# EARTH SCIENCE WEEK SCHOOLS EVENT

# THE ANTHROPOCENE

## GROUP OR INDIVIDUAL TASK

You are part of the 'Anthropocene working group' at the Geological Society of London. This is a real scientific research group. Your task is as follows:

**BASED ON THE INFORMATION PACK PROVIDED AND YOUR OWN KNOWLEDGE AND IDEAS, DETERMINE WHETHER THE EARTH HAS ENTERED A NEW GEOLOGICAL EPOCH, THE 'ANTHROPOCENE'.**

The information pack contains the following documents:

1. **GEOLOGICAL TIME SCALE**
2. **SUBDIVIDING THE QUATERNARY**
3. **WHAT COULD MARK THE HOLOCENE – ANTHROPOCENE BOUNDARY?**
4. **WHEN COULD THE HOLOCENE – ANTHROPOCENE BOUNDARY HAVE OCCURRED?**
5. **ANTHROPOCENE BOUNDARY IN 1610 OR 1964 – Lewis, L.L. & Maslin, M. A.**
6. **AGAINST THE ANTHROPOCENE – Gibbard, P.L. & Walker, M.J.C., 2014**

**If you think the Earth IS in the Anthropocene (FOR SIDE):**

1. What year or decade did this occur?
2. What is your supporting evidence?
3. How powerful are humans? Are we responsible for large-scale events like hurricanes, floods and earthquakes? Should we try to influence them if we can?

**If you think the Earth IS NOT in the Anthropocene (AGAINST SIDE):**

1. Why do you think the Earth is still in the Holocene?
2. What is your supporting evidence?
3. How should we live with Nature? Should we be ruled by natural forces (like river flooding or desertification) or should we try to tame them? (E.g. are we right to build houses on floodplains?)

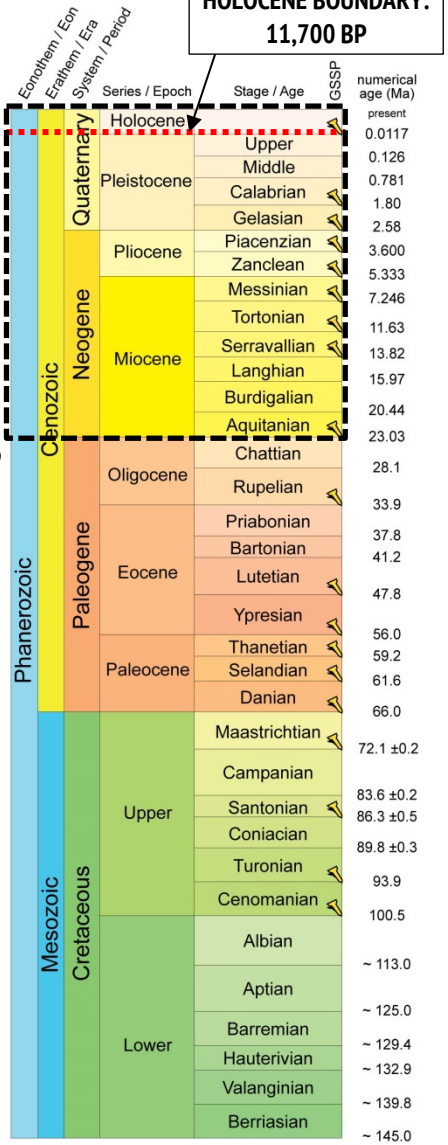
The Geological Society

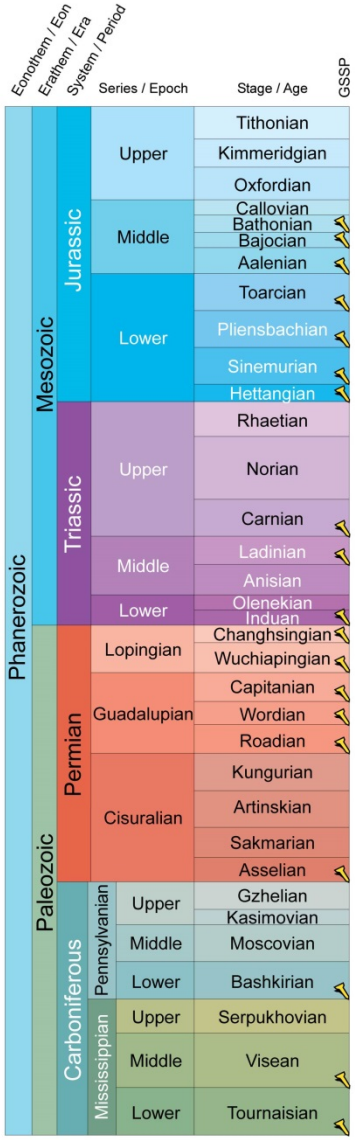
# INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

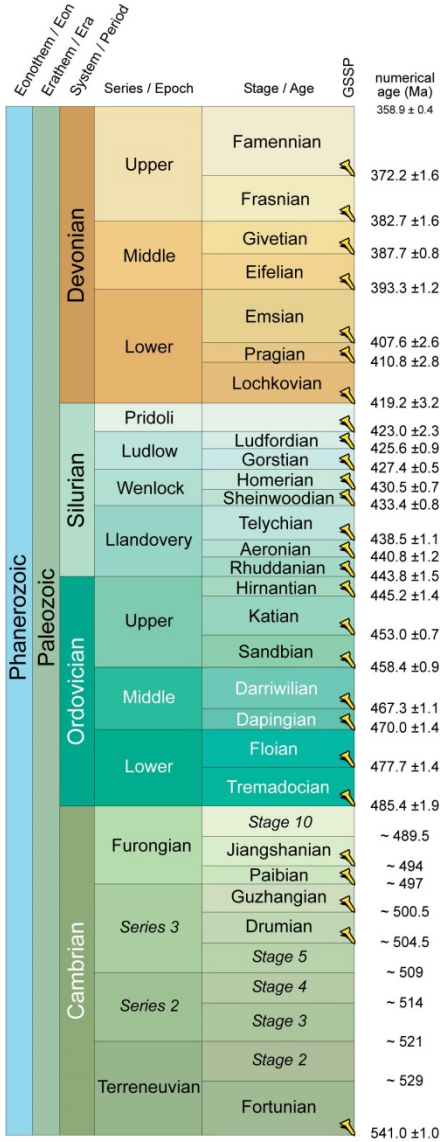
IUGS www.stratigraphy.org International Commission on Stratigraphy v 2015/01

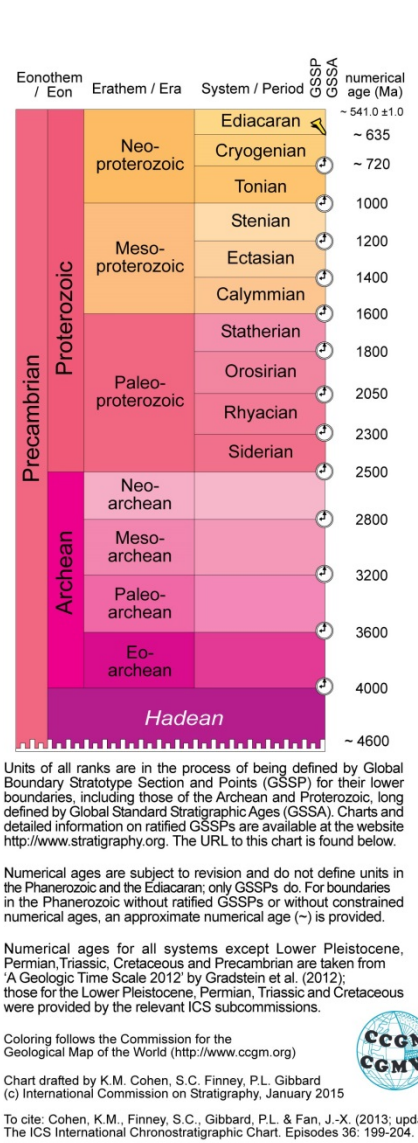
**HOLOCENE BOUNDARY: 11,700 BP**

Page 2 – this is the bit we're interested in




Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Charts and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is found below.

Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

Numerical ages for all systems except Lower Pleistocene, Permian, Triassic, Cretaceous and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012); those for the Lower Pleistocene, Permian, Triassic and Cretaceous were provided by the relevant ICS subcommissions.

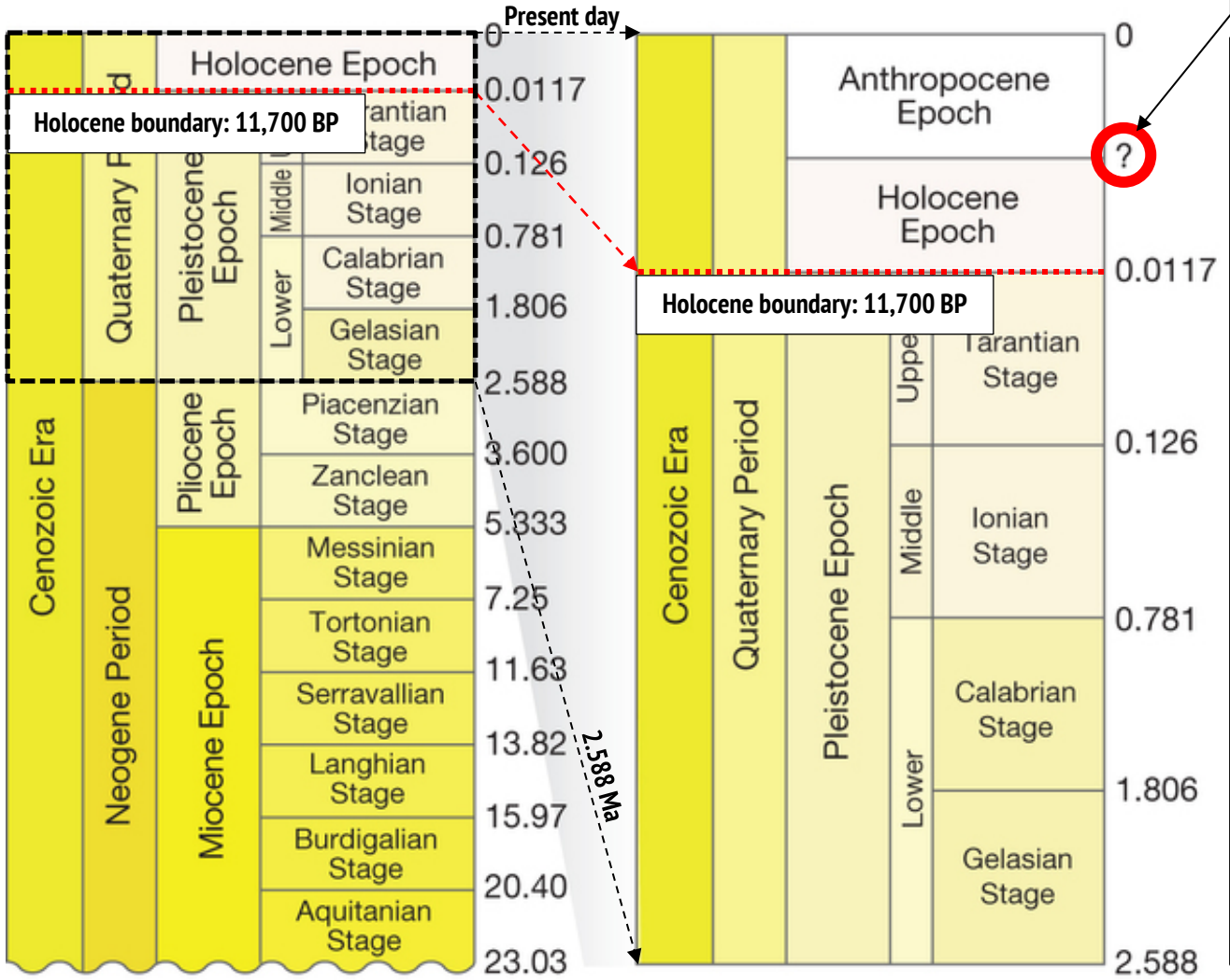
Coloring follows the Commission for the Geological Map of the World (http://www.ccgm.org)

Chart drafted by K.M. Cohen, S.C. Finney, P.L. Gibbard (c) International Commission on Stratigraphy, January 2015

To cite: Cohen, K.M., Finney, S.C., Gibbard, P.L. & Fan, J.-X. (2013; updated) The ICS International Chronostratigraphic Chart. Episodes 36: 199-204.

URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2015-01.pdf

# GEOLOGICAL TIME SCALE – THE QUATERNARY & THE 'ANTHROPOCENE'




**Does this boundary exist? If yes, when did it happen?**

## HOW IS GEOLOGICAL TIME SUB-DIVDED?

The currently accepted, complete geological time scale (GTS) is sub-divided into Eons, Eras, Periods, Epochs and Ages. These divisions are based on changes recorded in rock stratigraphy, which can represent dramatic global events such as mass extinctions or Ice Ages, or much smaller events.

Most boundaries between stratigraphic units are determined by the presence of a "Global Stratotype Section and Point" (**GSSP**), sometimes referred to as a '**Golden Spike**'. These define the LOWER BOUNDARY of a rock unit laid down during an episode of geological time.

Most of these GSSPs are defined by the appearance or disappearance of certain fossils or groups of fossils. However, significant chemical changes in the atmosphere or sea recorded in rock strata can mark the start of an age on the geological time scale, particularly during the most recent 2.6 million years (known as the Quaternary).

Image adapted after Lewis & Maslin, 2015.

# (2) SUBDIVIDING THE QUATERNARY – WHAT DO SCIENTISTS LOOK FOR?

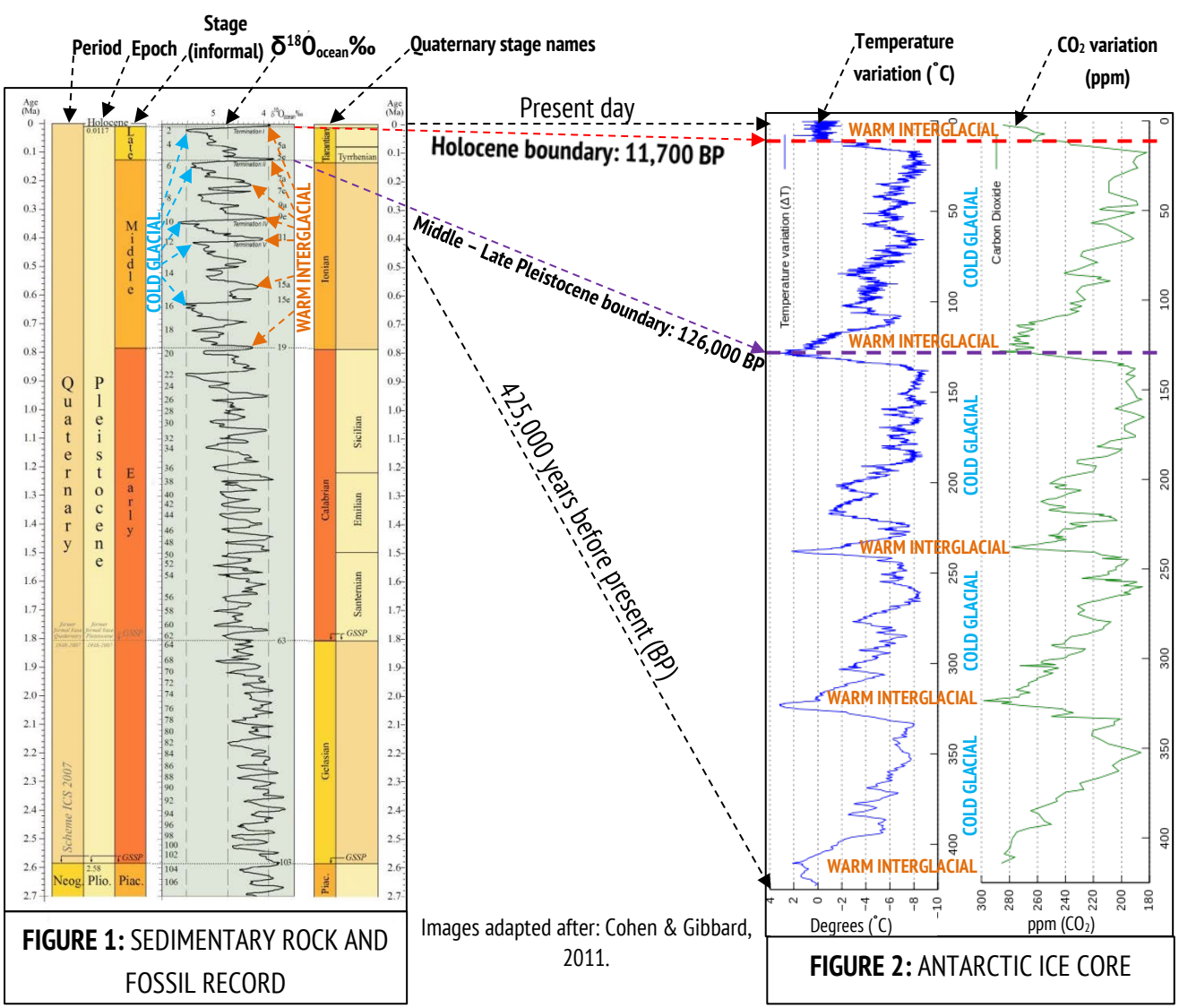



**FIGURE 1:** SEDIMENTARY ROCK AND FOSSIL RECORD

Images adapted after: Cohen & Gibbard, 2011.

**FIGURE 2:** ANTARCTIC ICE CORE

## HOW DO WE FIND A GOLDEN SPIKE IN THE QUATERNARY?

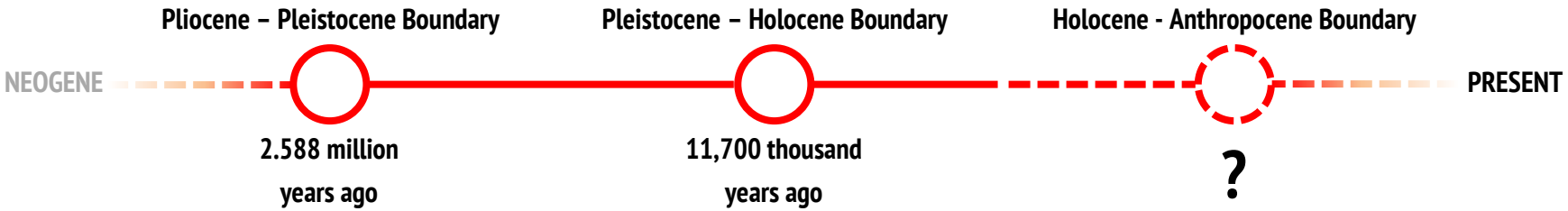
Two of the tools quaternary geologists use for determining when one epoch or stage of geological time has ended and another has begun are the '$\delta^{18}O_{ocean}$' system (Fig. 1) and ice cores (Fig. 2).

1) **$\delta^{18}O_{ocean}$: what is it?** This is known as 'delta oxygen-18'. It is used to measure historical temperature. Oxygen dissolved in the oceans is composed of a mixture of 2 isotopes ("oxygen-16" and "oxygen-18"). Their relative amounts depend upon how much ice covers the Earth's surface, and therefore roughly how warm or cold the climate is. Marine fossils contain minerals with oxygen in their chemical formulae. The minerals record the relative proportions of oxygen-16 and oxygen-18 present in the oceans in the past. From this, geologists can tell how hot or cold the planet was.

2) **Ice core:** In more recent geological history (about the last million years), geologists can use ice cores. These are long tubes of ice drilled out of the ice sheets in Antarctica or Greenland. They contain bubbles that trap air from the past. The amount of carbon dioxide these contain can be measured and this provides another estimate of how hot or cold the Earth's climate used to be.

**Temperature fluctuates throughout geological time quite regularly, as you can see in the figures. This is mostly due to changes in the Earth's orbit around the sun. When these fluctuations change their behaviour, geologists may mark a GOLDEN SPIKE as the Earth's climate might have changed.**

# SUBDIVIDING THE QUATERNARY – WHAT MAKES A BOUNDARY OF AN EPOCH?




## PLIOCENE – PLEISTOCENE BOUNDARY

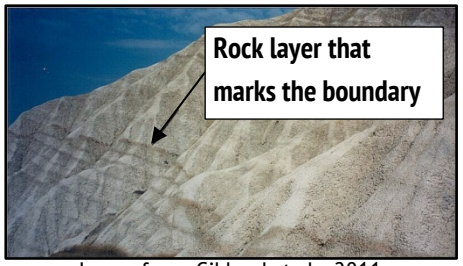



Image from: Gibbard et al.., 2011.

The 'Golden Spike' for the boundary – in southern Italy, but identifiable around the world.

- **It marks a major shift in global climate**: from a relatively warm and mostly ice-free climate in the earlier Pliocene to the colder Pleistocene with repeated glacial events.

## PLEISTOCENE – HOLOCENE BOUNDARY

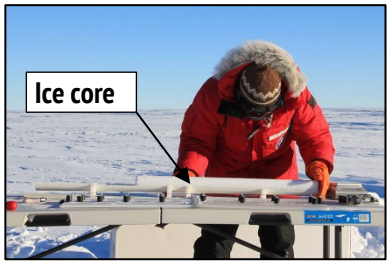



Image copyright: Wikimedia Commons/Russavia

The major 'Golden Spike' for the boundary is recorded in ice core.

- **It marks the end of the last ice age**: the Holocene represents a relatively stable and warm period compared to the colder and fluctuating glaciations of the earlier Pleistocene.
- **An extinction event occurred**: The extinction of the 'megafauna'. Animals like the famous woolly mammoth disappeared at this boundary.

## HOLOCENE – ANTHROPOCENE BOUNDARY

What could mark the boundary of the Holocene & Anthropocene?

**Go to document 3 to write down some ideas**

# (3) WHAT COULD MARK THE HOLOCENE – ANTHROPOCENE BOUNDARY?

Examples of key 'events' that could be used to define the boundary

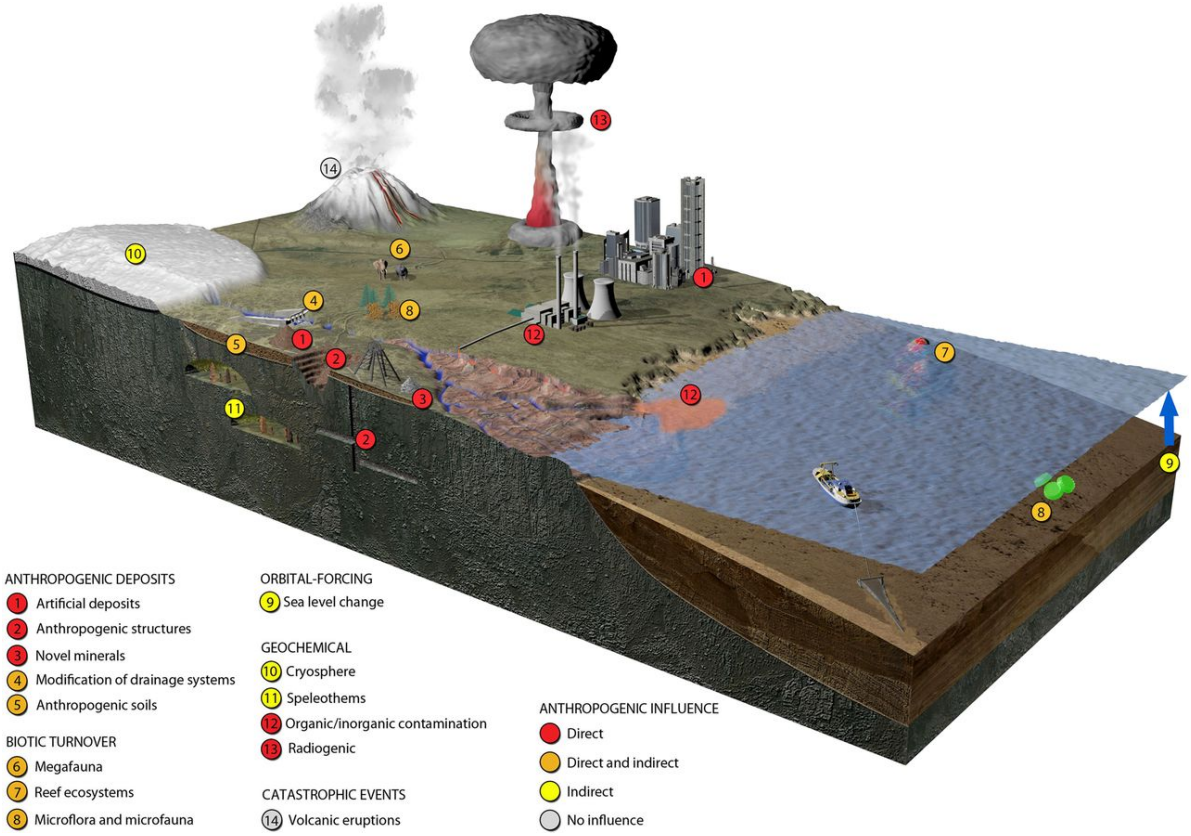



Image from: Waters et al., 2014

*Use the above image and your own knowledge to suggest some ideas for what could mark the 'golden-spike' boundary of the Holocene and Anthropocene under the headings below:*

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1. **"Appearance and increased abundance of anthropogenic (*man-made*) deposits":**

   What things that humans make could become part of the geological record?

**2. "Biotic turnover":**

Are humans causing the extinction of certain animals and/or plants? Which kinds of animals and plants (terrestrial or marine, large or small) might become extinct?

**3. "Climate change":**

How is climate change affecting the planet?

**4. Catastrophic events:**

What events, man-made or natural, could happen to represent the Holocene – Anthropocene boundary?

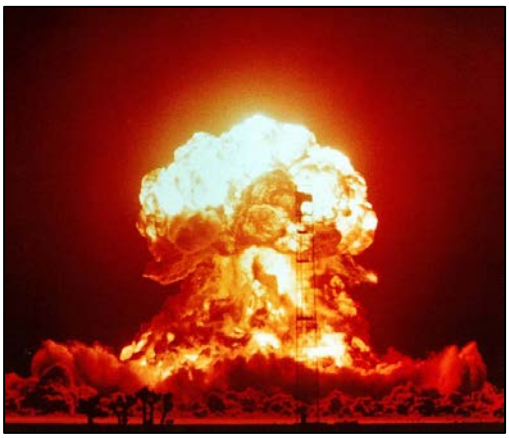
# (4) WHEN COULD THE HOLOCENE – ANTHROPOCENE BOUNDARY HAVE OCCURRED?

## *SOMETIME IN THE FUTURE?*

**1963 or 1964**

### THE NUCLEAR BOMB PROPOSAL

- During the earlier stages of the cold war (1950s and 60s), approximately 1,500 nuclear weapons were detonated in tests, mostly by the USA and Soviet Union.
- The bombs produced something known as 'radiogenic nuclides' released into the atmosphere.
- These are recorded in sediments as radioactive carbon (carbon-14).
- A spike of radioactive carbon-14 occurred in 1963 or 1964. Shortly afterwards, nuclear tests were banned and levels of carbon-14 returned to nearer normal levels. More details are provided on sheet 5.
- **Does this event mark the start of a new geological epoch, the Anthropocene?**

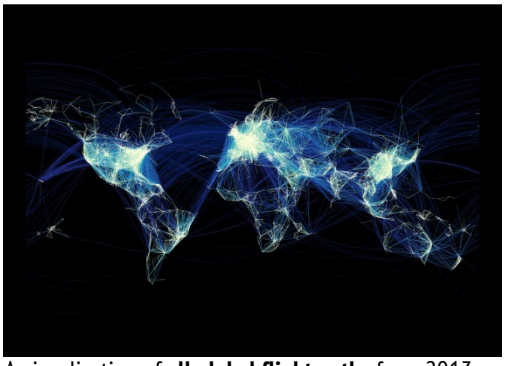


A 1953 **nuclear weapons test** in Nevada, USA. Nearly **2,500 weapons** have been 'fired' since the first test in 1945. Copyright: Wikimedia Commons.

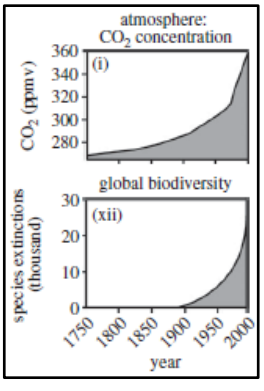
**1950s**

### THE GREAT ACCELERATION

- The years since World War 2 have been referred to as the 'Great Acceleration'.
- This relates to significant increases in global population, use of technologies and worldwide interconnectivity. For example, the number of automobiles in the entire world rose from just 40 million in 1945 to over 700 million in 1996.
- These advances are also reflected by very sharp increases in greenhouse gases (carbon dioxide and methane) and extinction rates of plants and animals (also referred to as a decrease in biodiversity).
- **Does the beginning of the 'Great Acceleration' during the 1950s mark the start of the Anthropocene?**



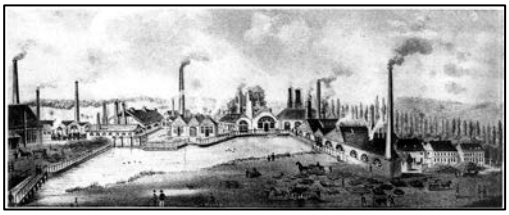
A visualisation of **all global flight paths** from 2013, one of the results of the Great Acceleration. Copyright: Michael Markieta / Arup.




Graphs showing how increases in **carbon dioxide** (top) and **extinctions** of species of plants and animals (bottom) have accelerated since the 1950s. Adapted after: Steffen et al., 2011.

## 1750 THE INDUSTRIAL REVOLUTION

- The Industrial Revolution was undoubtedly one of the most significant changes in man's effect on the environment.
- The energy of mined coal allowed manufacturing technology to advance and expand rapidly.
- Increases in carbon dioxide and methane are recorded in ice-core after 1750. The concentrations of these gases in the atmosphere (or in ice-cores) have continued to increase since then.
- However, the industrial revolution during the 18th and 19th centuries only really occurred in Europe and North America – other parts of the world industrialised later.
- **Does the Industrial revolution of Europe and North America mark the start of the Anthropocene?**



**Coal-powered** factories and steam engines during the Industrial Revolution caused significant atmospheric change. Copyright: Wikimedia Commons.

## 1610 EUROPEAN COLONISATION OF THE AMERICAS

- The colonisation of the Americas by Europeans brought fundamental and widespread changes to the population of the region.
- Diseases brought by Europeans are estimated to have wiped out up to 95% of the indigenous population (about 50 million people).
- This impacted mostly on agriculture, which decreased massively. The resulting re-forestation caused carbon dioxide to decrease and this is recorded in ice-core.
- However, this was not an entirely global event.
- More details are provided on sheet 5.
- **Does this colonisation of the Americas mark the start of the Anthropocene?**

The arrival of **Europeans in the Americas** caused widespread disease and death throughout the region. Copyright: Science Photo Library.

# (5) ANTHROPOCENE BOUNDARY IN 1610 OR 1964 – Lewis, L.L. & Maslin, M. A.

Journal article abstract

nature International weekly journal of science

# Defining the Anthropocene

Simon L. Lewis[1,2] & Mark A. Maslin[1]

**Time is divided by geologists according to marked shifts in Earth's state. Recent global environmental changes suggest that Earth may have entered a new human-dominated geological epoch, the Anthropocene. Here we review the historical genesis of the idea and assess anthropogenic signatures in the geological record against the formal requirements for the recognition of a new epoch. The evidence suggests that of the various proposed dates two do appear to conform to the criteria to mark the beginning of the Anthropocene: 1610 and 1964. The formal establishment of an Anthropocene Epoch would mark a fundamental change in the relationship between humans and the Earth system.**

BBC News article excerpt

BBC

Prof Mark Maslin, from University College London, a co-author of the paper, said: "We look for...golden spikes - a real point in time when you can show in a record when the whole Earth has changed.

"If you look back through the entire, wonderful geological timescale, we have defined almost every boundary in that way." The study suggests that one such golden spike places the start of the Anthropocene in 1610. The researchers say the arrival of the Europeans in the Americas 100 years earlier was the start of a major global transformation.

Co-author Dr Simon Lewis, also from UCL, said: "The rapid global trade after that time moved species around.

"Maize from Central America was grown in southern Europe and Africa and China. Potatoes from South America were grown in the UK, and all the way through Europe to China. Species went the other way: wheat came to North America and sugar came to South America - a real mixing of species around the world.

"We saw these species jump continents, which is a geologically unprecedented impact, setting Earth off on a new evolutionary trajectory."

Ancient pollen found in sediments provides a record of this change, but the team says another golden spike relates to deadly diseases brought into the Americas from Europe.

"Around 50 million people (in the Americas) died, and most of those people were farmers," Dr Lewis told the BBC World Service's Science in Action programme.

"And this farmland grew back to the original vegetation - tropical forest, dry forest or savannah. And about half the dry weight of a tree is carbon, so all that growing vegetation removed enough carbon from the atmosphere to see a pronounced dip in the global atmospheric carbon dioxide concentration that can be seen in ice core records.

"It provides an exact marker of the Anthropocene at 1610, the lowest point of $CO_2$ in the ice-core record at that time."

Figure from journal article – Defining the beginning of the Anthropocene

**OPTION 1**

The graph below shows the level of carbon dioxide recorded throughout the last 1,000 years (red line). The blue line represents the estimated temperature change of the earth's climate during the last 1,000 years.

**The scientists of the journal article think the drop in the carbon dioxide level during the year 1610 could represent a 'golden spike' that marks the start of the Anthropocene.**

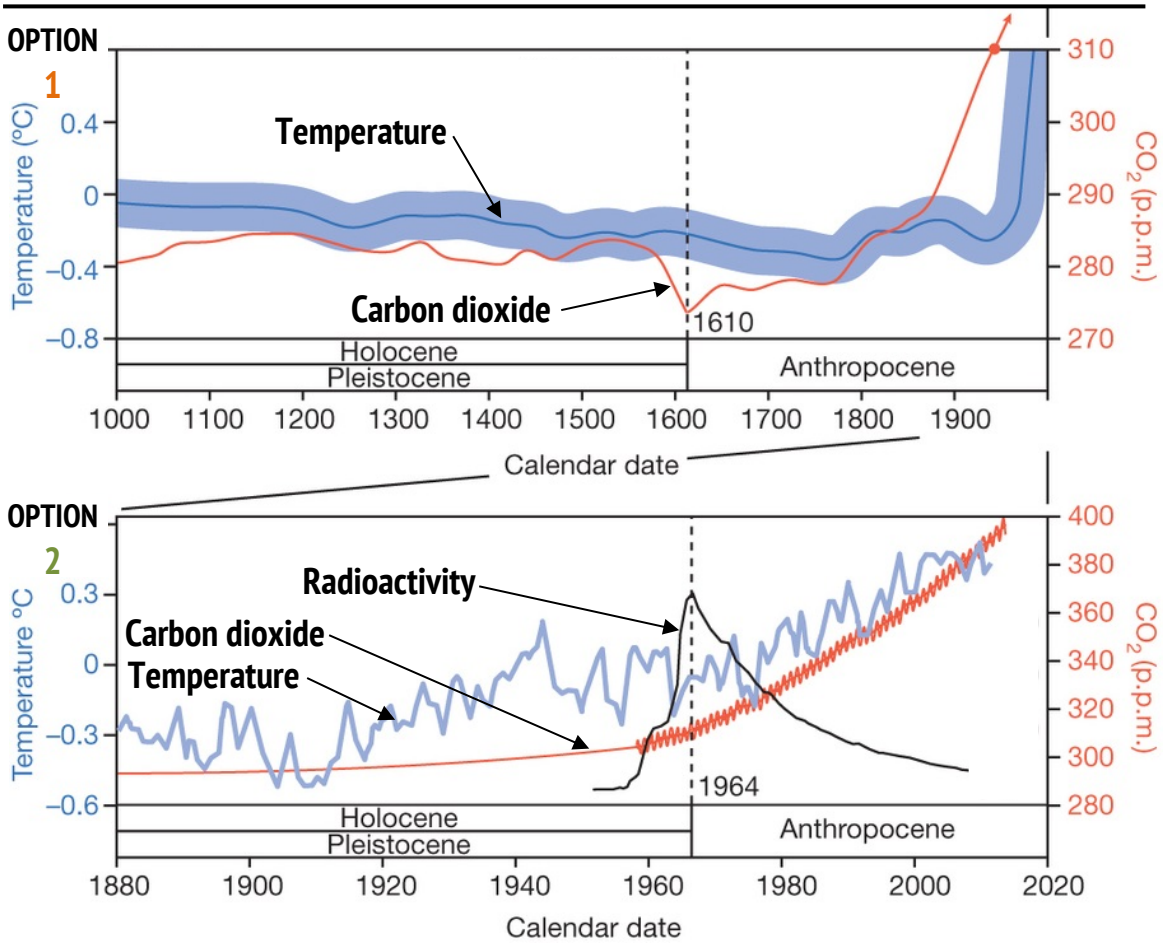
# WHAT DO YOU THINK?

**OPTION 2**

This graph is simply a zoomed in version of the option 1 graph. It shows a time span of 140 years between 1880 and into the near future, 2020. You will notice that the carbon dioxide (red line) and temperature (blue line) have more of a zig-zag-like pattern. This is simply due to seasonal variation in both temperature and carbon dioxide levels.

**However, the scientists think that the peak in global radiation (black line) caused by nuclear testing could represent a 'golden spike' that marks the start of the Anthropocene. (You may also notice that this coincides with an increase in carbon dioxide).**

# WHAT DO YOU THINK?




Images adapted after Lewis & Maslin, 2015.

# (6) AGAINST THE ANTHROPOCENE – Gibbard, P.L. & Walker, M.J.C. 2014

**Excerpt from journal article abstract**

For the Anthropocene to merit formal definition, a global signature distinct from that of the Holocene is required that is marked by novel biotic, sedimentary and geochemical change. Although there is clear evidence of anthropogenic (***man-made***) effects in geological sequences, it is uncertain whether these trends are sufficiently distinct, consistent and dated for the proposal for a Holocene/Anthropocene boundary to be substantiated (***created***). Adoption of the term 'Anthropocene' will ultimately depend on recognition of a global event horizon (***a 'golden spike'***). Without this, there is no justification for decoupling (***separating***) the Anthropocene from the Holocene.

**Arguments against the Anthropocene Epoch**

***The following arguments were made by the authors against the creation of the new Anthropocene epoch:***

1. **Is there a global, man-made and broadly time-parallel (i.e. occurred at the same time) event that could form a boundary (either in rock or ice-core) between the Holocene and Anthropocene?**

   **The arguments against this include:**

   - Man-made materials incorporated into the geological record, and man's modification of the earth's surface is very varied (i.e. some areas have a lot and others have very little) and has occurred for a long time in history (i.e. it is not just a recent event).
   - Ice-core does not record exact dates and there is a delay in the trapping of air bubbles in ice. Therefore deciding a calendar age of the Anthropocene (e.g. the year 1750 AD) makes little geological sense.
   - Using the industrial revolution of Western Europe and North America (around 1750 AD) does not consider the rest of the world, where industrialisation occurred much later.

2. **Are we now living in a geological period that is significantly different from the preceding Holocene?**

   **The arguments against this include:**

   - One of the major features of the Holocene is man's interaction with the global environment. So why do we need a new epoch with the same major feature?
   - Suggested dates for the boundary (most of which are very recent) ignore thousands of years of human interaction with the environment.
   - Most of these dates (e.g. Industrial Revolution in 1750 or the Great Acceleration in the 1950s) only mark one stage in human interaction with the environment, and few a truly global.
   - Ice cores from the Holocene record increases in carbon dioxide and methane from thousands of years ago related to human activity (e.g. deforestation for farming). Why are these dates not equally significant?

**References**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