

## ES 10 Lecture

January 31, 2001 J. Bartolome

### Paleoclimatology since 550 MYBP

1. Weather and climate
2. What controls temperature?
3. The greenhouse effect
4. Ice ages
5. Internal versus external controls on climate

Table 2.4 Allaby, Fig. 1.5 Schlesinger, Fig. 11.5 Schlesinger, Table 9-1 Turner et al 1990.

Table 2.4 Geologic time-scale

Eon	Era	Sub-era	Period	Epoch	Began (Ma)
Priscoan					4600
Archaean					4000
Proterozoic					2500
Phanerozoic					
	Palaeozoic				
		Lower Palaeozoic	Cambrian		590
			Ordovician		505
			Silurian		438
		Upper Palaeozoic	Devonian		408
			Carboniferous		
			Mississippian		360
			Pennsylvanian		320
			Permian		286
	Mesozoic		Triassic		248
			Jurassic		213
			Cretaceous		144
	Cenozoic				
		Tertiary			
			Palaeogene		
			Palaeocene		65
			Eocene		55
			Oligocene		38
			Neogene		
			Miocene		24.6
			Pliocene		5.1
		Quaternary			
			Pleistogene		
			Pleistocene		2.0
			Holocene		0.01

#### 1. Introduction

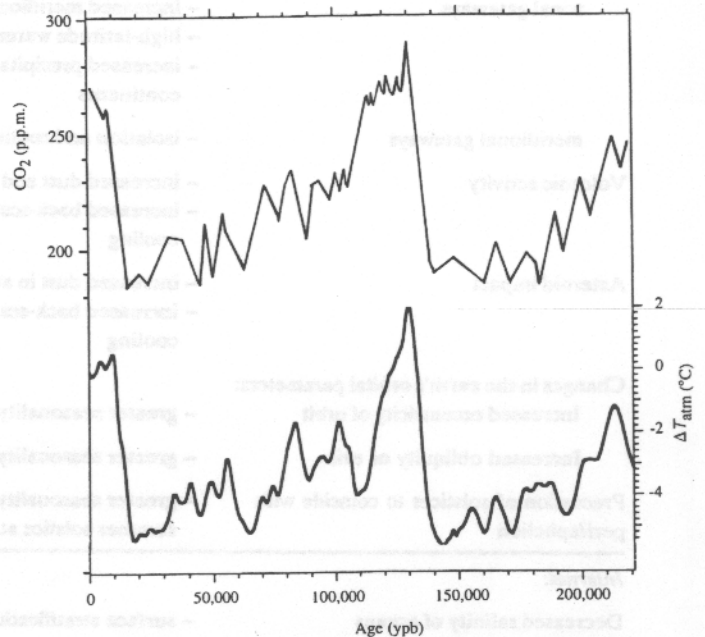


Figure 1.5 Variations in atmospheric CO<sub>2</sub> in bubbles of gas collected from the Vostok ice core, and variations in mean air temperature at the South Pole as calculated from isotope ratios in the ice, over the past 220,000 years. Modified from Jouzel et al. (1993).

#### 11. The Global Carbon Cycle

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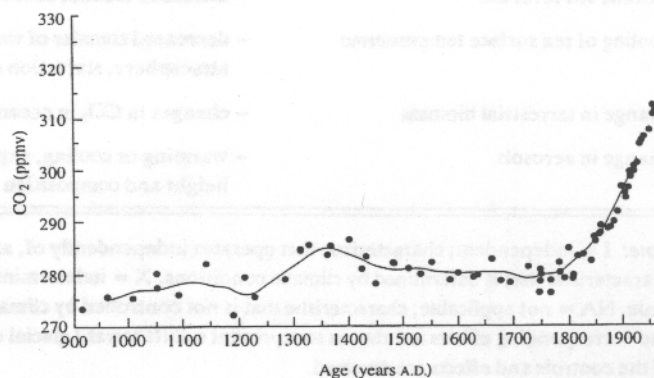


Figure 11.5 Concentrations of atmospheric CO<sub>2</sub> estimated from bubbles of gas trapped in ice cores from Antarctica. From Barnola et al. (1995).

Table 9-1 Controls of long-term climatic variability

Control	Effect	Status of control at time scales of (years)			
		10 <sup>7</sup>	10 <sup>5</sup>	10 <sup>3</sup>	≤10 <sup>1</sup>
<i>External:</i>					
Shift of continents to higher latitudes	– increased pole-equator temperature gradient – cooling of high latitudes	I	NA	NA	NA
Increased land area by tectonic processes	– increased albedo, cooling – increased monsoon intensity	I	NA	NA	NA
Changing orientation of ocean basins	– changes in circulation controls and monsoons	I	NA	NA	NA
Mountain-building and increased continental elevation	– changes in circulation controls, monsoon intensity, and albedo	I	I	NA	NA
Closing (tectonic and eustatic) of gateways between ocean basins:		I	I	NA	NA
zonal gateways	– increased meridional transport of warm water – high-latitude warming – increased precipitation on high-latitude continents				
meridional gateways	– isolation and cooling of high-latitude oceans				
Volcanic activity	– increased dust and SO <sub>2</sub> in atmosphere – increased back-scattering of solar radiation, cooling	X	X	I	I
Asteroid impact	– increased dust in atmosphere – increased back-scattering of solar radiation, cooling	I	I	I	I
Changes in the earth's orbital parameters:					
Increased eccentricity of orbit	– greater seasonality for one hemisphere	X	I	I	NA
Increased obliquity of axis	– greater seasonality for both hemispheres	X	I	I	NA
Precession of solstices to coincide with peri/aphelion	– greater seasonality for hemisphere with summer solstice at perihelion	X	I	I	NA
<i>Internal:</i>					
Decreased salinity of oceans	– surface stratification of oceans, decrease in heat storage	I	X	D	I
Growth of ice sheets	– increased albedo, cooling – shifts in circulation features	D	D	I	I
Growth of sea ice	– increased albedo, cooling – shifts in circulation features	D	D	I	D
Eustatic sea level fall	– increased albedo, cooling	D	D	I	I
Cooling of sea surface temperatures	– decreased transfer of water vapor to atmosphere, starvation of ice sheets	D	D	D	I
Change in terrestrial biomass	– changes in CO <sub>2</sub> in ocean and atmosphere	X	X	D	I
Change in aerosols	– warming or cooling, depending on aerosol height and composition	X	X	D	D

*Note:* I = independent; characteristic that operates independently of, and to some extent controls, climatic variation. D = dependent; characteristic that is determined by climatic conditions. X = indeterminate; characteristic that is too variable to be reconstructed at the time scale. NA = not applicable; characteristic that is not controlled by climate, or that varies too slowly to be significant. For brevity, most controls and corresponding effects are chosen to represent a shift toward glacial conditions. During a shift toward interglacial conditions, the direction of the controls and effects are reversed.