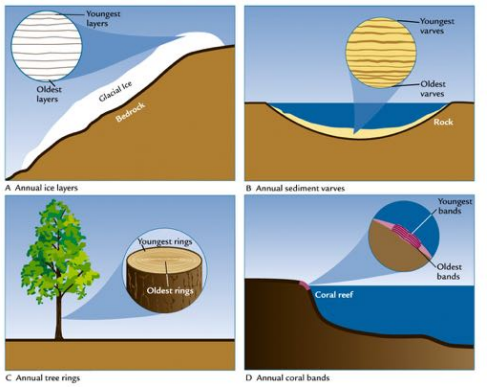
Sediment Records

Dr Christelle Not
Department of Earth Sciences
ENVS 2001: Laboratory and Field Methods



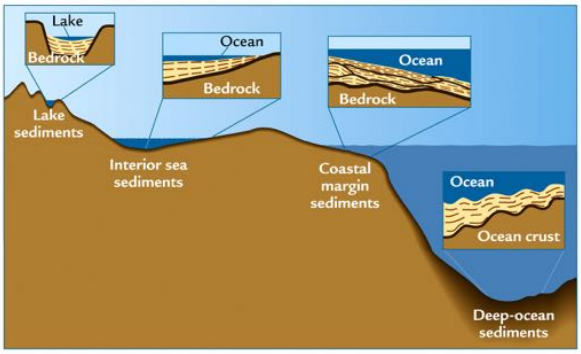
Ruddiman, 2001

Sediment Records

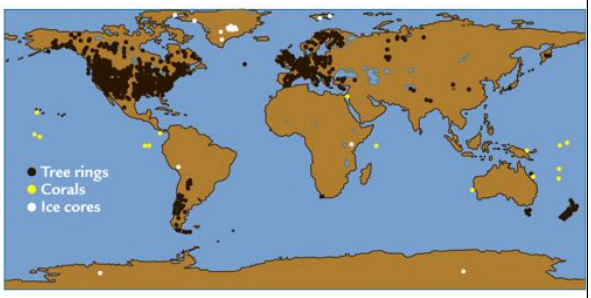
=

Which

How? When? What ?



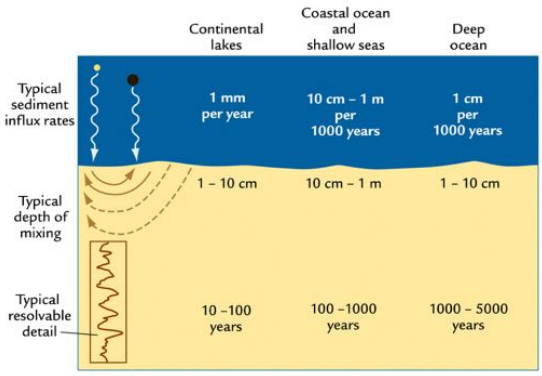
Ruddiman, 2001



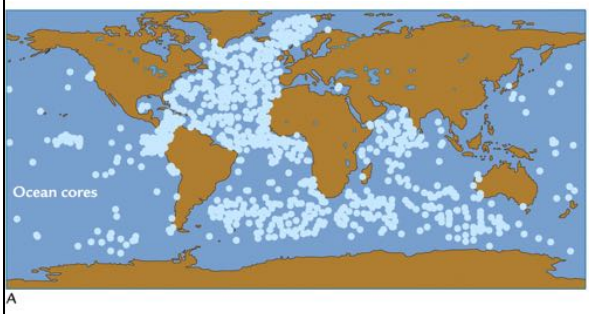
Ruddiman, 2001

Principles

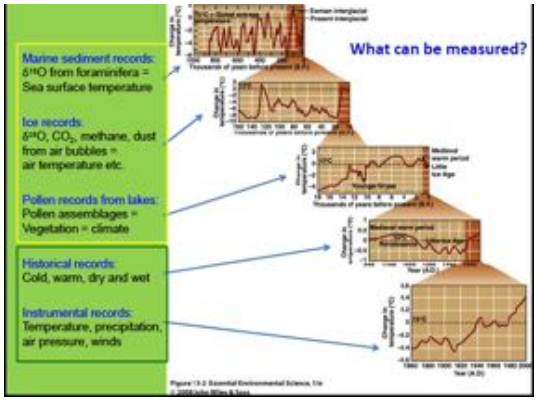
- A layer of sediment that is characterized by a combination of lithological/biological/ chemical properties, distinguishable from other layers
- Sediment layers found one above the other in a core, without an hiatus, must have formed in environments found one after the other, or side by side.



Ruddiman, 2001

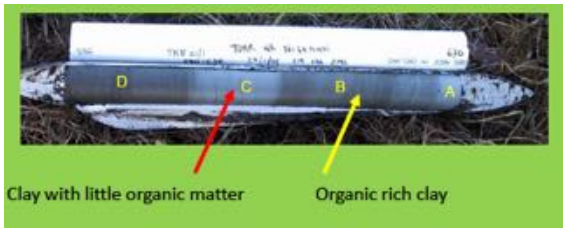


Ruddiman, 2001

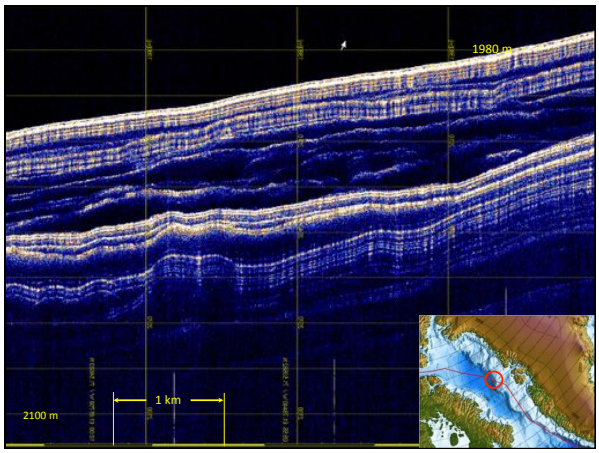


How?

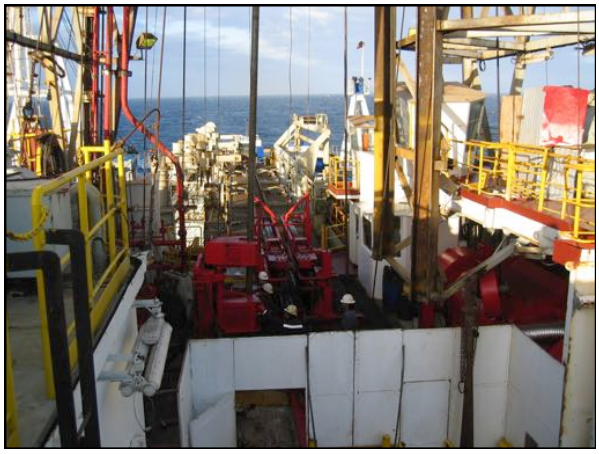
Coring techniques

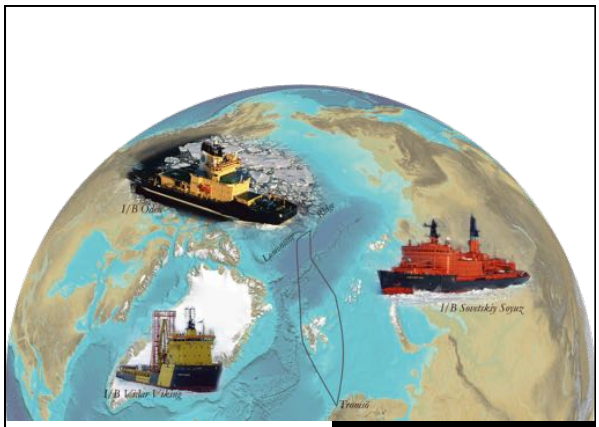


BIAUHAUS
BIAUHAUS


1980 m
2100 m
1 km

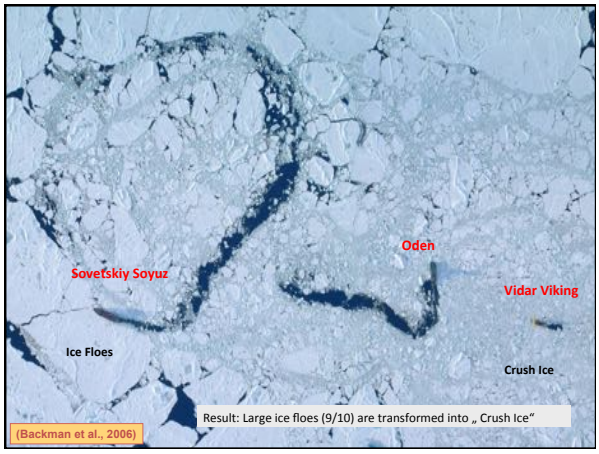
PS66/309-1
350-400cm



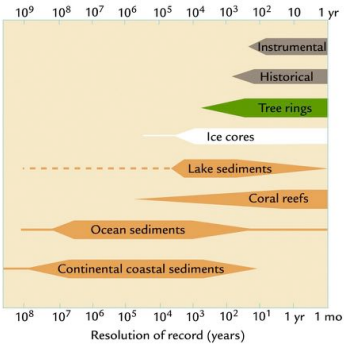


(Backman, Moran et al., 2006)

7 August - 13 September, 2004



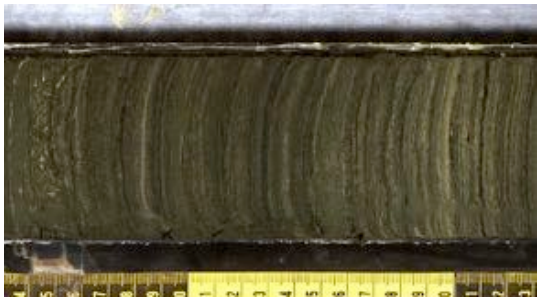
When ?

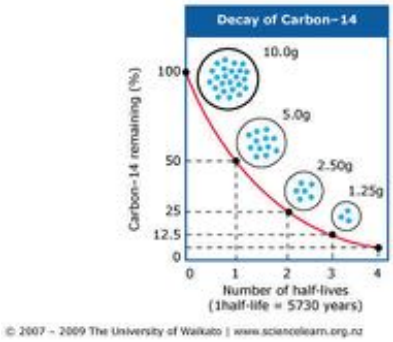


When ?

- Lithostratigraphy
- ^{14}C
- ^{18}O
- Biostratigraphy
- Paleomagnetism
- ^{210}Pb

Absolute vs relative




Decay of Carbon-14
10.0g
5.0g
2.50g
1.25g
Carbon-14 remaining (%)
100
50
25
12.5
0
0
1
2
3
4
Number of half-lives
(1half-life = 5730 years)
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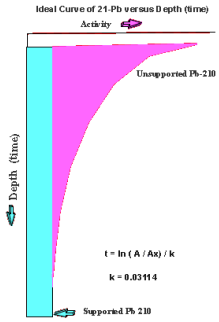
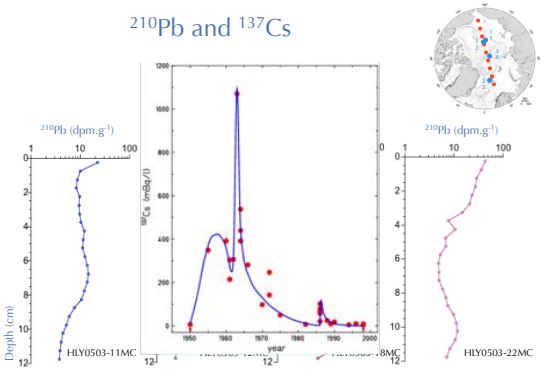
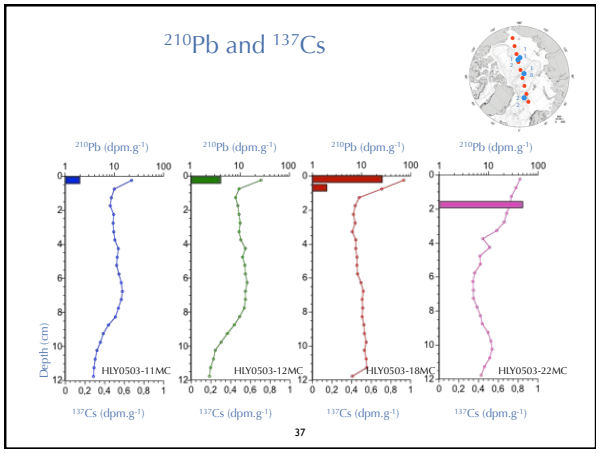
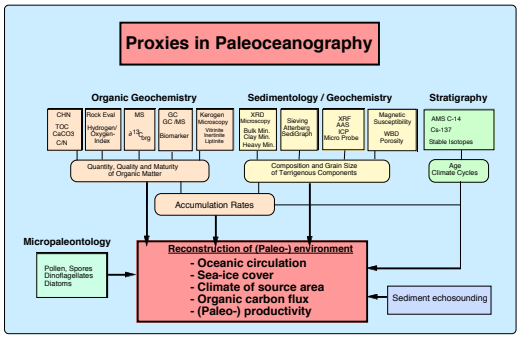
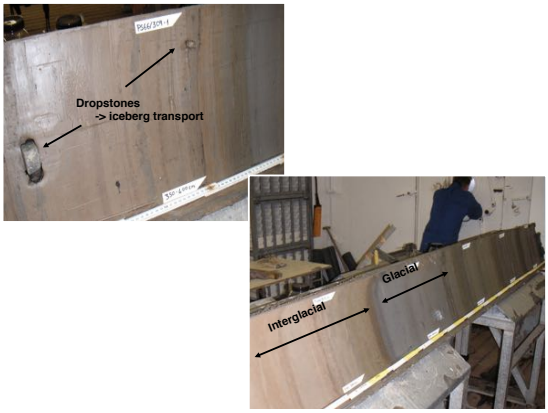

Ideal Curve of 21-Pb versus Depth (time)
Activity
Unsupported Pb-210
Depth (time)
t = ln (A / Ax) / k
k = 0.03114
Supported Pb 210

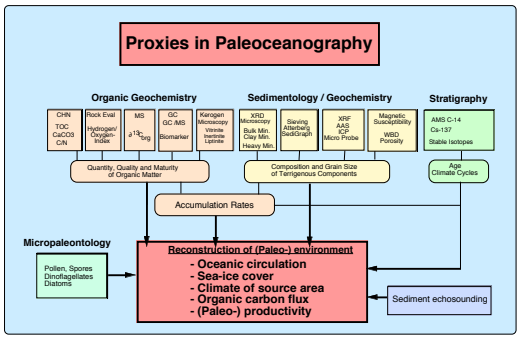

210Pb and 137Cs
210Pb (dpm.g-1)
Depth (cm)
HLY0503-11MC
137Cs (mBq/l)
year
210Pb (dpm.g-1)
HLY0503-22MC

36


210Pb and 137Cs
210Pb (dpm.g-1)
Depth (cm)
HLY0503-11MC
HLY0503-12MC
HLY0503-18MC
HLY0503-22MC
137Cs (dpm.g-1)
37


What ?
Proxies in Paleoceanography
Organic Geochemistry
Sedimentology / Geochemistry
Stratigraphy
CHN
TOC
CaCO3
C/N
Rock Eval
Hydrogen/ Oxygen-Index
MS
GC
GC /MS
Biomarker
Kerogen Microscopy
Vitrinite
Inertinite
Liptinite
XRD
Microscopy
Bulk Min.
Clay Min.
Heavy Min.
Sieving
Atterberg
SedGraph
XRF
AAS
ICP
Micro Probe
Magnetic Susceptibility
WBD
Porosity
AMS C-14
Cs-137
Stable Isotopes
Quantity, Quality and Maturity of Organic Matter
Composition and Grain Size of Terrigenous Components
Age
Climate Cycles
Accumulation Rates
Micropaleontology
Pollen, Spores
Dinoflagellates
Diatoms
Reconstruction of (Paleo-) environment
- Oceanic circulation
- Sea-ice cover
- Climate of source area
- Organic carbon flux
- (Paleo-) productivity
Sediment echosounding


Dropstones
-> iceberg transport
Glacial
Interglacial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Stratigraphy
Quantity, Quality and Maturity of Organic Matter
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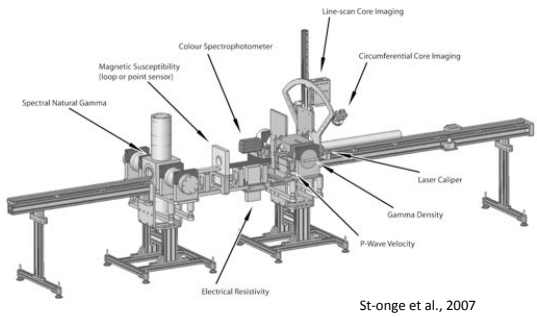
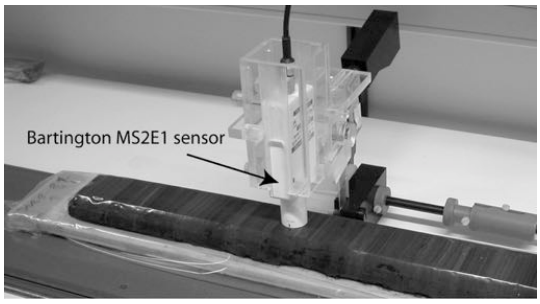
Sediment echosounding

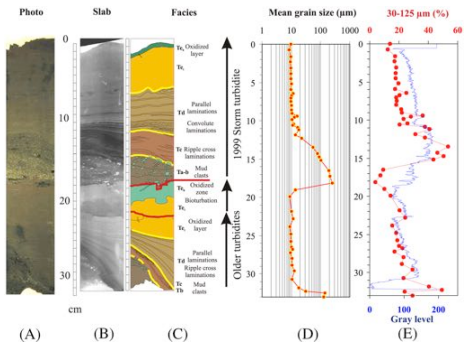
Multi-sensor core logger MSCL



St-onge et al., 2007



St-onge et al., 2007



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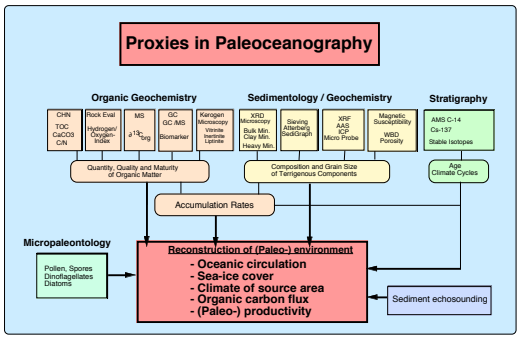
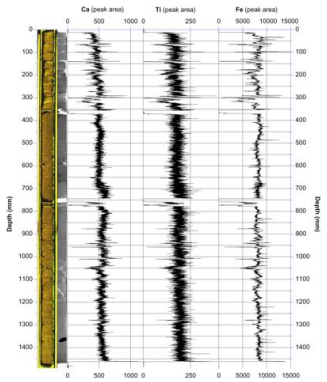
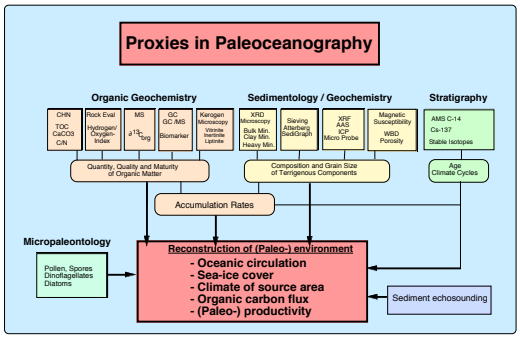
What ?





XRF

What ?



1 cm^3 (~ 1 g of sediment)

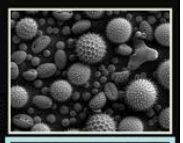
Calcareous microfossils
→ 10^2-10^5 foraminifera
→ 10^9 coccoliths
+ pteropodes, ostracods…

Siliceous microfossils
→ 10^6 diatoms
+ radiolaria, silicoflagellates....

Organic walled microfossils
→ 10^2-10^5 dinocysts
→ 10^1-10^5 pollen grains
+ spores of pteridophytes, tintinnids, chlorococcale algae, organic linings of foraminifers, copepod eggs, etc.

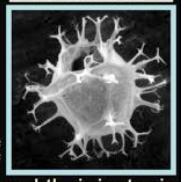
Some proxies of climate and ocean changes in high latitudes

Pollen from terrestrial vegetation
→ Terrestrial climate



Pollen grains from flowering plants

Organic-walled dinoflagellate cysts
→ Sea-surface temperature and salinity, sea-ice cover



Spiniferites ramosus

Globigerina bulloides

Planktonic foraminifers and their isotopic composition ($\delta^{18}O$ and $\delta^{13}C$)
→ Temperature conditions in surface and sub-surface water masses

Pollen: function – pollination to enable seed production

Pollen: formed in the anther (male part of the flower); function is to fertilise the stigma (the female organ of the plant). Pollen needs to transfer from one plant to another & has features which help it do this.

Flowers

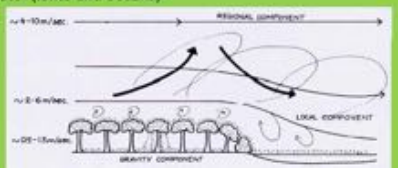
Pollen dispersal:
- most pollen types are wind pollinated
- some have large air sacs and can be transported 1000+ km
- some are sticky & insect pollinated
- produced in great numbers, e.g. typical forest floor receives 30000 – 280000 pollen grains cm^{-2} yr^{-1}

Production, Disposal and Deposition:

Production – unquantifiable
hundreds thousands to several millions per tree

Dispersal routes (transportation) – indefinable
mostly by wind and rivers

Deposition – various processes
on ground (grasslands and peat bogs)
in water (lakes and oceans)



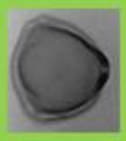
Pollen types

Grass (Poaceae)

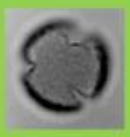
Alder (*Alnus*)

Chenopodiaceae

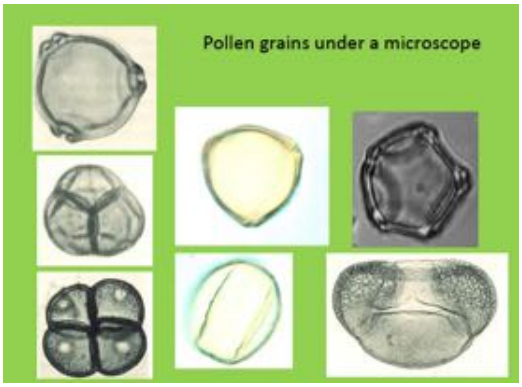
Pine (*Pinus*)

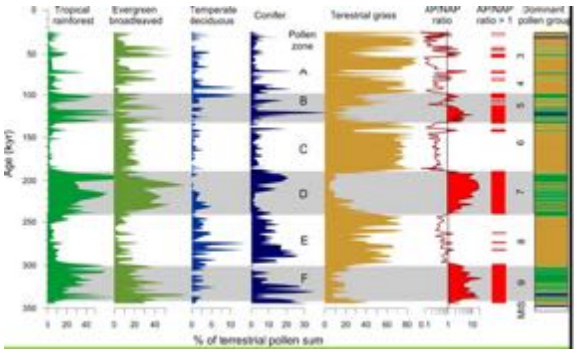


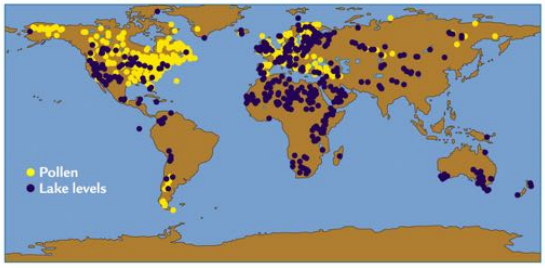
Hazel (*Corylus*)



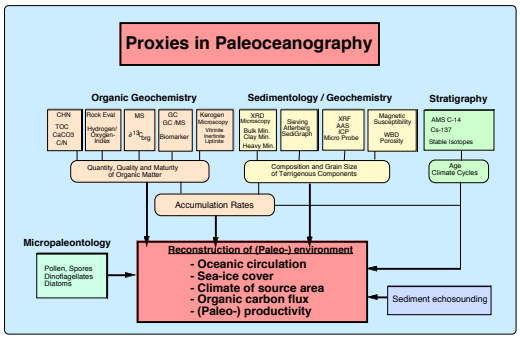
Oak (*Quercus*)


Pollen grains under a microscope


Tropical rainforest
Evergreen broadleaved
Temperate deciduous
Conifer
Terrestrial grass
AP/NAP ratio
AP/NAP ratio > 1
Dominant pollen group
Pollen zone
A
B
C
D
E
F
Age (kyr)
% of terrestrial pollen sum


Pollen
Lake levels

What ?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Sedimentology / Geochemistry
Stratigraphy
CHN
TOC
CaCO3
C/N
Rock Eval
Hydrogen/ Oxygen-Index
MS
δ13Corg
GC
GC /MS
Biomarker
Kerogen Microscopy
Vitrinite
Inertinite
Liptinite
XRD
Microscopy
Bulk Min.
Clay Min.
Heavy Min.
Sieving
Aerobag
SedGraph
XRF
AAS
ICP
Micro Probe
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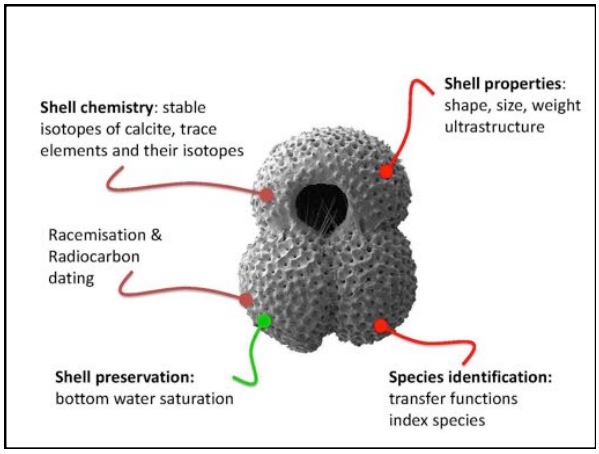
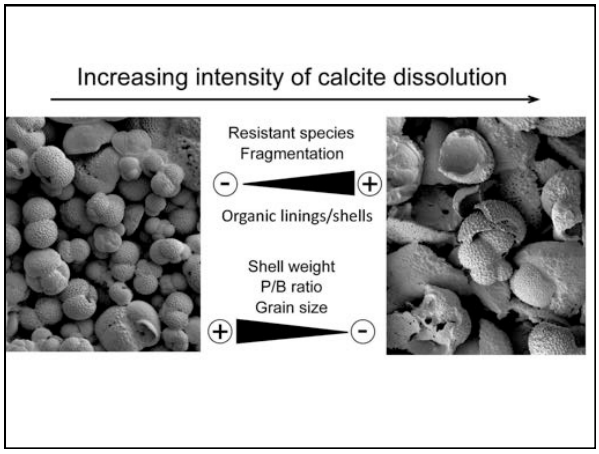
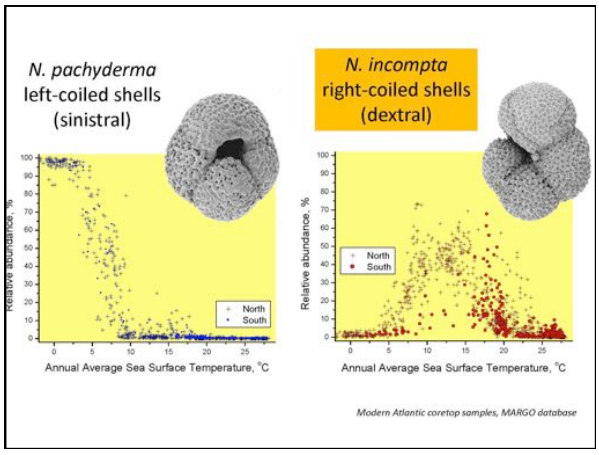






Isotopes

Atom consist of:

- electron in orbit
  - define chemical state (ionization)
  - number/distribution
- nucleus (mass) is composed of two types of nucleons (A)
  - protons, Z (charged), defined the element (chemistry)
  - neutrons, N (no charge) add stability and mass

difference between 2 isotopes

$$A = Z + N$$

mass number — atomic number

^{1}H = 1 p + 0n (more commun; 99.985%)
^{2}H = 1 p + 1 n (deutérium; 0.015%)
^{3}H = 1 p + 2 n (tritium, radioactif isotope)

^{12}C = 6 p + 6 n (morecommun; ~98.89%)
^{13}C = 6 p + 7 n (stable isotope ~ 1.11%)
^{14}C = 6 p + 8 n (radioactif isotope)

^{16}O = 8 p + 8 n (~99.759%)
^{18}O = 8 p + 10 n (~ 0.204%)

A note on terminology

- Traditionally isotope information presented in δ notation, referred to a generally accepted/available standard:

$$\delta_X = \left(\frac{R_{\text{Unknown}}}{R_{\text{Standard}}} - 1\right) \times 1{,}000\ ‰$$

Composition isotopique – généralités/suite

$\delta\ ^{18}O = [(^{18}O/^{16}O_{sample} - ^{18}O/^{16}O_{std})/\ ^{18}O/^{16}O_{std}]x10^{3}$

= ‰

Carbonate Std= PDB (Pee Dee Belemnite, fossile)
Std Water= SMOW (Standard Mean Ocean Water, from International Atomic Energy Agency, Vienne, 20ml = 3000 HK$)

Oxygen-18

- Water, Ice
- Carbonates
- Silicates

- Trace:
  - Temperature
  - Ice volume
- Why?
  - Isotopic fractionation

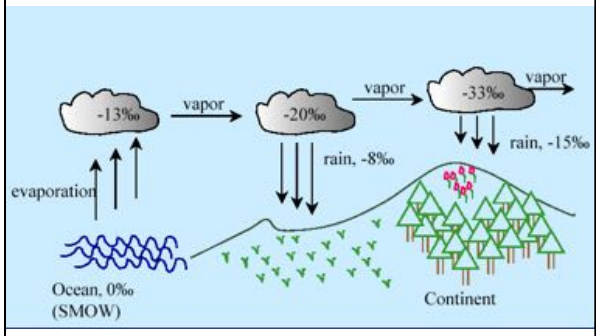
Isotopic fractionation

Isotopic Fractionation(ε): describes processes that affect the relative abundance of isotopes in a physical or chemical process

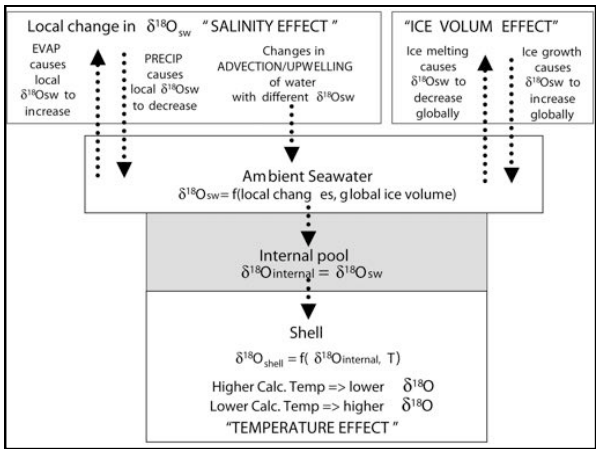
Equilibrium isotope fractionation is the partial separation of isotope between two or more substance in chemical equilibrium (strongest at low temperatures)

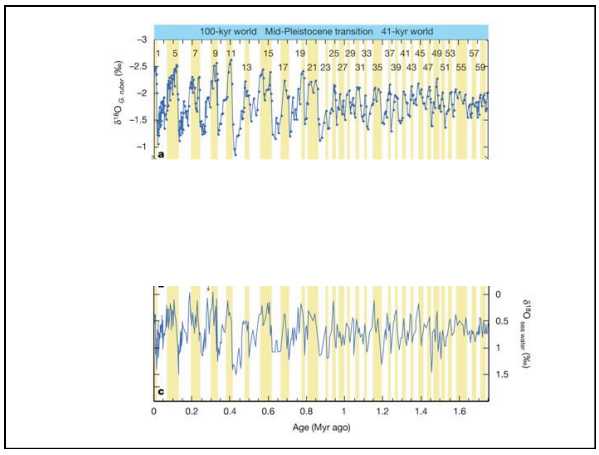
Kinetic fractionation is an isotopic fractionation process that separates stable isotopes from each other by their mass.

$\delta\ ^{18}O = [(^{18}O/^{16}O_{sample} - ^{18}O/^{16}O_{std.})/\ ^{18}O/^{16}O_{std.}]x10^3$

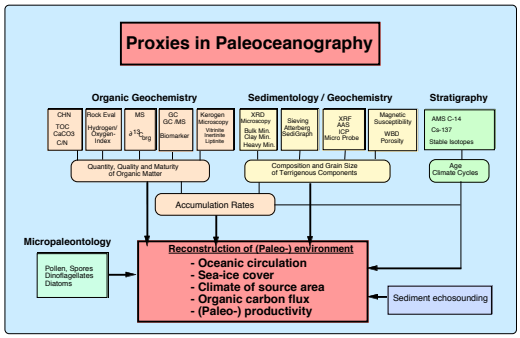


Fractionation (evaporation) is T dependant





What ?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Sedimentology / Geochemistry
Stratigraphy
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TOC
CaCO3
C/N
Rock Eval
Hydrogen/
Oxygen-
Index
MS
$\delta^{13}C_{org}$
GC
GC /MS
Biomarker
Kerogen
Microscopy
Vitrinite
Inertinite
Liptinite
XRD
Microscopy
Bulk Min.
Clay Min.
Heavy Min.
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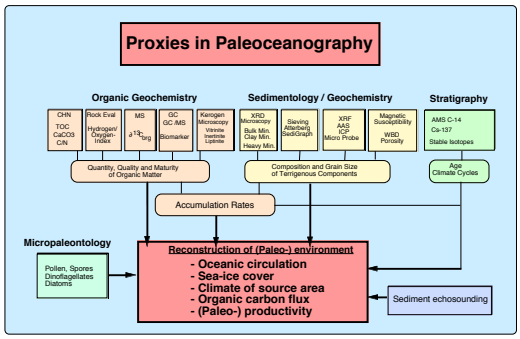
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