also found evidence of the SN explosion's initial shockwave in 34 kyr-old mammoth tusks from Alaska and Siberia, which are peppered with tiny impact craters apparently produced by iron-rich grains. These grains may have been emitted from a supernova that exploded roughly 7 Ka earlier and about 250 light years away from Earth.

Firestone and West found magnetic metal spherules in the sediment of nine Clovis sites in Michigan, Canada, Arizona, New Mexico and the Carolinas. Their composition is very similar to lunar igneous rocks, known as KREEP, which were discovered on the moon by the Apollo astronauts, and have also been found in lunar meteorites that fell to Earth in the Middle East and estimated to be 10 kyr-old. Meanwhile, the potassium-40 detected in the Clovis layer is much more abundant than potassium-40 found in the entire solar system. The physical evidence discovered in various Clovis sites and in the mammoth tusks coincides also with radiocarbon peaks found in Icelandic marine sediment samples that are 41, 34 and 13 kyr-old. These peaks, which represent radiocarbon spikes being highly above modern levels, can only be caused by a cosmic ray-producing event, such as a supernova explosion (Firestone and Topping, 2001; Firestone, et al., 2006; Firestone, et al., 2007a-c; Fiedel, 2009; Firestone, 2009).

Another most recent research speaks of asteroidal debris and bolides, the orbits of which were quite perturbed not only by close encounters with the Earth-Moon system, but also with the orbits of Venus, Mars and Ceres. Such a cluster could be dated between 40 and 20 Ka, and a by-product (a fragment of asteroid 2011 EO40) could be the Chelyabinsk superbolide observed in the skies of the Urals on February 15 2013 (de la Fuente Marcos & de la Fuente Marcos, 2013).

Moreover, a Vela SN explosion (known as the Vela Supernova Remnant or SNR) occurred between 12.3 and 11 Ka, about 800 light years away, in the southern constellation of Vela, which represents the sail of the mythical Argonaut's ship. This event is also considered responsible for the abrupt warming of the Earth's climate, by 20°C or more, that ended the last Ice Age before the Holocene, and for the ASPM mutation (Abnormal spindle-like microcephaly-associated protein or abnormal spindle protein homolog or Asp homolog).

In brief, new studies have shown that: (1) Genotypic changes in ASPM preceded marked phenotypic changes in hominoid brain evolution (Kouprina, et al., 2004). (2) ASPM may be a major genetic component underlying the evolution of the human brain (Zhang, 2003). (3) There is no evidence for positive selection on ASPM in current human populations, although relatively strong purifying selection is detected (Zhang, 2003). (4) The human brain expansion set the stage for the emergence of human language and other high-order cognitive functions. The detected selective sweep in human FOXP2, a gene involved in speech and language development (Enard, et al., 2002; Zhang, et al., 2002), was estimated to have occurred no earlier than 0.2 - 0.1 Ma. So, the adaptive evolution of FOXP2 postdated that of ASPM, consistent with the common belief that a big brain may be a prerequisite for language (Deacon, 1988; Barkow, et al., 1992; Schepartz, 1993; D' Errico, et al., 2003).

Microcephalin mutation had already occurred, as well as advanced cognitive functions in modern *Homo sapiens* ca 40 Ka. According to scientists, the gene *microcephalin* (MCPH1), one of six genes causing primary microcephaly (the others being: MCPH2, CDK5RAP2, MCPH4, ASPM and CENPJ), regulates brain size during development and has gone through positive selection in the lineage leading to *Homo sapiens*. Within modern humans, haplogroup D arose from a single copy ca 37 Ka and swept to exceptionally high frequency (70% worldwide today, except Sub-Saharan Africa) because of positive selection. But it could have originated from a lineage separated from modern humans ca 1.1 Ma, and could have introgressed into humans by 37 Ka (Zhang, 2003; Evans, et al., 2004; Wang and Su, 2004; Mekel-Bobrov, et al., 2005; Evans, et al., 2006; Mekel-Bobrov, et al., 2007). Although *Homo neanderthalensis* has been proposed as the main gene pool for this mutation, the haplotype has so far not been found by the scientists who studied the *Neanderthal* genome (Hawks, et al., 2007; Pennisi, 2009; Green, et al., 2010; Lari, et al., 2010). Extraterrestrial radiation, nevertheless, could be the triggering mechanism of such mutations throughout human history.

A new allele (version) of ASPM appeared sometime between 14.1 and 0.5 Ka with a mean estimate of 5.8 Ka. The new allele has a frequency of about 50% in populations of the Middle East and Europe, it is less frequent in East Asia but highly frequent in Papua New Guinea, and has low frequencies among Sub-Saharan African populations. Currently, two alleles of this gene exist: the older (pre-5.8 Ka) and the newer (post-5.8 kya). About 10% of humans have two copies of the new ASPM allele, while about 50% have two copies of the old allele. The other 40% of humans have one copy of each. The rapid spread of a mutation (such as the new ASPM) through the population indicates that the mutation is somehow advantageous to the individual. Recent statistical analysis has shown that the older forms of the gene are found more heavily in populations that speak tonal languages like Chinese or many Sub-Saharan African languages (Dediu and Ladd, 2007).

Similar cosmic phenomena that caused turbulence on Earth have also been predicted by Paul la Violette, a pioneering American scientist, who proposed a unified Super Wave Theory (1983, 1985 & 2005). Many years of astronomical observations confirmed that the centre of our Galaxy explodes about every 10 Ka, each of these events lasting 100 years or so. Similar events trigger a lethal 'Galactic super wave'. La Violette suggested that a volley of Galactic cosmic rays had bombarded Earth and our solar system toward the end of the last Ice Age (ca. 14 Ka). Later on, he was confirmed by the largest acidity spike in the entire Antarctic ice core record, which was of extraterrestrial origin. With his findings, he suggested that other such super waves had passed over us, too, at earlier times, being responsible for the initiation and termination of the Ice Ages and mass extinctions. So he was the first to suggest recurrent highly-frequent cosmic ray bombardment of the Earth.

Moreover, his hypothesis that large amounts of interstellar dust and frozen cometary debris lie outside the solar system just beyond the heliopause sheath, forming a reservoir of material that would have supplied large amounts of cosmic dust during a prehistoric super wave event, was recently confirmed. In addition, he was the first to measure the extraterrestrial material content of prehistoric polar ice. Using the neutron activation analysis technique, he found high levels of iridium and nickel in 6 out of 8 polar ice dust samples (73 to 35 Ka), an indication that they contain high levels of cosmic dust (see also Frisch, et al., 2013). Finally, satellite observations, together with geoarchaeological evidence (i.e. Usselo Horizon, a black layer found in Allerød sediments in southern England and in the Great Lakes Region) confirmed that a giant solar coronal mass ejection engulfed Earth and Moon near 16 Ka.

One of the pioneering catastrophists and renowned researcher, Hans Kloosterman, in a personal e-communication (January 25, 2014), described the evidence as a horizon/layer which "don't behave like a soil (no B and C layers, an undersurface as well as an upper surface). The granulometry clearly shows that it is a Layer, with 2% extra material in the finest fractions - and that is wherein the North Americans find the "ET proxies" (pointing out that the correct spelling is Usselo and not Ussello, the E being almost mute and the U pronounced as an English Up).

Nevertheless, the Usselo Black Horizon case is still highly debated, since the scenario for the onset of the Younger Dryas (YD) stadial (an extraterrestrial impact over the North American ice sheet caused rapid cooling, but also resulted in worldwide high temperature biomass burning, North

American mega-faunal extinction, and the disappearance of the human Clovis culture), proposed by Firestone et al. (2007), contradicts the geological and geochemical evidence of nanodiamonds and wildfire events in the same horizon (Kloostermann, 1999; Haynes, 2008; Kaiser, et al., 2009; van Hoesel, et al., 2012; Bement, et al., 2013; Mahaney, et al., 2013; Petaev, et al., 2013). But also, apart from Earth's deadly engulfment by Galactic cosmic rays, GCRs could exert significant influence over global temperatures, as the Danish physicist Henrik Svensmark proposed first in 1997 (2007). Cosmic ray flux on Earth has been monitored since the mid-20th century CE. In fact, since the 1990's, the galactic cosmic ray flux on Earth has increased dramatically (Lockwood and Fröhlich, 2007; Erlykin, et al., 2013).

Gradually, famous worldwide myths have been interpreted as symbolic recordings of impact events of many kinds. According to the ancient Greek story of the Tantalides, Pausanias, when describing the catastrophe of the Greek Helike and Boura in 373 BCE (7.24.5 ff.), knew an analogy from his homeland (de Grazia, 2005). It was the mythical city of Tantalos on mount Sipylus (Northwest of Ermos river), 48 km East of Smyrna, which disappeared into a chasm (? the city of Zippasla in the Hittite texts). From the fissure in the mountain, water gushed forth into this chasm, named Lake Saloe. The ruins remained visible in the waters of the lake until the deposits of the local torrent covered them up with mud. Homer (*Iliad*, II.575, VIII.203 & XXIV.614-617) & Diodorus (XIV.80.1) speak of it, too. P. James (1991) located the legendary city in the area of Magnesia, in ancient southwestern Anatolia. The tragic location is also related to the heroine Niobe, daughter of Tantalus and wife of Amphion, king of Thebes-Central Greece (Homer, *Iliad* XXIV.602; Plato *Cratylus*, 395D - E: devastation of Tantalos due to an earthquake and flood; Demokles in Strabo, 1.3.17; Apollodorus, *The Library* 3.46; Antoninus Liberalis *Metamorphoses*, 36; Plinius the Younger, 5.31; Ovid, *Metamorphoses* VI.145-310; Diodorus, IV.74; Quintus Smyrnaeus, *Fall of Troy* 1.390), whose 14 children, after being killed by Apollo (the boys) & Artemis (the girls) respectively, had remained unburied for nine days, because Zeus had turned the local people into stones. Devastated, Niobe fled to Mount Sipylus (Spil Mount) of Lydia in Anatolia, where, later, she turned into a stone waterfall, as she was weeping unceasingly for her lost children.

Artemis, symbolizing the unseen forces of disease and sudden death, was, in addition, connected to other legendary plagues as a result of her wrath against local inhabitants of Bronze Age Greece. She was the goddess who brought sudden death to infants, girls and women, for she was not only the protector of girls, but their destroyer, too. Apollo possessed the complementary role, bringing sudden death, illness and disease to boys and men. Ancient philological evidence is clear about this: "Zeus has made you [Artemis] a lion among women, and given you leave to kill any at your pleasure" (Homer, *Iliad* XXI.470). "[Odysseus to the ghost of his mother Antikleia] "What doom of distressful death subdued you? Was it some long-continued sickness, or did the Artemis Iokheaira (archeress) visit you with her gentle shafts and slay you?" (Homer, *Odyssey* xi.172). "And Artemis has her name from the fact that she makes people 'Artemias' (Safe and Sound)... And both pestilential diseases and sudden deaths are imputed to these gods [Artemis and her brother Apollo]" (Strabo, Geography 14.1.6). "They say [the people of Phokis] that whatever cattle they consecrate to Artemis grow up immune to disease" (Pausanias, *Guide to Greece* X.35.7).

Apart from the afore-said legend of the Niobids, there was other evidence for the existence of plagues during prehistoric and historic times in Greece. Koronis was the daughter of king Phlegyas (Thessaly) and got pregnant by Apollo of Asclepius. "[Artemis] smote her [Koronis] down [with her arrows of plague]: and many a neighbour, too, suffered alike and was destroyed beside her; as when on the mountain from one small spark a raging fire leaps up, and lays in ruin all the widespread forest" (Pindar, *Odes* Pythian 3 str1-ant3). Furthermore, the wrath of Artemis began to destroy the inhabitants [of Patrai in Achaia]; the earth yielded no harvest, and strange diseases occurred of an unusually fatal character. When they appealed to the oracle at Delphi, the Pythian priestess... [ordered] that every year a sacrifice should be made to the goddess of the fairest youth and the fairest maiden" (Pausanias, *Guide to Greece* VII.19.1).

Similarly, "The people of Aigialeia were smitten by a plague. The seers bade them propitiate Apollo and Artemis, they sent seven boys and seven maidens as suppliants to the river Sythas" (Pausanias, *Guide to Greece* 2.7.6). The "[Spartans] Astrabakos and Alopekos... when they found the

image [of Artemis Orthia] straightway became insane. Secondly, the Spartan Limnatiens, the Kynosourians, and the people of Mesoa and Pitane, while sacrificing to Artemis, fell to quarrelling, which led also to bloodshed; many were killed at the altar and the rest died of disease. Whereat an oracle was delivered to them, that they should stain the altar with human blood" (Pausanias, *Guide to Greece* III.16.7). In addition, "after a female bear appeared in it [the shrine of Artemis at Mounykhia in Attika] and was done away with by the Athenians, a famine ensued, and the god prophesied the means of relieving the famine: someone had to sacrifice his daughter to the goddess [to compensate her for the death of her sacred bear]" (Suidas s.v. *Embaros eimi*). "A wild she-bear [sacred to Artemis] used to come to the deme of Phlaidoi [Brauron] and spend time there ... [until some men] speared the she-bear, and because of this a pestilential sickness fell upon the Athenians. When the Athenians consulted the oracle [the god] said that there would be a release from the evils if, as blood price for the she-bear that died, they compelled their virgins to play the bear" (Suidas s.v. *Arktos e Brauronioi*).

The Goddess Hera was also involved in a case of plague (similar to the myth of Keos with the Lion and the Nymphs). This parallel myth which described severe hydroclimatic changes in Bronze Age Greece was the one referring to the island of Aigina in the Saronic Gulf, initially colonized by the Pelasgians. According to this version, the jealous goddess Hera wanted to punish the inhabitants of the islands by sending a dragon (instead of a lion), in the form of drought and plague, which devastated the majority of the living population. Then Zeus transformed the ants of the islands into people and called them Myrmidons, the ancestral tribe of the Homeric hero Achilles (Ovid, *Metamorphoses* VII. 520 ff; Strabo, *Geography* VIII.6.16)

Respectively, the famous opening of the Homeric *Iliad* (I, 9-11) tells us that "Zeus' son and Leto's, Apollo, who in anger at the king drove the foul pestilence along the host, and the people perished, since Atreus' son had dishonoured Chryses, priest of Apollo....". Perhaps, the information derived from the very first verses of Homer's *Iliad* about the plague which hit the Achaeans as a mark of divine presence, could be used as a chronological tool of the events during the period of the last one of the three cities of Troy described in the Epics (Laoupi, 2006a).

Another Bronze Age plague probably occurred in mainland Greece, during the reign of Oedipus at Thebes. Oedipus, after killing his father Laius without knowing his crime, married his mother Jocasta. They were happily married and over the years Thebes prospered under Oedipus' reign. Oedipus was known as a wise and just king. After two decades, the land started to suffer from drought and famine or a plague (Sophocles, *Oedipus the King* 1316). Oedipus was determined to learn the truth of what was causing the woes to his kingdom. He learned that the plague was caused by the murder of Laius, and that his killer went unpunished.

The symbolic language of ancient myths correlates the heavenly bodies/phenomena (gods and goddesses) to the leitmotif of deadly arrows that bring havoc and plagues among people. Those arrows are also correlated with falling 'stones', 'fires', and other objects from the sky. In many races (de Grazia, 1983c), people believed that stone axes fell from the heavens. In Japan, stone arrow-heads rain from heaven, sent by the flying spirits, who shoot them. Similar beliefs are found in Brittany, in Brazil, Madagascar, Ireland, China, the Shetlands, Scotland, Portugal etc., as well as from the Aztec prayer to Tezcatlipoca, and from the Bible (*Deuteronomy* xxviii).

Throughout history, humans have been faced with disastrous catastrophes which needed to be endured in order to survive. One of the most deadly disasters for humanity has been the plague. This term in Greek can refer to any kind of sickness; in Latin, the terms are *plaga* and *pestis*. In antiquity, two of the most devastating plagues were the Athenian plague of 430 BCE and the Justinian plague of AD 542. Although many disastrous epidemics probably occurred between the Athenian and Justinian plagues, few sources detailing these plagues have survived. One such disease, known as the Antonine plague, occurred during the reign of Marcus Aurelius (AD 161-180). It was brought back by soldiers returning from Seleucia, and before it abated, it had affected Asia Minor, Egypt, Greece, and Italy. The plague destroyed as much as one-third of the population in some areas, and decimated the Roman army. Another plague occurred during the reigns of Decius (AD 249-251) & Gallus (AD 251-253). This pestilence broke out in Egypt in 251, and from there infected the entire empire. Its mortality rate

severely depleted the ranks of the army, and caused massive labour shortages. The plague was still raging in 270, when it caused the death of the emperor Claudius Gothicus (AD 268-270).

The dendrochronologist Mike Baillie of Queen's University, (Belfast, Ireland) has just noticed some strange tree ring patterns that happened to coincide with the historical catastrophe during the Justinian Plague (2007). In addition, there was some sort of environmental downturn that weakened the human population, making humanity susceptible to bacterial or viral death on a large scale. More specifically, he compared these tree rings to dated ice-core samples that had been analyzed, and he discovered a very strange coincidence, ammonium. There are, as it happens, at least four occasions in the last 1500 years during which scientists can confidently link dated layers of ammonium in Greenland ice to high-energy atmospheric interactions with objects coming from space: AD 539, 626, 1014, and 1908 (the Tunguska event). In short, there is a connection between ammonium in the ice cores and extra-terrestrial bombardment of the surface of the Earth, forming high-energy interactions.

All these environmental coincidences have also been related to the frequency of fireball activity in the Taurid meteor streams recorded in Chinese archives, in the AD 400-600 time frame, and supported in works by British cometary astrophysicists. Baillie also points out that a series of such impacts/overhead explosions would more adequately explain the longstanding problem of the end of the Bronze Age in the eastern Mediterranean during the 12th century BCE. During that malefic period of time, many major sites were destroyed and totally burned by the notorious 'Sea People'. But, if that was the case, there ought to at least be some evidence for that, like dead warriors or signs of warfare... There were almost no bodies found, and no precious objects except those that were hidden away as though someone expected to return for them, or didn't have time to retrieve them. The people who fled were probably killed, too, in the act of fleeing and the result was total abandonment and total destruction of the cities in question.

So, in his book, *Exodus to Arthur: Catastrophic Encounters with Comets* (1999), he correlates the findings of his tree-ring studies with a series of global environmental traumas over the past 4,400 years that may mark events such as the biblical Exodus, the disasters which befell Egypt, the collapse of Chinese dynasties and the onset of the European Dark Ages.

In another work by him, co-authored with Patrick McCafferty (2005), he focuses on the AD 540 event, as recorded in the historical records and myths of Ireland, showing that the imagery in the myths and the times between events are consistent with a comet with an earth-crossing orbit similar to P/Encke, as described by the British astronomers Victor Clube and Bill Napier (1990). His latest book (2006) shows how the case of tree-ring and Greenland ice core evidence, along with descriptions in annals, myths and metaphors adduced in support of the global environmental downturn at AD 540 (including the Justinian plague), also applies to conditions obtaining at the time of the appearance of the Black Death in AD 1348.

But let us return to the case of the Justinian Plague, known also as the Pelusium Plague, because it was first recorded there, via the maritime 'silk road' (Gregory of Tours, 1974; Stathakopoulos, 2004; Tsiamis, Poulakou-Rebelakou and Petridou, 2009). Even if many writers documented the Justinianic period, there are three main sources for that plague: John of Ephesus (*Historia Ecclesiastica*), Evagrius Scholasticus (*Historia Ecclesiastica*), and especially Procopius. Another source for the Justinianic plague is the *Historia* of Agathias. A lawyer and poet, he continued the history of Procopius. A further account is the *Chronicle* of John Malalas; however, this work may have copied Procopius (Mc Neil, 1976; Cartwright and Biddiss, 1991; Rosen, 2007; Little, 2006; Orent, 2004).

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