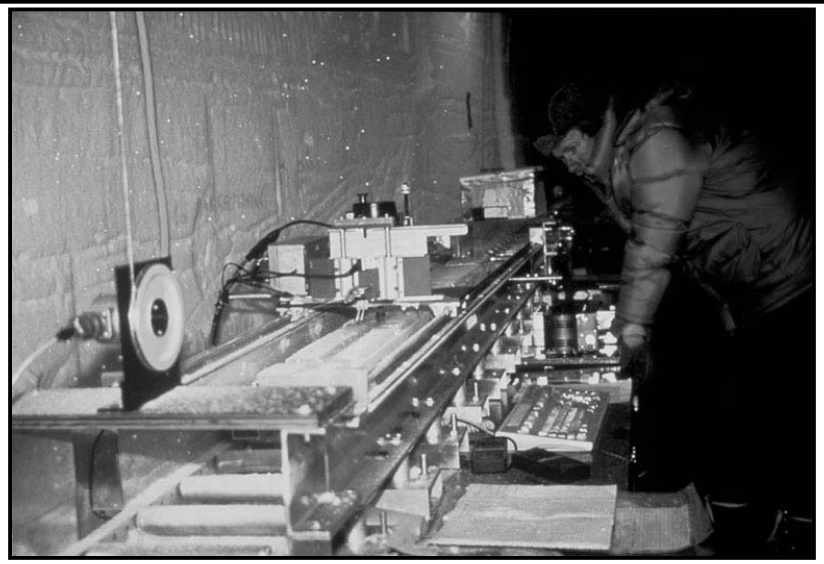
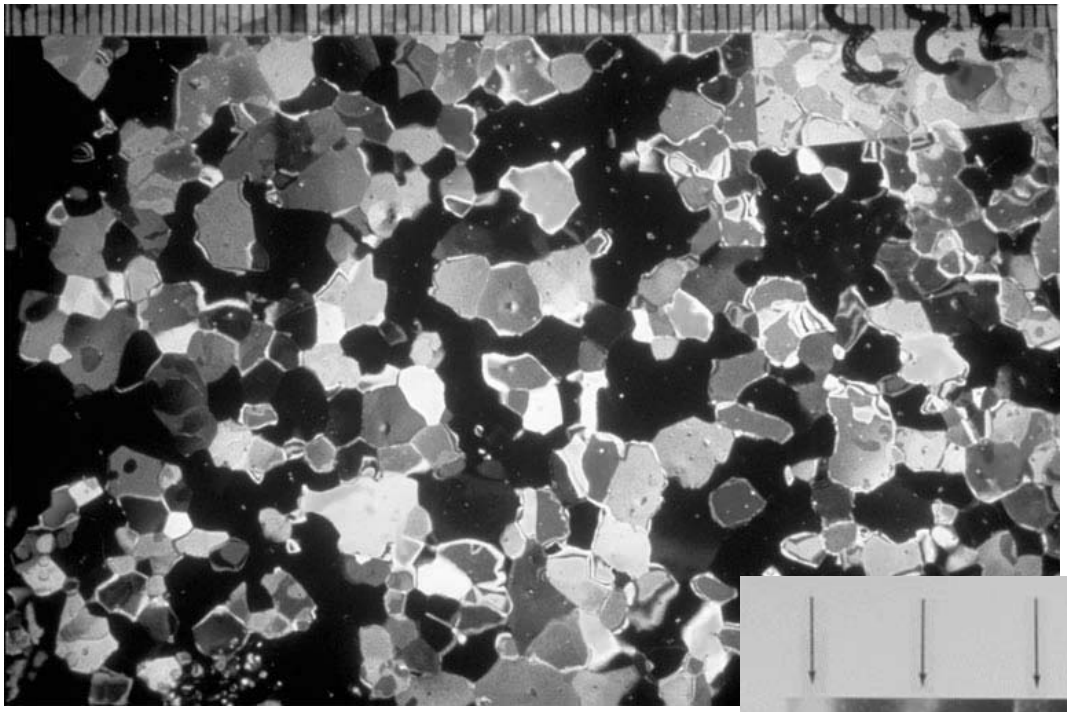
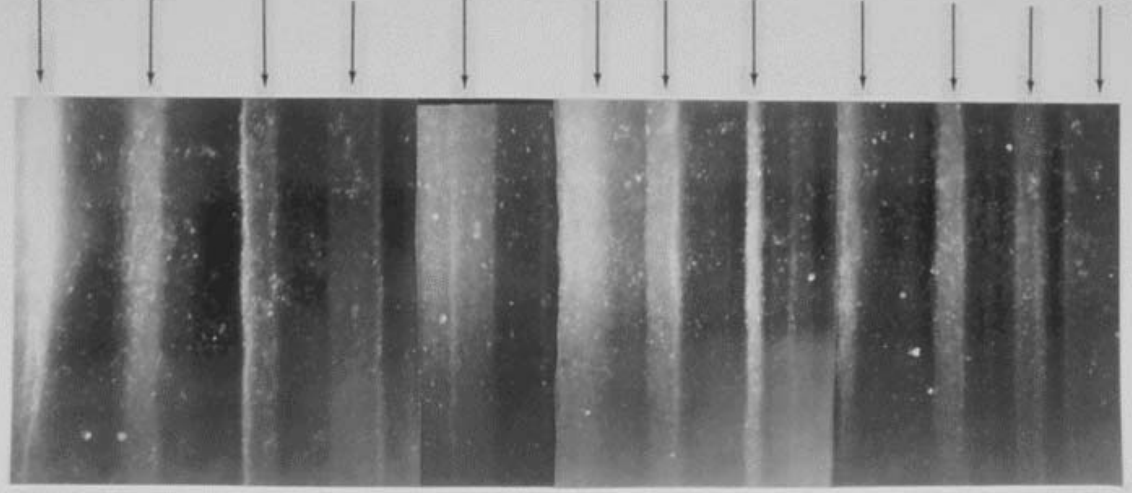
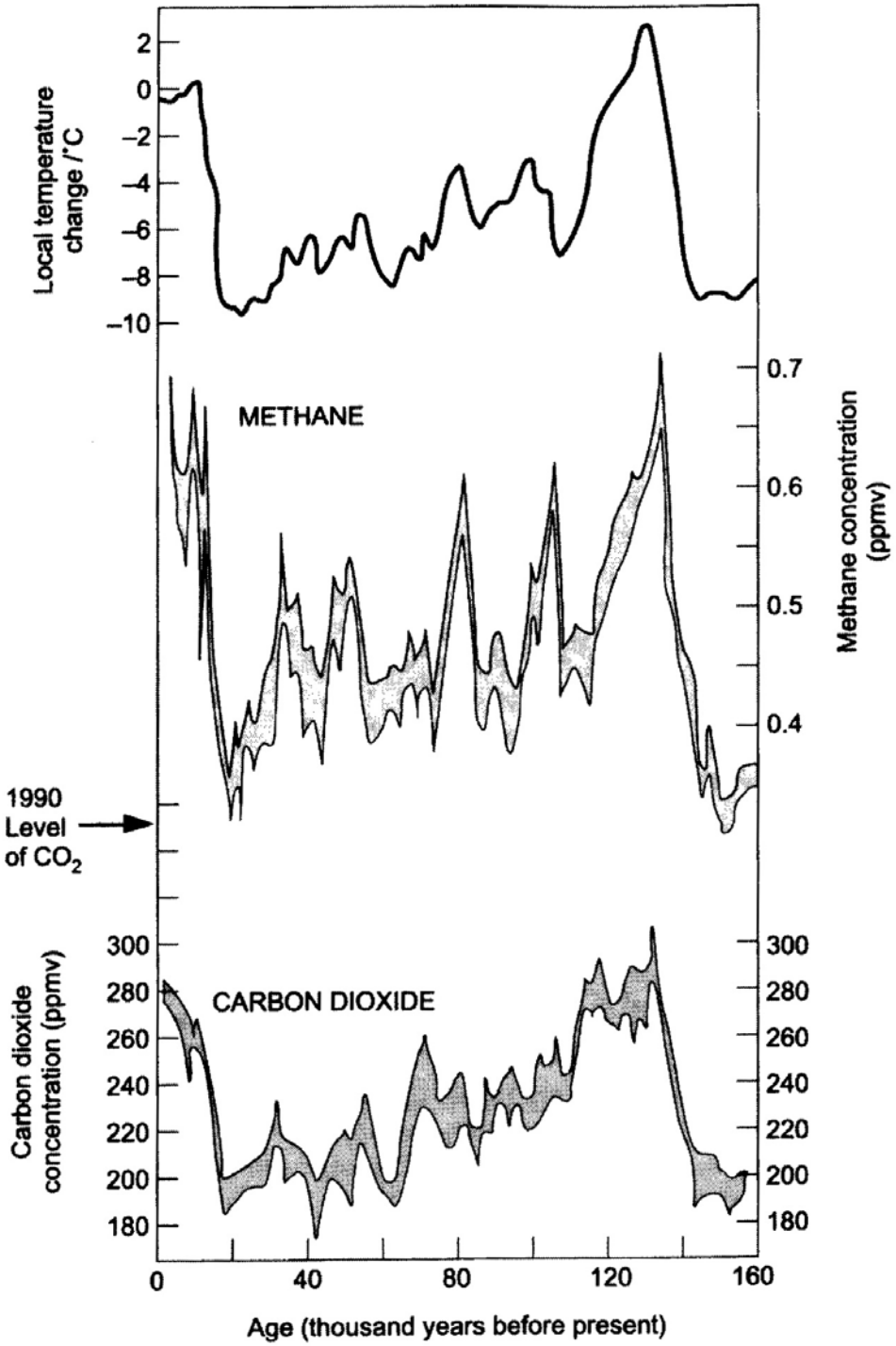
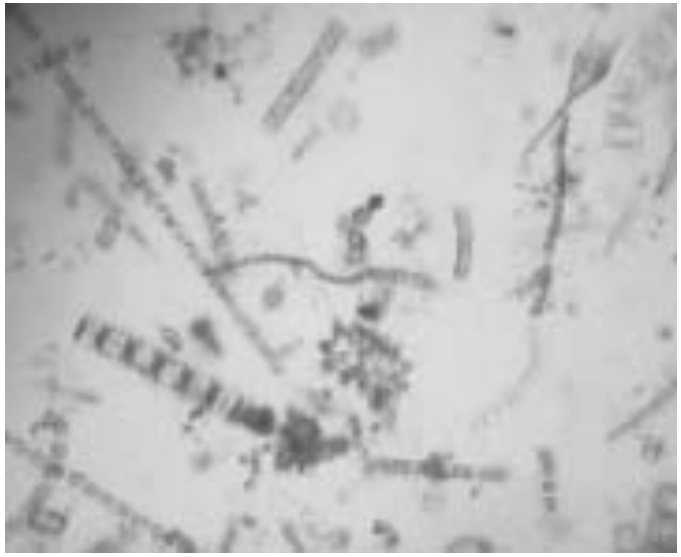


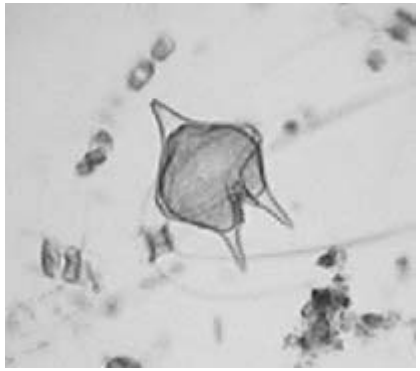


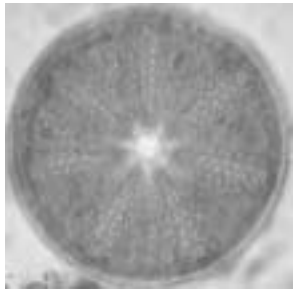


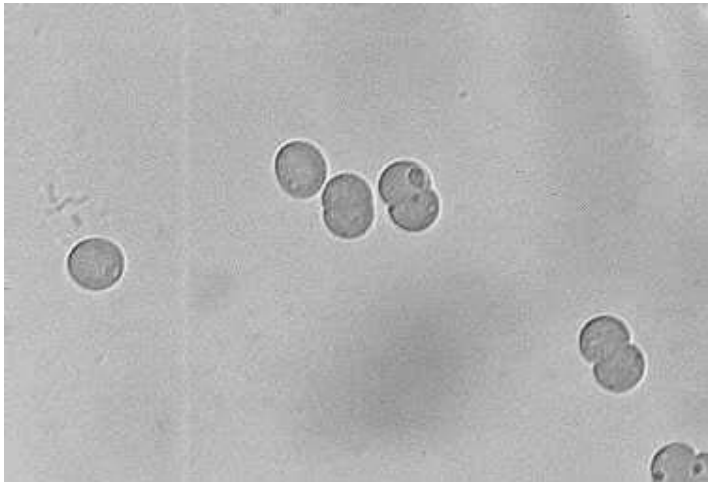
19 cm long section of GISP 2 ice core from 1855 m showing annual layer structure illuminated from below by a fiber optic source. Section contains 11 annual layers with summer layers (arrowed) sandwiched between darker winter layers.

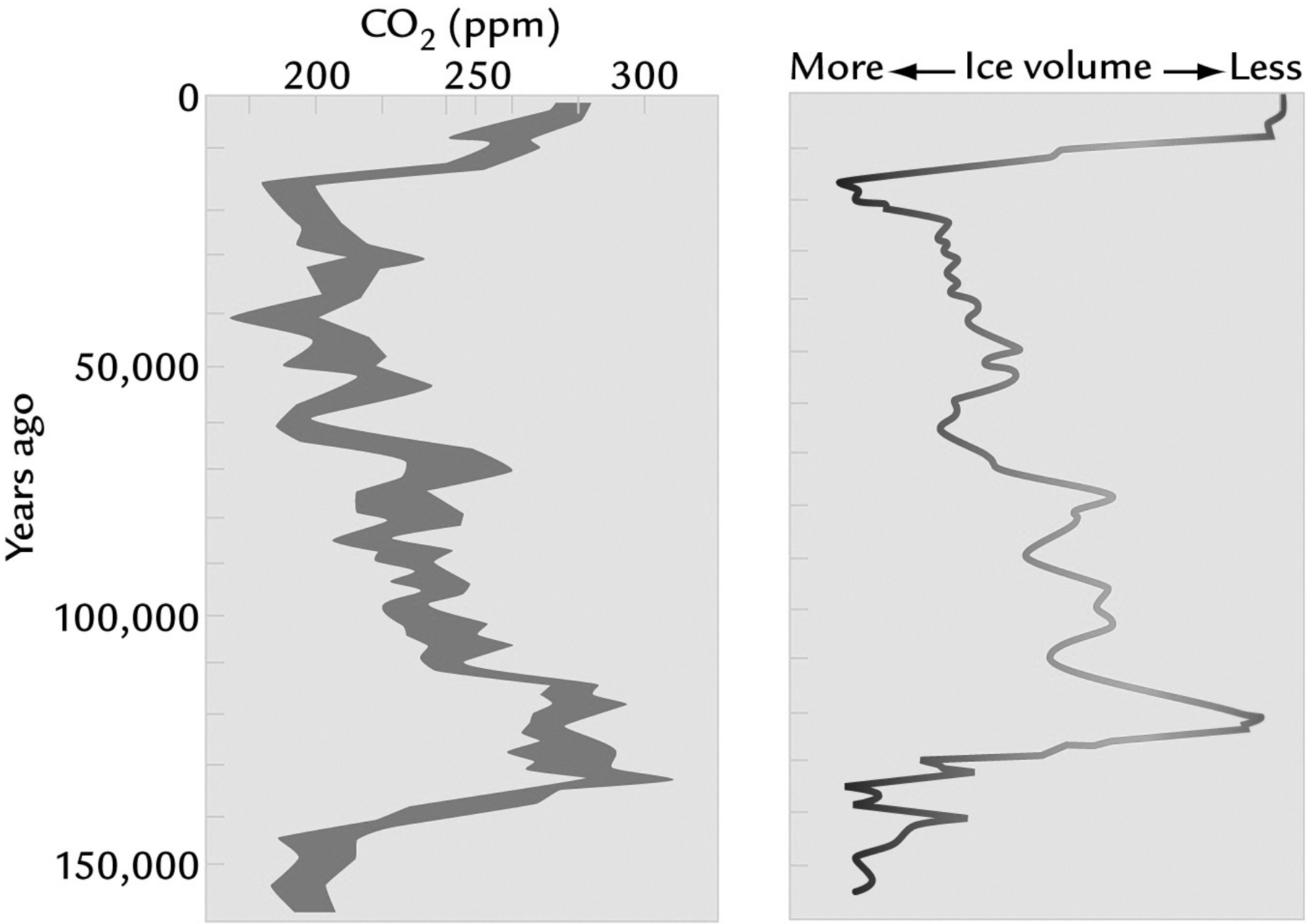

Local temperature change /°C
2
0
−2
−4
−6
−8
−10
METHANE
Methane concentration (ppmv)
0.7
0.6
0.5
0.4
1990 Level of CO_2
CARBON DIOXIDE
Carbon dioxide concentration (ppmv)
300
280
260
240
220
200
180
0
40
80
120
160
Age (thousand years before present)



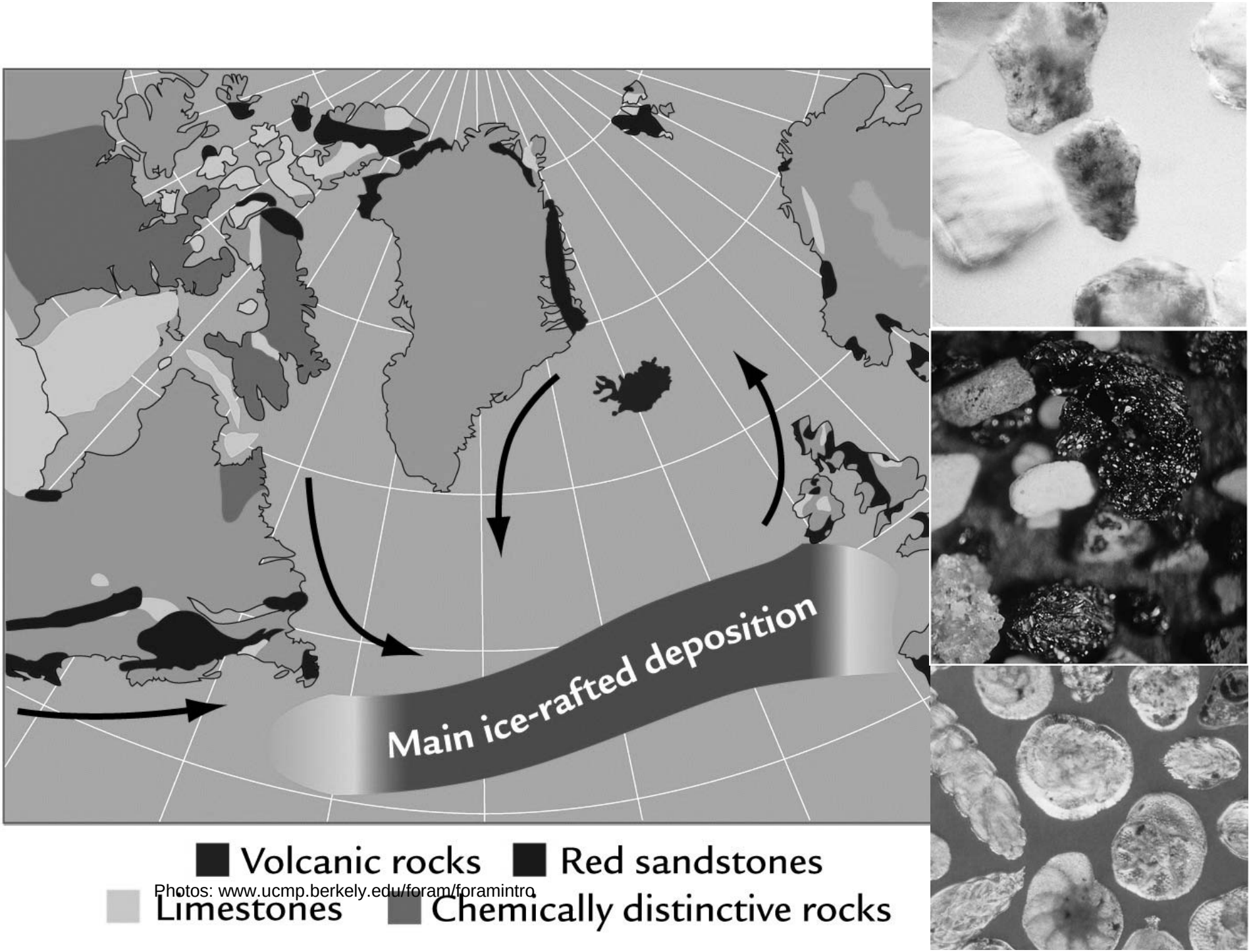




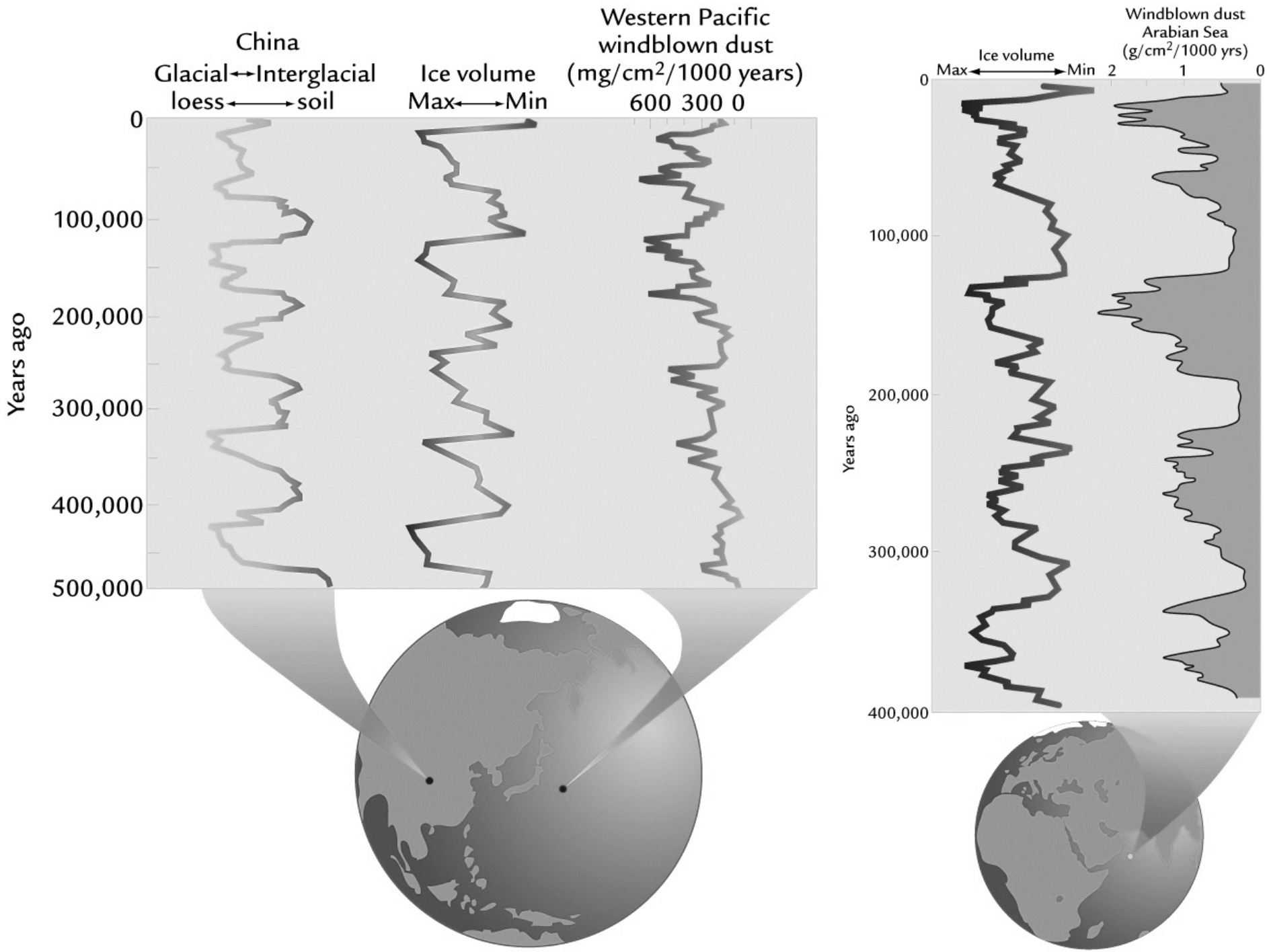


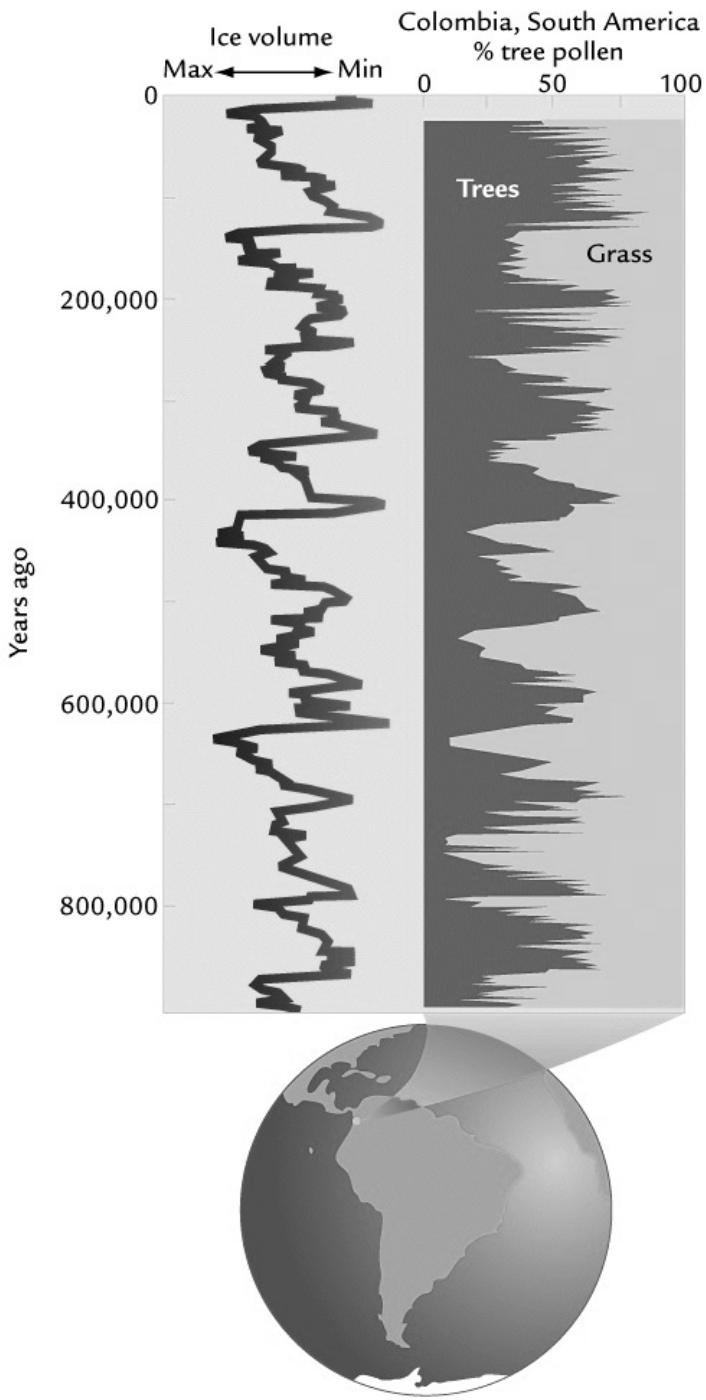

CO_2 (ppm)
200
250
300
0
50,000
100,000
150,000
Years ago
More ← Ice volume → Less

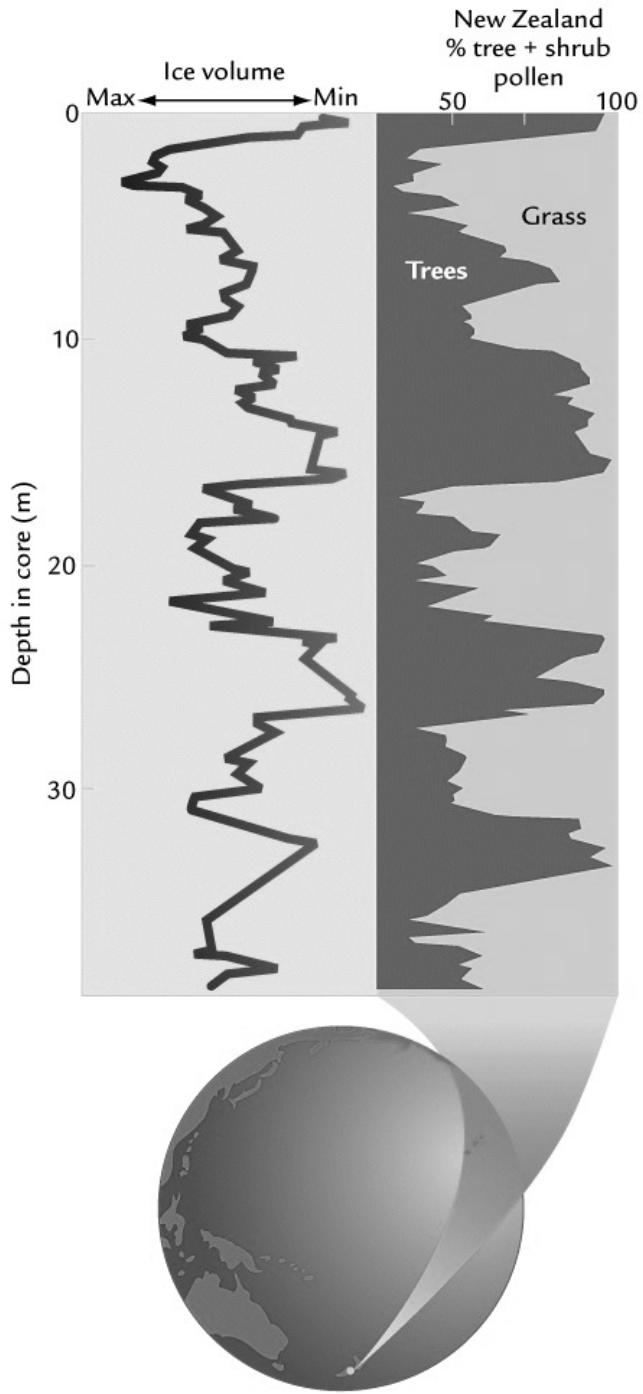
agiweb.org
nsf.gov
rcom.marum.de

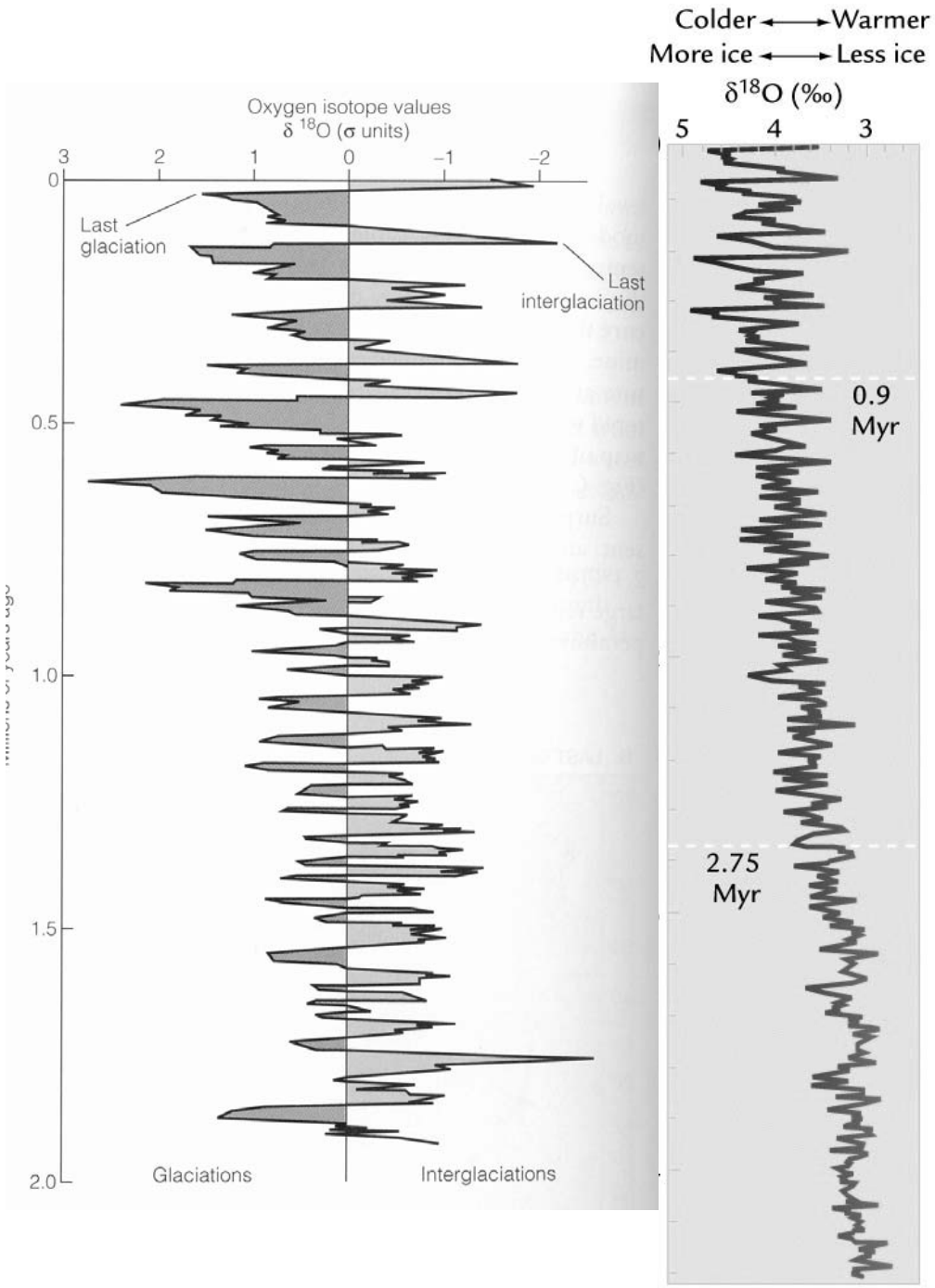


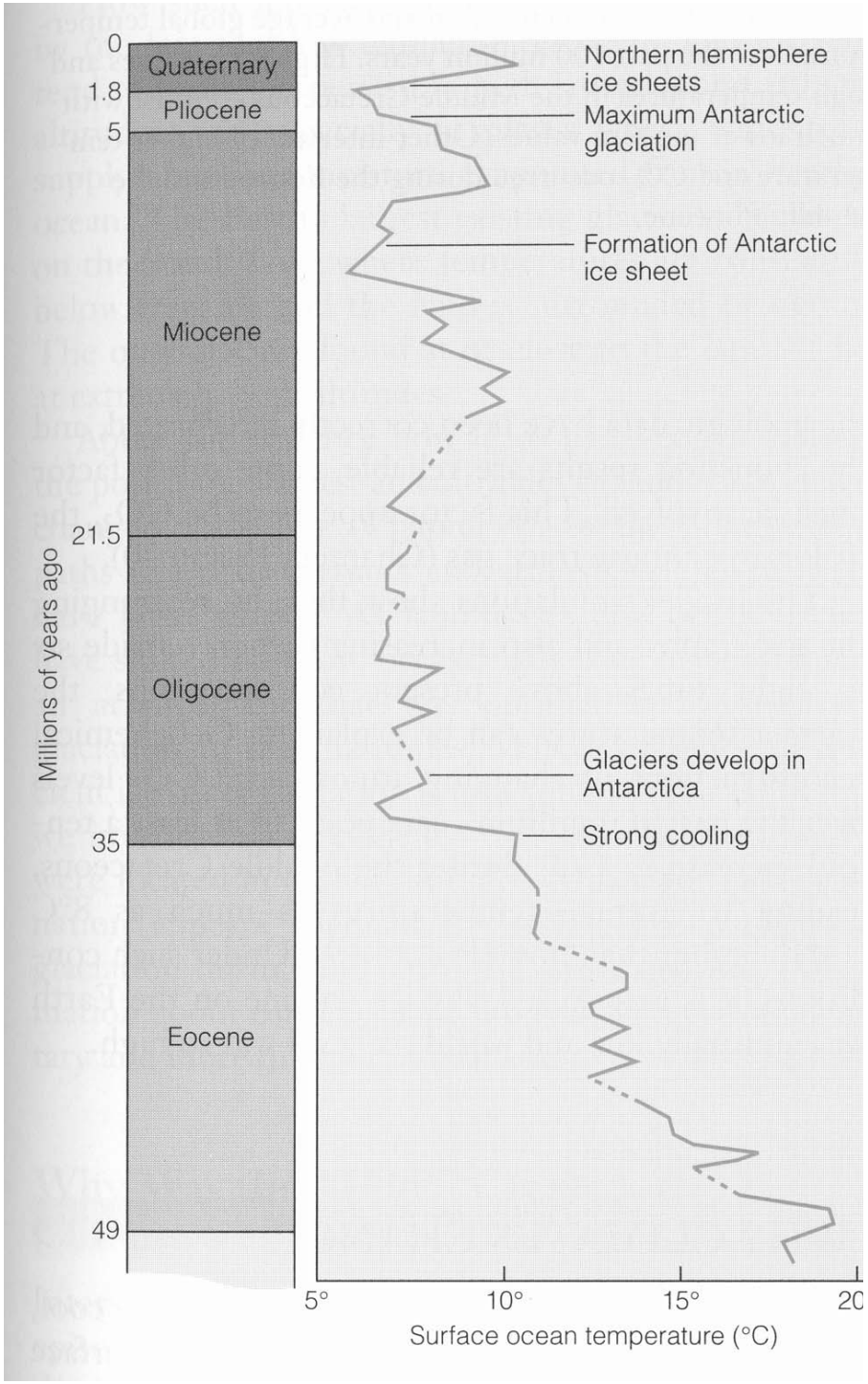
Photos: www.ucmp.berkely.edu/foram/foramintro

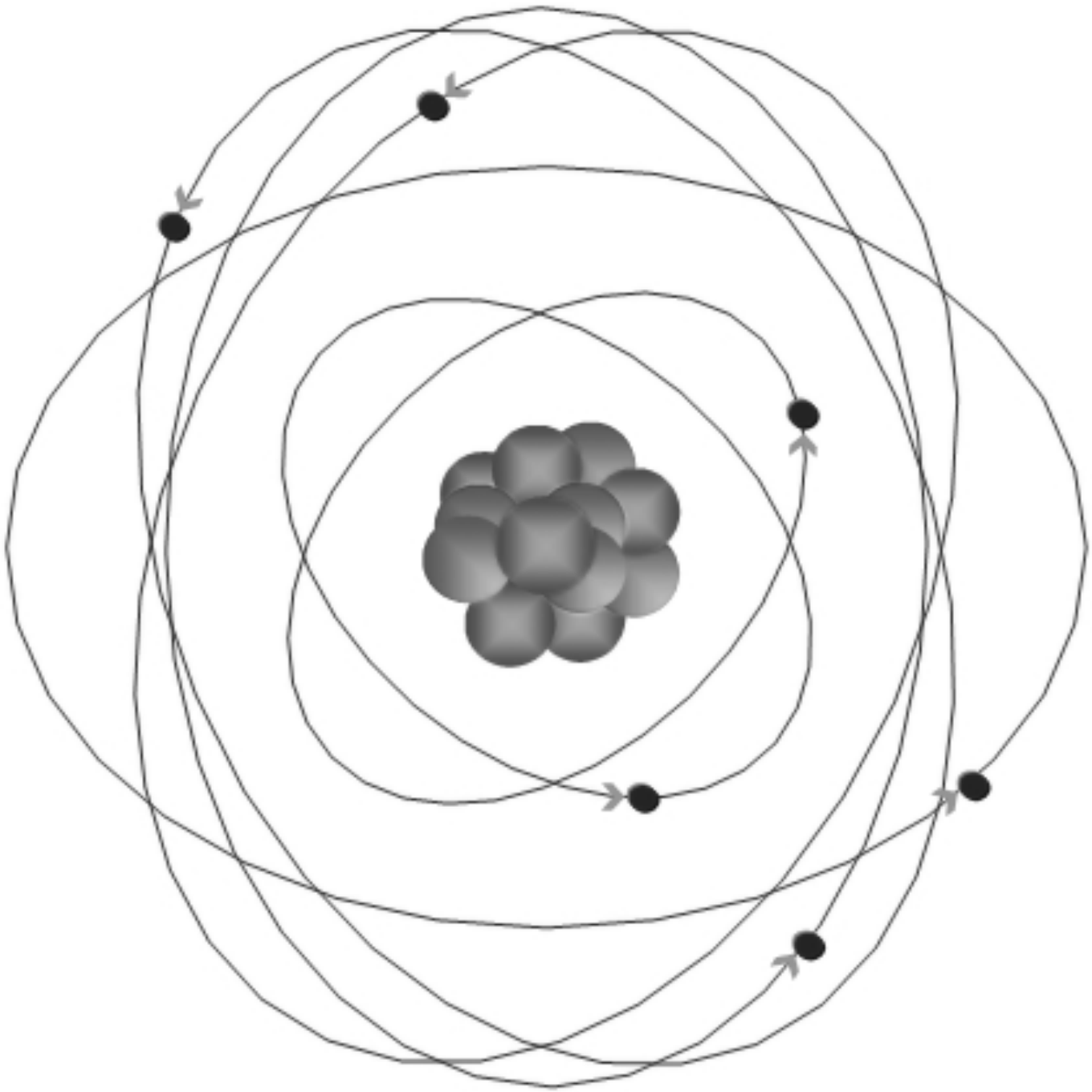

China
Glacial ↔ Interglacial
loess ← → soil
Ice volume
Max ← → Min
Western Pacific
windblown dust
(mg/cm2/1000 years)
600 300 0
Years ago
0
100,000
200,000
300,000
400,000
500,000
Ice volume
Max ← → Min
Windblown dust
Arabian Sea
(g/cm2/1000 yrs)
2 1 0
Years ago
0
100,000
200,000
300,000
400,000


Ice volume
Max
Min
Colombia, South America
% tree pollen
0
50
100
Trees
Grass
Years ago
0
200,000
400,000
600,000
800,000


Ice volume
Max
Min
New Zealand
% tree + shrub
pollen
50
100
Grass
Trees
Depth in core (m)
0
10
20
30

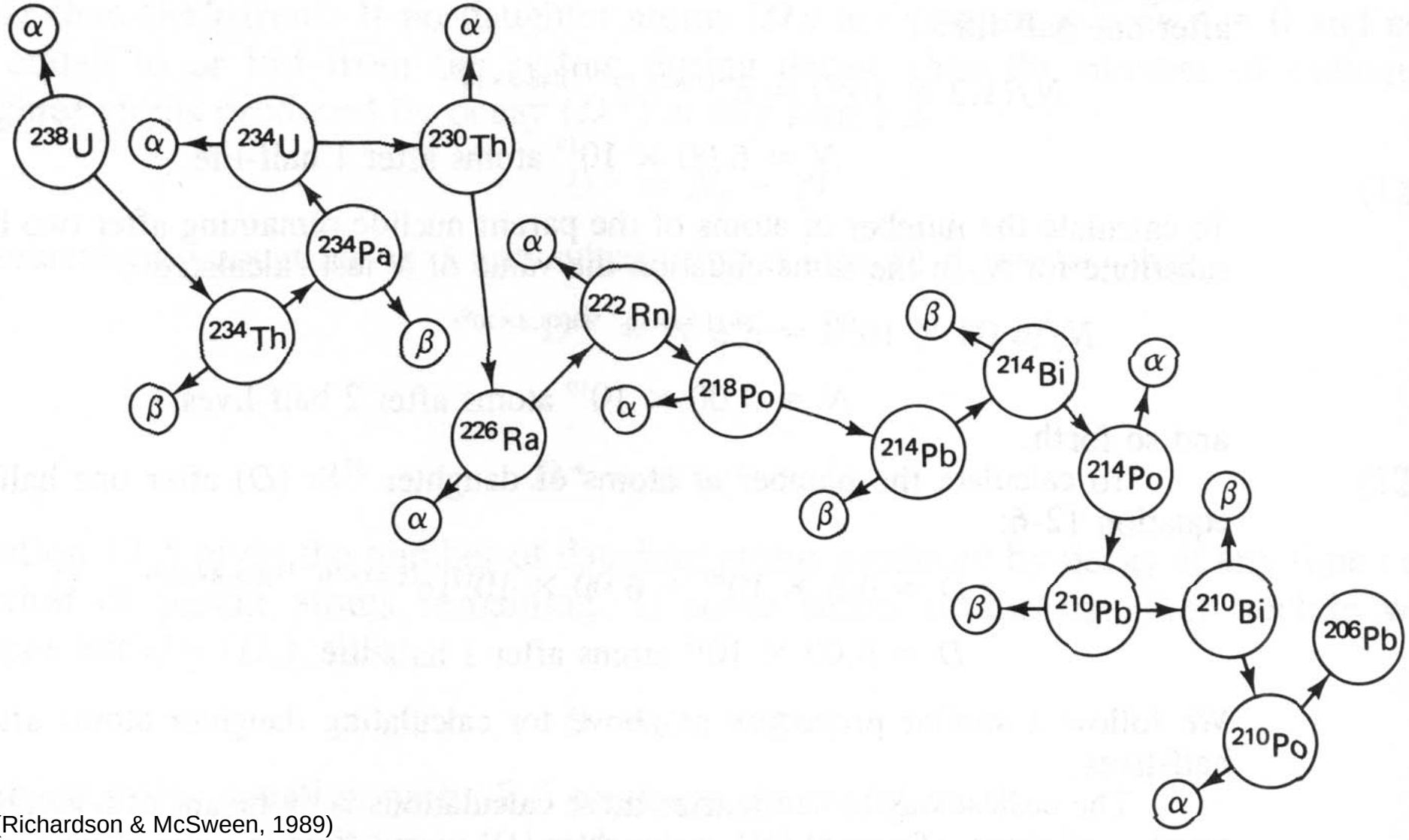

Oxygen isotope values
δ 18O (σ units)
3
2
1
0
−1
−2
0
0.5
1.0
1.5
2.0
Last glaciation
Last interglaciation
Glaciations
Interglaciations
Colder ⟷ Warmer
More ice ⟷ Less ice
δ18O (‰)
5
4
3
0.9 Myr
2.75 Myr


0
1.8
5
21.5
35
49
Quaternary
Pliocene
Miocene
Oligocene
Eocene
Millions of years ago
Northern hemisphere ice sheets
Maximum Antarctic glaciation
Formation of Antarctic ice sheet
Glaciers develop in Antarctica
Strong cooling
5°
10°
15°
20
Surface ocean temperature (°C)



carbon atom
vtaide.com

Isotopes



(Richardson & McSween, 1989)

TABLE 12-1 RADIONUCLIDES USED IN GEOCHRONOLOGY

Parent	Stable daughter	Half-life (yr)	Decay constant (yr^{-1})
Long-lived radionuclides			
^{40}K	^{40}Ar	1.25×10^{9}	5.54×10^{-10}
^{87}Rb	^{87}Sr	4.88×10^{10}	1.42×10^{-11}
^{147}Sm	^{143}Nd	1.06×10^{11}	6.54×10^{-12}
^{232}Th	^{208}Pb	1.40×10^{10}	4.95×10^{-11}
^{235}U	^{207}Pb	7.04×10^{8}	9.85×10^{-10}
^{238}U	^{206}Pb	4.47×10^{9}	1.55×10^{-10}
Short-lived radionuclides			
^{14}C	^{14}N	5.73×10^{3}	1.21×10^{-4}
Extinct radionuclides			
^{26}Al	^{26}Mg	7.20×10^{5}	9.60×10^{-7}
^{107}Pd	^{107}Ag	6.50×10^{6}	1.07×10^{-7}
^{129}I	^{129}Xe	1.60×10^{7}	4.30×10^{-8}
^{244}Pu	$^{131-136}Xe^{*}$	8.20×10^{7}	8.50×10^{-9}

*Many other fission products are also produced.

(Richardson & McSween, 1989)

<u>Key Minerals:</u>

1) volcanic mins interstratified btwn sed rx (K-spar; $KAlSi_3O_8$)
2) early diagenetic mins (YPO_4)
3) volcanic rx/mins that cross-cut, underlie, recycled into sed rx ($ZrSiO_4$)