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# ANTHROPOCENE: THE RECENT AGE OF MAN

**Arun Kumar**

***The word Anthropocene has been used to highlight the concept that we are now living in a time when the global environment, at some level, is shaped by humankind rather than vice versa..... The word 'Anthropocene' was coined in 1980s by ecologist Eugene F. Stormer from the Greek words* anthropo, *meaning "man" and* cene *meaning "new".....At present the Anthropocene Epoch is an unofficial unit of geologic time used to describe a span of time when anthropogenic activities began to have a significant negative impact on the Earth's climate and ecosystems.***

Scientists estimate our home planet Earth to be 4.6 billion years old. Interpreting Earth's history and its geological events are the primary objective of geological investigation. A geological time scale was developed in due course of time to show sequence of events on the Earth based on relative dating principles using radiometric techniques, fossils, and various other geological criteria. The present geological time scale subdivides the 4.6-billion-year long history into Eons, Eras, Periods and Epochs. Eons represent the greatest expanses of time. The International Chronostratigraphic Chart published by the International Commission on Stratigraphy is the most up to date version of the Geological Time Scale. The Precambrian time spans over four billion years; it is divided into three eons, the Hadean, the Archaen, and the Proterozoic. The Phanerozoic Eon began about 541.0±1.0 million years ago, and rocks deposited during this span of time contain abundant and varied forms of fossils. This eon is divided into three eras, the Paleozoic (ancient life), the Mesozoic (middle life), and the Cenozoic (recent life). Each era is further divided into Periods, and finally each Period is further subdivided into Epochs.

The Cenozoic Era is divided from older to younger into Paleogene, Neogene, and Quaternary Periods. Quaternary Period is subdivided into Pleistocene and Holocene Epochs. The base of the Holocene is dated to be 11,700 years and this span of time is further divided from older to younger as the Greenlandian, Northgrippian and Meghalayan Ages. This formal subdivision of the Holocene Epoch was proposed by the International Subcommission on Quaternary Stratigraphy (ISQS) (a subcommission of the International Commission on Stratigraphy - ICS), and was ratified unanimously by the International Union of Geological Sciences (IUGS). The subdivisions are now formally defined as follows:

**1. Greenlandian Stage/Age** = Lower/Early Holocene Subseries/Subepoch

Boundary Stratotype (GSSP): NorthGRIP2 ice core, Greenland (coincident with the Holocene Series/Epoch GSSP, ratified 2008). Age: 11,700 yr b2k (before AD 2000).

**2. Northgrippian Stage/Age** = Middle/Mid-Holocene Subseries/Subepoch

Boundary Stratotype (GSSP): NorthGRIP1 ice core, Greenland. Global Auxiliary Stratotype: Gruta do Padre Cave speleothem, Brazil. Age: 8,326 yr b2k.

**3. Meghalayan Stage/Age** = Upper/Late Holocene Subseries/Subepoch

Boundary stratotype (GSSP): Mawmluh Cave speleothem, Meghalaya, India. Global Auxiliary Stratotype, Mount Logan ice core, Canada. Age: 4,250 yr b2k.

Anthropocene is officially not yet recognized as an 'Epoch' or 'Stage/Age' as defined in the Holocene subdivision of the Holocene Epoch ISQS.

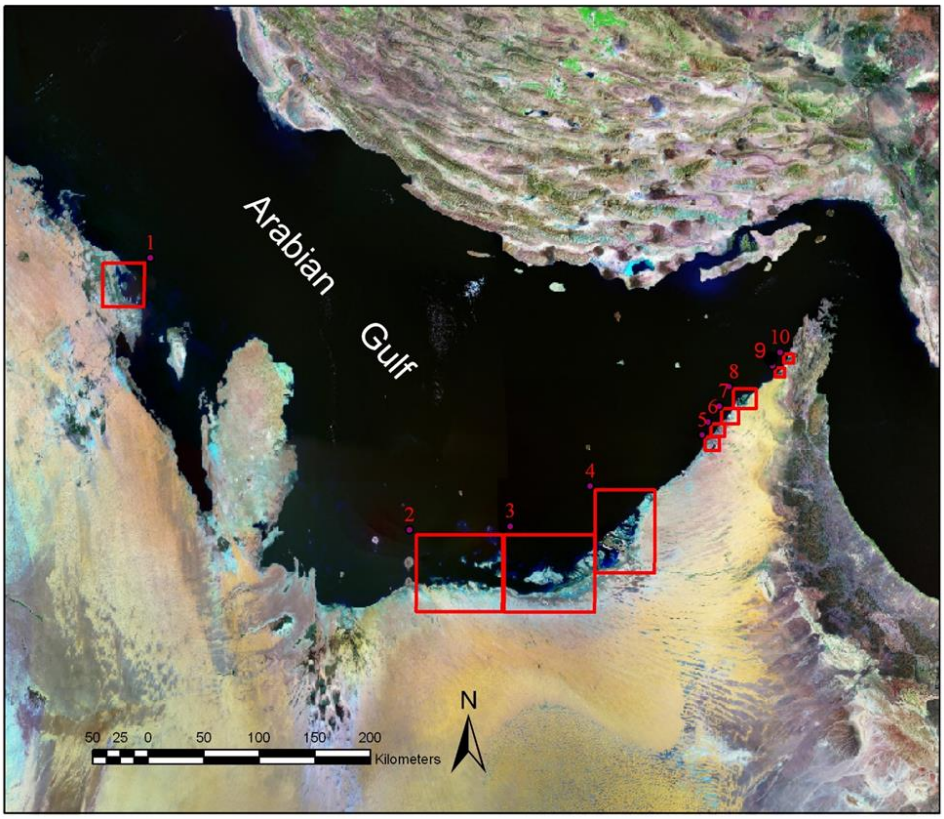


**Figure. 1.** Southern and western coast of the Arabian Gulf showing ten localities where temporal changes in distribution of mangroves was studied. Locality 1 is Tarut Island, Saudi Arabia (after Khan and Kumar, 2009).

## Idea of Anthropocene

The word Anthropocene has been used to highlight the concept that we are now living in a time when the global environment, at some level, is shaped by humankind rather than vice versa. Humans have significantly altered Earth's land surface, oceans, rivers, atmosphere, flora, and fauna (Edwards, 2015).

**Table 1.** Past 25-30 years' temporal changes in the geographical area of mangroves for sites 1 through 10 in both numerical values in hectares and percentages (after Khan and Kumar, 2009).

| Location | Image Acquisition Date | Mangrove area (hectares) | Image Acquisition Date | Mangrove area (hectares) | Temporal change in mangrove area (hectares) | Percentage temporal change in mangrove area |
|---|---|---|---|---|---|---|
| site-1 | 08-01-1973 | 622 | 05-11-1999 | 390 | -232 | -37 |
| site-2 | 30-11-1972 | 2639 | 30-06-2001 | 2590 | -49 | -2 |
| site-3 | 30-11-1972 | 4028 | 30-06-2001 | 3488 | -540 | -13 |
| site-4 | 22-01-1973 | 4066 | 23-08-2000 | 4822 | 756 | 19 |
| site-5 | 22-01-1973 | 648 | 23-08-2000 | 30 | -618 | -95 |
| site-6 | 22-01-1973 | 84 | 23-08-2000 | 0 | -84 | -100 |
| site-7 | 22-01-1973 | 212 | 23-08-2000 | 115 | -97 | -46 |
| site8 | 22-01-1973 | 1063 | 23-08-2000 | 1131 | 68 | 6 |
| sit-9 | 22-01-1973 | 100 | 23-08-2000 | 317 | 217 | 217 |
| site-10 | 22-01-1973 | 182 | 23-08-2000 | 294 | 112 | 62 |

The impact of human activities on the environment includes changes to biophysical environments and ecosystems, biodiversity, and natural resources caused directly or indirectly by humans, including global warming, environmental degradation such as ocean acidification, mass extinction and biodiversity loss, ecological crises, etc. A good example of such a blatant destruction of the coastal environments, both nearshore and shallow marine is in the Arabian Gulf showing the loss of mangroves during a span of 25 to 30 years (Figure 1, Table 1). In a desert region such as the Arabian Peninsula coastal mangrove swamps are a valuable natural asset for the region, but reckless industrial and infrastructure development in the region has destroyed a lot of mangrove stands (Khan and Kumar, 2009, Kumar 2011a and b). An example of mangrove destruction due to infrastructure development in the Tarut Island, Arabian Peninsula, is shown in Figures 2 and 5. Human activities that cause damage to the environment on a global scale include population growth, overconsumption, overexploitation, pollution, and deforestation (website a). Humans have not just spread all over the planet, but they are changing the way it works as well.


**Figure 2.** Destruction of mangroves along the Arabian Gulf coast resulting from urban development near Tarut Island, Saudi Arabia. A, C. Urban development encroaching the mangroves, B. Death of mangroves resulting from pollution of coastal waters, B, D. Town garbage being dumped on the mangroves (Location 1, Figure 1) (Photographs were taken by the author in 2009).

Following changes on the Earth due to human activities are briefly described (website b).

**Holocene extinction and Biodiversity loss:** The Holocene extinction of numerous species of plants and animals is an ongoing extinction event during the recent times because of human activities. Widespread degradation of highly biodiverse habitats such as coral reefs and rainforests is common (Figures 3, 4, and 5). The current rate of extinction of species is estimated at 100 to 1,000 times higher than natural background rates (website c). The state of environmental degradation in the Arabian Gulf region is quite serious (Kumar, 2017). The human impact on biodiversity is one of the primary characteristics of the Anthropocene. Biodiversity loss is the extinction of plant or animal species including the local loss of species in a certain habitat. Global extinction has so far been proven to be irreversible (website d).

**Biogeography:** Biogeography is the study of the distribution of species and ecosystems in space and through geological time. Human influence on permanent changes in the distribution of organisms will eventually become identifiable in the geologic record. Documented movement of many species into regions formerly too cold for them have been recorded. This is due to changing climate, and in response to farming and fishing (website b).

**Climate:** Global warming is the rise in average temperature of Earth's climate system, causing changes in patterns of rainfall, extreme weather, and arrival of seasons. Its effects are known as climate change. Several times in the geological past Earth has witnessed global warming, however, observed changes since the mid-20th century have been unprecedented in rate and scale (website e). The Intergovernmental Panel on Climate Change (IPCC) concluded that "human influence on climate has been the dominant cause of observed warming since the mid-20th century". This is primarily due to the emission of greenhouse gases (carbon dioxide and methane) from fossil fuel burning, agricultural emissions and deforestation. Temperature rise is enhanced by self-reinforcing climate feedbacks, such as loss of snow cover, increased water vapour, and melting permafrost (website e). The negative impact of global warming in the Arabian Gulf region has been discussed (Kumar, 2016).

**Figure 3.** Man-made islands offshore Dubai, UAE. Some of them are already completed and others are under construction. Such offshore urban and infrastructure developments cause massive geomorphological changes and result in serious damage to onshore and offshore coastal ecosystems. (image: https://www.bing.com/images/search?q=palm+islands+dubai&qpvt=Palm+Islands+Dubai&form=IGRE&first=1&scenario=ImageBasicHover)

**Geomorphology:** Changes in drainage patterns due to human activity will persist over geologic time in large parts of the continents. This includes roads and highways defined by their grading and drainage control. Other changes to the Earth's surface due to quarrying and landscaping adversely impacts geomorphology of a region (website b). An excellent example of such a change is the alteration of the shallow coastal regions of many countries in the Arabian Gulf which has destroyed coastal ecosystems and shallow marine benthic communities by dredging the shallow environments and reclaiming the area for the purpose of urban development (Figures 3 and 4; Kumar, 2009, 2010).

**Figure 4.** Homes built on the offshore Palm Islands offshore Dubai causing damage to shallow marine ecosystem and loss of benthic flora and fauna. (image: https://www.bing.com/images/search?q=palm+islands+dubai&qpvt=Palm+Islands+Dubai&form=IGRE&first=1&scenario=ImageBasicHover)

**Sedimentological record:** Massive deforestation and extensive road construction all over the world have contributed to elevated levels of sediment fluxes across the Earth's surface. However, construction of dams on rivers around the world reduces the rates of sediment deposition. River deltas are currently starved of sediment by such dams and are subsiding instead of growing, they are failing to keep up with the rise in sea levels (website 2). The change in chemistry due to fossil-fuel carbon accumulating in the oceans will raise the carbon compensation depth preventing the deposition of carbonate sediments in the shallow seas. Thus, new carbonates will not be laid down and old ones will be dissolved (see The Economist).


**Figure 5.** Degradation and pollution of the Arabian Gulf coastal environment resulting from infrastructure and urban development near Tarut Island, Saudi Arabia (Location 1, Figure 1) (Photographs were taken by the author in 2009).

**Fossil record:** Commonly various periods of the geological time scale are distinguished by their fossil contents. Fossils characterizing Anthropocene will be easily identifiable because that will contain crushed structures and bizarre mixtures of mostly inorganic materials that have never been recorded in the geological history (Figures 2 and 5). Erosion increases due to farming and infrastructure and industrial developmental activities will be reflected by changes in sediment composition and increases in the rates of deposition elsewhere. In many terrestrial environments, engineered structures will be buried and preserved, along with litter and debris. Litter and debris dumped in rivers will be carried and will ultimately accumulate in the marine environments, mainly in coastal areas. Such man-made artifacts preserved in stratigraphy are known as "technofossils" (website b)

**Trace elements**: In terms of trace elements, distinct signatures have been left by human beings in the sedimentary records and ice cores. Chlorine, mercury, and a high concentration of radionuclides are some of these examples. Fossil fuel burning has left

elevated concentrations of black carbon, inorganic ash, and spherical carbonaceous particles in recent sediments across the world (website b).

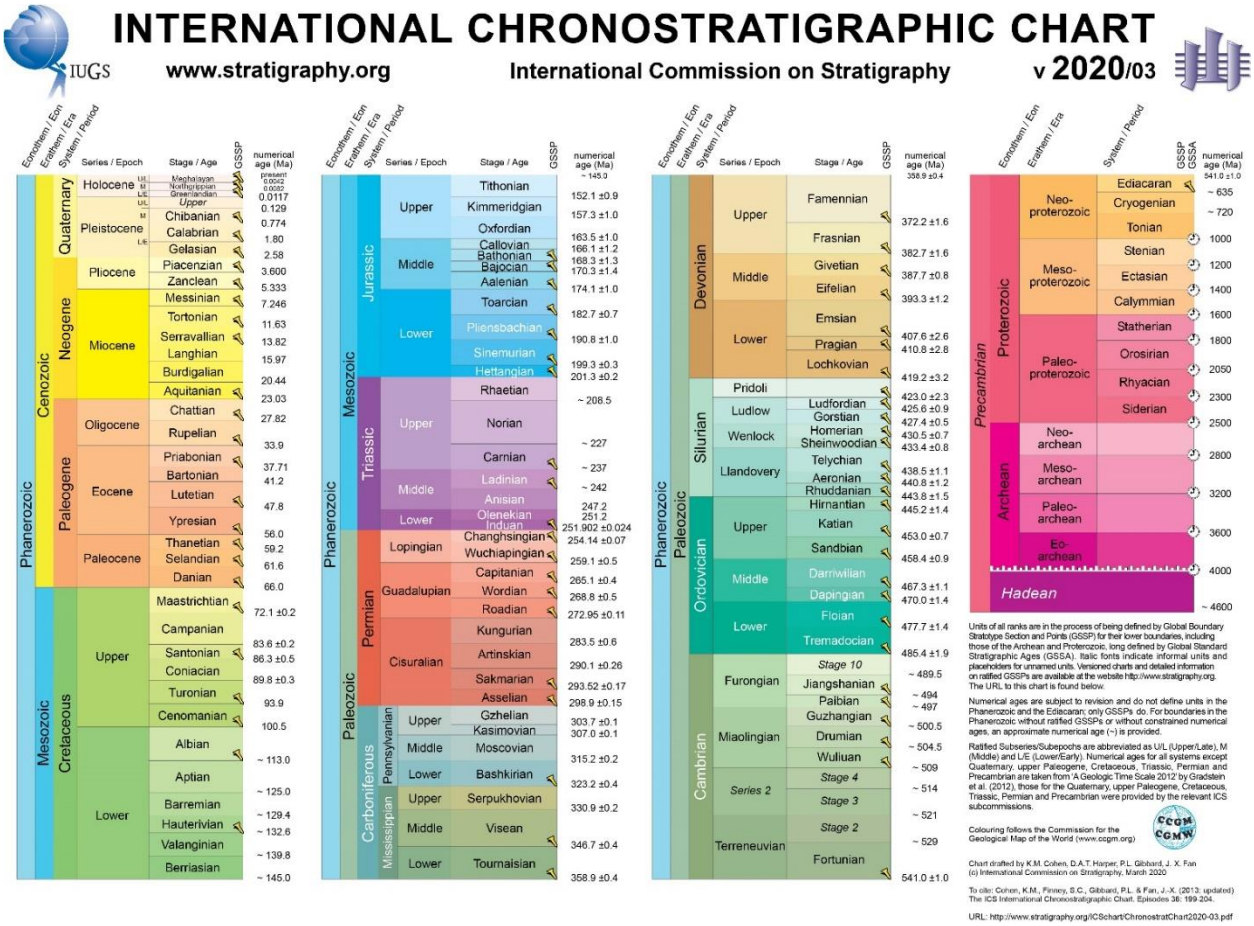


**Figure 6.** Geological Time Scale showing various divisions and subdivisions along with absolute time of their boundaries in million years showing Holocene Epoch as the youngest part of the scale. (source: International Commission on Stratigraphy - ICS).

## Anthropocene: a potential new epoch of the geological time scale

At present, we are living in the Holocene Epoch, which began 11,700 years ago after the last major ice age (Figure 6). During the past two hundred years human beings have left immense negative footprints on the Earth's environment. Scientists consider this span of time as a new geological age because human population has become a powerful force of nature fast reshaping the Earth on a geological scale; thus it is named as the age of human impact on Earth or the Anthropocene (Figure 7). Worldwide industrial and infrastructure developmental activities have caused degradation of the environment (Figures 3, 4 and 5) and the climate change at an unprecedented rate never witnessed in any other time in history of the Earth.

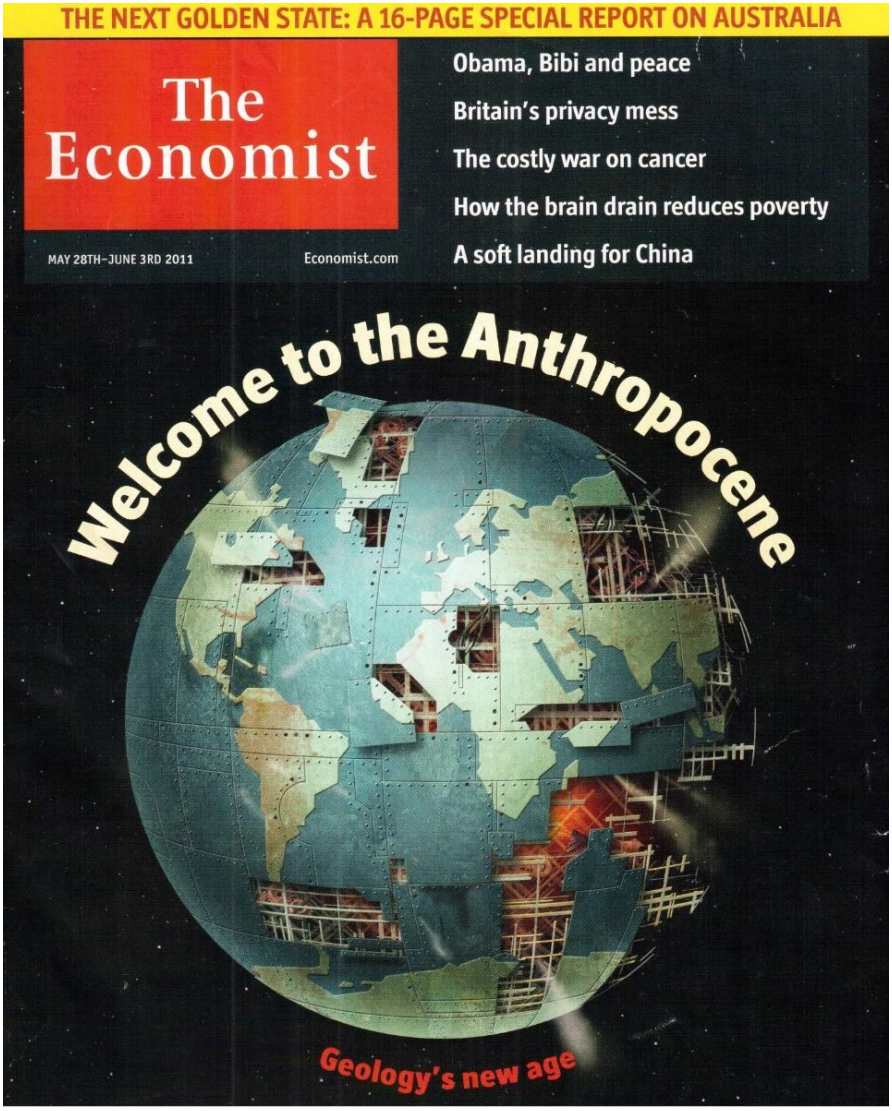


**Figure 7.** The cover page of the magazine 'The Economist' dated May 28-June 3, 2011 highlighting The Anthropocene.

The Anthropocene Epoch is yet to be officially part of geologic time because it has not been formally adopted by the International Union of Geological Sciences (IUGS); the IUGS is the international organization that names and defines epochs (Figure 8). The primary question that the IUGS needs to answer before declaring the Anthropocene an epoch is that have humans changed the Earth's system to the point that it is reflected in the rock strata. At present the Anthropocene Epoch is an unofficial unit of geologic time used to describe a span of time when anthropogenic activities began to have a significant negative impact on the Earth's climate and ecosystems (websites b and f).

The word 'Anthropocene' was coined in 1980s by ecologist Eugene F. Stormer from the Greek words *anthropo,* meaning "man" and *cene* meaning "new". However, atmospheric chemist Paul J. Crutzen popularized this word in 2000 by concluding that the influence of human behavior on Earth's atmosphere in recent centuries is so significant, as to constitute a new geological epoch (websites b and f). Several natural processes are part of this change; for example, the carbon and the nitrogen cycles, and extinction rates are far higher than during normal geological periods.

Rafferty (2016) described the Anthropocene Epoch, as "unofficial interval of geologic time, making up the third worldwide division of the Quaternary Period (2.6 million years ago to the present), characterized as the time in which the collective activities of human beings (*Homo sapiens*) began to substantially alter Earth's surface, atmosphere, oceans, and systems of nutrient cycling." He further added that, a group of scientists argue that the Anthropocene Epoch should follow the Holocene Epoch (11,700 years ago to the present) and begin in the year 1950.

## History

The Stratigraphy Commission of the Geological Society of London considered a proposal to make the 'Anthropocene' a formal unit of the Geological Time Scale. However, the question about its beginning has been widely debated among scientists. The range of ideas include, beginning of the Industrial Revolution (1780) with the invention of steam engine; and rise of agriculture and the Neolithic Revolution (~12000 yr BP). Select members of the International Anthropocene Working Group (AWG) suggested July 16, 1945 the day of the Trinity Test (first atomic bomb test), as the beginning of 'Anthropcene'. Climatic, biological, and geochemical signatures of human activities identified in the sediments and ice cores suggested the mid-20$^{th}$ century to be the beginning of this epoch. Edwards (2015) discussed various conflicting ideas on the concept of formally integrating Anthropocene Epoch in the Geological Time Scale.

Generally, publications on the Anthropocene distort the nature of the units of the International Chronostratigraphic Chart, produced by the International Commission on Stratigraphy (ICS). The stratigraphic record of the Anthropocene is minimal, especially with its recently proposed beginning in 1945; it is that of a human lifespan, and that definition relegates considerable anthropogenic change to a "pre-Anthropocene" (Figure 9). The drive to officially recognize the Anthropocene may, in fact, be political rather than scientific (Finney and Edwards, 2016). Ruddiman (2018) objected to the proposal to start of a formally designated 'Anthropocene' epoch be placed in the middle-to-late 1900s because major human alterations of Earth's environment long preceded the 1900s. In March 2019, the International Anthropocene Working Group (AWG), published a comprehensive document "The Anthropocene as a Geological Time Unit: A Guide to the Scientific Evidence and Current Debate" that presents all the information and discussions on the topic of "Anthropocene" (Figure 10).

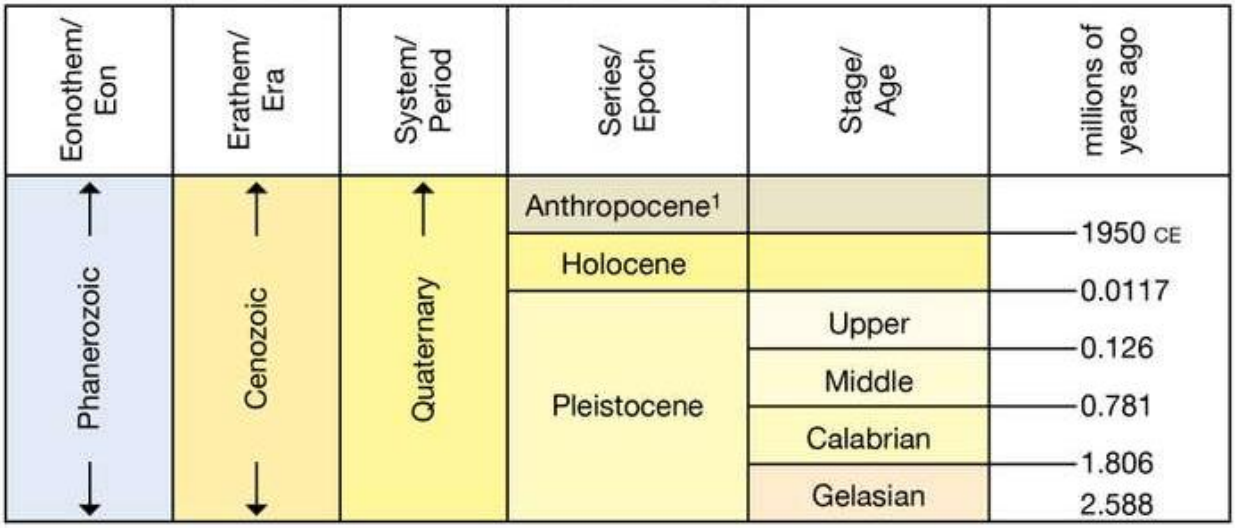


**Figure 8.** Recommendation by the Anthropocene Working Group (AWG) to make Anthropocene Epoch a formal time interval in the Geological Time Scale. (https://www.britannica.com/science/Anthropocene-Epoch)

Waters et al. (2018) reviewed published examples for their suitability of different stratified palaeoenvironmental settings and facies as potential hosts for a candidate in the Global Boundary Stratotype Section and Point (GSSP), and the relevant stratigraphical markers for correlation. They considered that a marked upturn in abundance of radioisotopes of 239Pu or 14C, approximately in 1952 and 1954 CE respectively, broadly coincident with a downturn in δ13C values, is applicable across most environments. This conclusion was arrived after examining environmental settings associated with accumulations of anthropogenic material, such as marine anoxic basins, coral reefs, estuaries and deltas, lakes at various latitudes, peat bogs, snow/ice layers, speleothems, and trees. On May 21, 2019 the majority of members of the AWG voted in favor of making the mid-20$^{th}$ century as the beginning of this epoch. Ten candidate sites for a GSSP were identified; one of which will be chosen to be included in the final proposal. Possible markers include microplastics, heavy metals, or the radioactive nuclei left by tests from thermonuclear weapons (websites b and f).

Subramanian (2019) reviewed various aspects of the Anthropocene debate. The AWG put forward a proposal to identify a GSSP, or 'golden spike' (Waters et al. 2018). This section will primarily be a geological marker at a location that could be correlated with sites around the globe in varied environments. The GSSP needs to demonstrate that there was a globally synchronous moment when physical, chemical, and biological processes amounted to the irreversible crossing of a geological threshold from the Holocene to something altogether different (Subramanian, 2019). AWG members supported a GSSP in the mid-twentieth century that was the beginning of the 'Great Acceleration' after the Second World War when the growing population began consuming resources and creating completely new materials at an exponential rate, eclipsing even the Industrial Revolution. All that activity releases extraordinary amounts of organic

pollutants into the environment, accelerating the rate of animal extinctions and creating geological features that had never existed (Subramanian, 2019).

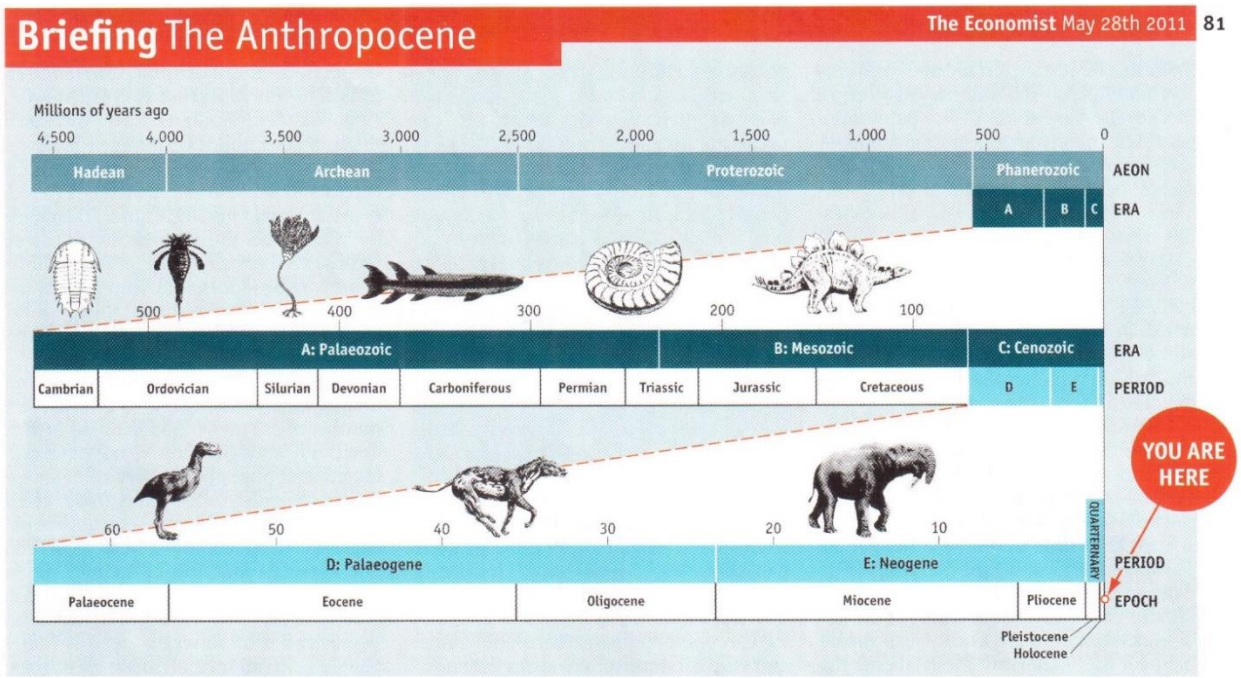


**Figure 9.** Evolution of various forms of life on Earth through its geological history (over 4,500 Million years) showing how recent is the Holocene Epoch. 'Anthropocene' is yet to be included in the Geological Time Scale. (source: The Economist, May 28-June 3, 2011, page 81)

There are ten sites being studied as potential markers for the start of the Anthropocene. They are Crawford Lake, near Toronto, Canada; a reservoir in California; an ice core from Antarctica; cave deposits in northern Italy; coral reefs in the Caribbean and Australia; a peat bog in Switzerland; Searsville Lake in California's San Francisco Bay area; and an ice core from the Antarctic Peninsula. Every site will be tested for the radionuclide signal, carbon14 and the long-lived isotope plutonium 239, and secondary markers such as persistent organic pollutants and microplastics to fly ash from coal burning (Subramanian, 2019).

Crawford Lake near Toronto in southern Ontario is one of the candidates for the GSSP. The cored mud layers in this lake could be ground zero for the Anthropocene, a potential new epoch of the Geological Time Scale. The sediment cores from this lake archive environmental history of the region reaching back nearly 1,000 years. The sediments record evidence of the Iroquois people, who cultivated maize (corn) along the lake's banks at least 750 years ago, and the European settlers, who began farming by clearing forested lands more than five centuries later. Now, scientists are looking for more recent, and significant, signs of upheaval tied to humans. The research team on the Crawford Lake study is led by Prof. Francine McCarthy of Brock University, St. Catharine's, Canada, who is collaborating with researchers in Canada and around the

world to analyze core samples from 1940 to 1965, the years bordering peak nuclear fallout along with the onset of the Great Acceleration. The core samples are being tested for the primary marker of radionuclides, surging concentrations of fly ash, to see if they are all synchronous. Prof. Timothy Patterson and his colleagues at Carleton University, Ottawa, Canada, will be measuring the abundance of testate amoebae; the single-celled microorganisms surrounded by a shell that persists for thousands of years primarily in lacustrine environments. Researchers at Brock University will search for microplastics that could have arrived by water, by wind on airborne fibers, or even with insects that had ingested them (Subramanian, 2019).

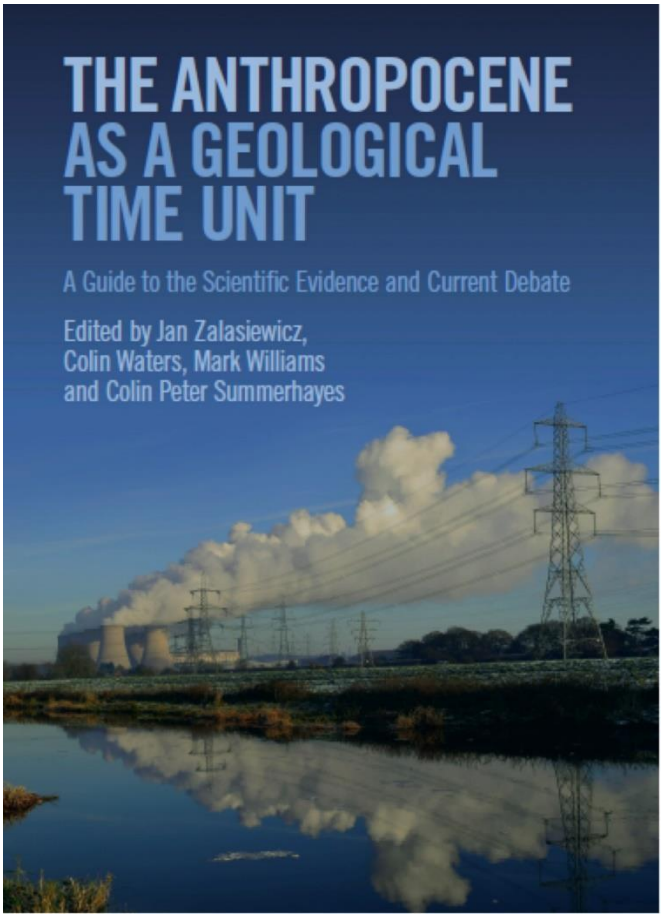


**Figure 10.** The Anthropocene Working Group (AWG) published "The Anthropocene as a Geological Time Unit: A Guide to the Scientific Evidence and Current Debate" Cambridge University Press, March 2019.

Davison (2019) published an article in The Guardian titled, "The Anthropocene epoch: have we entered a new phase of planetary history?" in which she presented a short history of this topic and the controversies around it. The idea of "Anthropocene" put forward by Crutzen and Stoermer was explained as, "We were entering an entirely new phase of planetary history, in which human beings had become the driving force. And without a major catastrophe, such as an asteroid impact or nuclear war, humankind would

remain a major geological force for many millennia." However, "the Anthropocene seemed not to be catching on: among the geologists who actually define these terms." That geological timescale is the backbone of geology, and modifying it is a slow and tortuous process, overseen by the ICS. One cannot just make up a new epoch and give it a convincing name; the care taken over the timescale's construction is precisely what gives it authority.

## Consequences of the Anthropocene

The severe environmental changes occurring to the Earth will alter the way the Earth's natural systems work. Some of the serious consequences will be changes in the water cycle, imbalances and destructions in the marine and terrestrial ecosystems, the increase of extreme meteorological phenomena, the acidification of the oceans, and the disappearance of forests.

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**Youtube videos**

https://www.youtube.com/watch?v=84QRAmyJ7FQ&feature=emb_rel_end
https://www.youtube.com/watch?v=yS5v1whmt90
https://www.youtube.com/watch?v=3WpaLt_Blr4
https://www.youtube.com/watch?v=LvWPO_ZfIMM
https://www.youtube.com/watch?v=PGtCkv7_nIs

**Films**

Understanding Problems at the Age of Humans
https://www.youtube.com/watch?v=0V7OeLyURuc&list=PLlUOqrHReOCcjEMqSGDLAu5Wi-4RnCuGL&index=3
Anthropocene: The Human Epoch. A Canadian documentary film (poster below).


## About the Author

**Dr. Arun Kumar** is Research Associate, Carleton Climate and Environment Research Group (CCERG), Department of Earth Sciences, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1S 5B6, CANADA
Email: arun.kumar@alumni.carleton.ca; arunkumarlko@hotmail.com