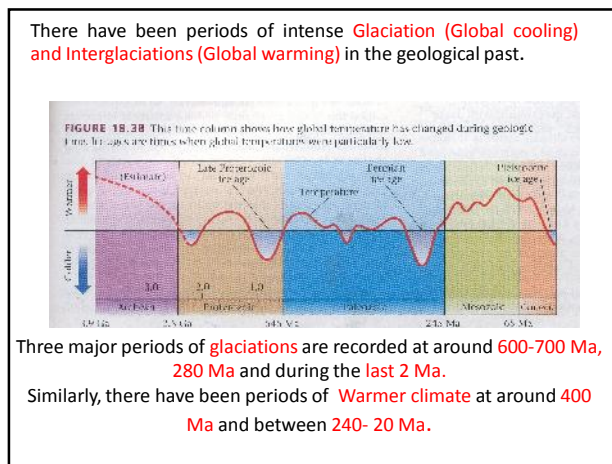


Geologic Time Scale				
Era	System & Period	Series & Epoch	Strata & Stratigraphic Features	Years Before Present
CENOZOIC	Quaternary	Quaternary	Quaternary	2.6 Ma - Present
	Pliocene	Pliocene	Pliocene	2.6 Ma - 2.3 Ma
	Pleistocene	Pleistocene	Pleistocene	2.3 Ma - 11.7 Ma
	Neogene	Neogene	Neogene	23 Ma - 2.6 Ma
	Quaternary	Quaternary	Quaternary	2.6 Ma - Present
MESOZOIC	Cretaceous	Cretaceous	Cretaceous	145 Ma - 66 Ma
	Jurassic	Jurassic	Jurassic	201 Ma - 145 Ma
	Triassic	Triassic	Triassic	252 Ma - 201 Ma
PALEOZOIC	Permian	Permian	Permian	299 Ma - 252 Ma
	Carboniferous	Carboniferous	Carboniferous	359 Ma - 299 Ma
	Devonian	Devonian	Devonian	419 Ma - 359 Ma
	Silurian	Silurian	Silurian	444 Ma - 419 Ma
	Ordovician	Ordovician	Ordovician	485 Ma - 444 Ma



- The **Quaternary (the Quaternary Period)** is a subdivision of geological time scale.
- It covers approximately the last two million years up to the present day.
- The exact duration has been debated: the onset of the Quaternary Period has previously been placed at 1.8 million years ago; but many workers now favour a longer Quaternary chronology, placing its onset at 2.6 million years ago.
- **The Quaternary and the Tertiary Periods together form the Cenozoic Era.**

- There have been five known ice ages in the Earth's history, with the Earth experiencing the **Quaternary Ice Age during the present time**. Within ice ages, there exist periods of more severe glacial conditions and more temperate referred to as glacial periods and interglacial periods, respectively.
- **The Earth is currently in an interglacial period of the Quaternary Ice Age**, with the last glacial period of the Quaternary having ended approximately 10,000 years ago with the start of the Holocene epoch.

- **Quaternary glaciation**, also known as the **Pleistocene glaciation**, the **current ice age** or simply the **ice age**, refers to the period of the last few million years (2.58 Ma to present) in which permanent ice sheets were established in Antarctica and perhaps Greenland, and fluctuating ice sheets have occurred elsewhere.

- The entire Quaternary Period (2.58 Ma) is referred to as an ice age because at least one permanent large ice sheet — Antarctica — has existed continuously.

-

- The Quaternary can be subdivided into two epochs:

- The **Pleistocene** (up to about 11,500 years ago) and

- The **Holocene** (about 11,500 years ago to the present day).

- The Quaternary Period has witnessed one of extraordinary changes in global environment as well as the period during which much of human evolution took place.

The Pleistocene is the epoch from 2,588,000 to ~12,000 years BP that spans the world's recent period of repeated glaciations. The name *pleistocene* is derived from the Greek πλεῖστος (*pleistos* "most") and καινός (*kainos* "new").

The Pleistocene Epoch follows the Pliocene Epoch and is followed by the Holocene Epoch.

The end of the Pleistocene corresponds with the retreat of the last continental glacier. It also corresponds with the end of the Paleolithic age used in archaeology.

Holocene

- The **Holocene** is a geological epoch which began 11,700 years ago (around 10 000 ¹⁴C years ago) continues to the present.
- The Holocene is part of the Quaternary period. Its name comes from the Greek words ὅλος (*holos*, whole or entire) and καινός (*kainos*, new), meaning "entirely recent". It has been identified with the current warm period, known as MIS 1, and can be considered an interglacial in the current ice age.
- All human written history and urban living has occurred within the Holocene. The word **Anthropocene** is also used for the time period from when humans have had a significant impact on the Earth's climate and ecosystems to the present.

Thus

- Pleistocene has been a Cooler phase (Periodic build up of Ice Sheets) AND
- Holocene has been a Warmer phase
- In general, Quaternary has been marked by major phases of cooling ie. **Glacial Stages** and Shorter **Inter glacial Stages**.
- Not only the ice sheets expanded and covered the land, but there has also been an impact on the Landscape/Fauna/ Flora -Their Extinction and modifications.
- Changes occurred at the scale of few centuries/decades/and even at few year scale.

- The **Last glacial period** was the most recent glacial period within the current ice age occurring during the last years of the Pleistocene, from approximately 110,000 to 10,000 years ago.
- During this period there were several changes between glacier advance and retreat. The **Last Glacial Maximum (LGM)** refers to the time of maximum extent of the ice sheets during the last glacial period, between 26,500 and 19,000–20,000 years ago
- The maximum extent of glaciation was approximately 22,000 years ago. While the general pattern of global cooling and glacier advance was similar, local differences are present.

Quaternary glaciation /Pleistocene glaciation/ Current ice age/ Ice age:

Refers to the period of the last few million years (2.58 Ma to present)

Glacial Stages
Interglacial Stages

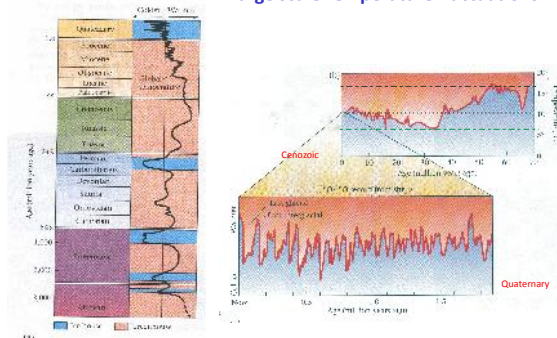
Last glacial period: Most recent glacial period within the current ice age occurring during the last years of the Pleistocene (110,000 to 10,000 years ago).

Last Glacial Maximum (LGM): Time of maximum extent of the ice sheets during the last glacial period, between 26,500–20,000 years ago

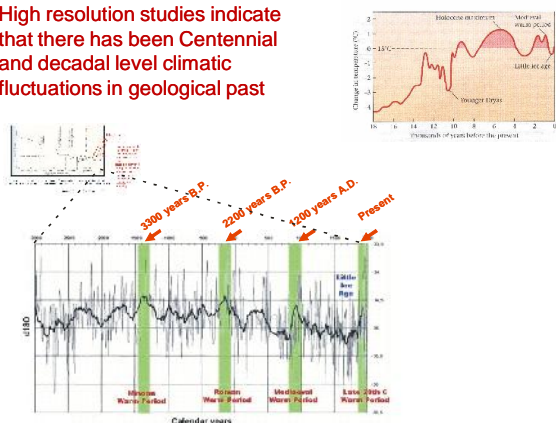
- **Currently, the earth is in an interglacial period, which marked the beginning of the Holocene epoch.**
- **The current interglacial began between 10,000 and 15,000 years ago, which caused the ice sheets from the last glacial period to begin to disappear.**
- **Remnants of these last glaciers, now occupying about 10% of the world's land surface, still exist in Himalaya, Greenland and Antarctica etc**
- **During the glacial periods, what we see as the normal (i.e. interglacial) hydrologic system was completely interrupted throughout large areas of the world and was considerably modified in others.**
- **Due to the volume of ice on land, sea level was approximately 120 meters lower than present. The evidence of such an event in the recent past is robust.**

- Over the last century, extensive field observations have provided evidence that continental glaciers covered large parts of Europe, North America, and Siberia.
- Even before the theory of worldwide glaciation was generally accepted, many observers recognized that **more than a single advance and retreat of the ice had occurred.** Extensive evidence now shows that a number of periods of growth and retreat of continental glaciers occurred during the ice age, called glacial and interglacial.
- The interglacial periods of warm climate are represented by buried soil profiles, peat beds, and lake and stream deposits separating the unsorted, unstratified deposits of glacial debris.

There have been **Small scale as well as Large scale Temperature fluctuations**



High resolution studies indicate that there has been **Centennial and decadal level climatic fluctuations in geological past**



Thus, the climate on the Planet earth has been and is variable ever since its birth.

The changes have taken place in the geological past at various scales :

- At global level
- At regional level
- At local level
- At different latitudinal and altitudinal positions
- At millennial scale
- At centennial scale
- At decadal scale

- **The major effects of the ice age have been:**
- Erosion and deposition of material over large parts of the continents
- **Modification of river systems**
- **Creation of millions of lakes**
- **Changes in sea level**
- **Development of pluvial lakes far from the ice margins**
- **Isostatic adjustment of the crust, and abnormal winds.**
- **It affected oceans, flooding, and biological communities.**
- **The spread of ice sheets caused increase in the albedo that effected a major feedback on climate cooling**

- The evidences of Glacial and Interglacial periods are preserved in the form of Terrestrial as well as Marine records.
- **Terrestrial records (mostly fragmentary)**
 - Lake deposits
 - Ice Cores from Ice sheets

Vostok Ice Core Data for 420,000 Years
Oxygen Isotope
- **Marine records (undisturbed)**

Climatic changes during Quaternary

Interstadials

- **Sudden and short-lived warm events** occurred many times **during the generally colder conditions** that prevailed between 115,000 and 14,000 years ago (isotope Stages 2-5.4).
- First picked up as brief influxes of warm climate plants and insects into the glacial tundra zone of northern Europe, they are known as interstadials' to distinguish them from the cold phases or 'Stadials'.

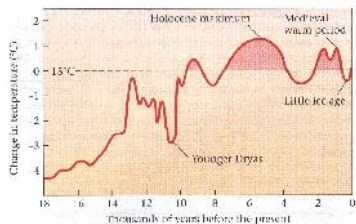
- The interstadials show up strongly in the Greenland ice core records. Between 115,000 and 14,000 years ago, 24 of these warm events have been recognized in the Greenland ice cores.
- **Interstadials both began and ended suddenly**, though in general the 'jump' in climate at the start of an interstadial was followed by a more gradual decline involving a stepwise series of smaller cooling events.

Heinrich events

- Opposite in sign to the Interstadials are **extreme and short-lived cold events during the general colder climatic conditions, known as 'Heinrich events'** which were first recognized as periods with very ice-rafting in the North Atlantic. These events occur against the general background of the glacial climate, and **represent the brief expression of the most extreme glacial conditions.**
- During such events, icebergs broke off from glaciers and traversed the North Atlantic. The icebergs contained rock mass eroded by the glaciers, and as they melted, this matter was dropped onto the sea floor. *These deposits are called ice rafted debris (IRD) or ice rafted deposits.*
- **Ice rafting was a primary mechanism of sediment transport during glacial episodes of the Pleistocene when sea levels were very low and much of the land was covered by large masses (sheets) of ice.**

- **Heinrich events**, occurred during the last glacial period, or "ice age". Scientists drilling through marine sediments can distinguish six distinct events.
- **The last Heinrich event (known as H1) *sensu stricto* occurred just after the Last Glacial Maximum and seems to mark the extreme cold and aridity that occurs in many parts of the world around 17,000-15,000 years ago.**

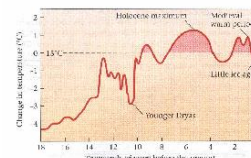
The Younger Dryas



The Younger Dryas cold event at about 12,900-11,500 years ago seems to have had the general features of a Heinrich Event, and may in fact be regarded as the most recent of these. There is sudden onset and ending of the Younger Dryas

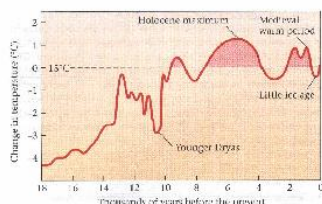
The Younger Dryas

- A detailed study suggests that the main Younger Dryas-to-Holocene warming took several decades in the Arctic, but was marked by a series of warming steps, each taking less than 5 years. About half of the warming was concentrated into a single period of less than 15 years.
- The event at 8200 ka is the most striking sudden cooling event during the Holocene, giving widespread cool, dry conditions lasting perhaps 200 years before a rapid return to climates warmer and generally moister than the present.

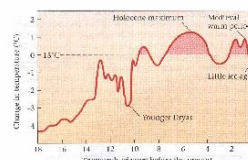


Holocene climatic optimum

The Holocene Climate Optimum was a warm period during roughly the interval 9,000 to 5,000 years B.P.



- This event has also been known by many other names, including: **Hypsithermal, Altitheal, Climatic Optimum, Holocene Optimum, Holocene Thermal Maximum, and Holocene Megathermal.**
- This warm period was followed by a gradual decline until about 2,000 years ago.

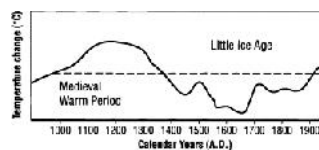


- The **Medieval Warm Period (MWP)** or **Medieval Climate Optimum** was a time of warm climate lasting from about AD 950–1250.
- It was followed by a cooler period in the North Atlantic termed the Little Ice Age (**Medieval Climatic Anomaly**).

- Despite substantial uncertainties, especially for the period prior to 1600 when data are scarce, the warmest period of the last 2,000 years prior to the 20th century very likely occurred between 950 and 1100.
- The heterogeneous nature of climate during the 'Medieval Warm Period' is illustrated by the wide spread of values exhibited by the individual records.

Little Ice Age

- The **Little Ice Age (LIA)** was a period of cooling that occurred after the **Medieval Warm Period**. While not a true ice age, it is conventionally defined as a period extending from the 16th to the 19th centuries.
- **The temperature has varied according to local conditions.**
- It is observed that there were three phases of cold intervals between 1550 AD and 1850 AD:
 - One beginning about 1650
 - Another about 1770
 - And the last in 1850,
- Each of these are separated by intervals of slight warming



- **Dansgaard-Oeschger events** (often abbreviated *D-O events*) are rapid climate fluctuations that occurred 25 times during the last glacial period (110,000 – 10,000 Yrs).
- **Bond events** are North Atlantic climate fluctuations occurring every $1,470 \pm 500$ years throughout the Holocene.
- Eight such events have been identified, primarily from fluctuations in ice-rafted debris.