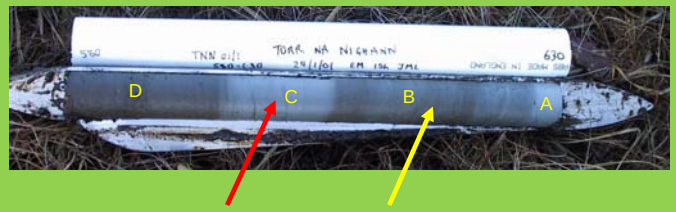
ENVS2001 /2014: Laboratory and Field Methods

Environmental stories from the sediment

Prof Y Zong
Department of Earth Sciences

A record of environmental history

A sediment sequence from a small lake



Clay with little organic matter

Organic rich clay

The local environment has changed several times.
What has changed?
Time?

Principles

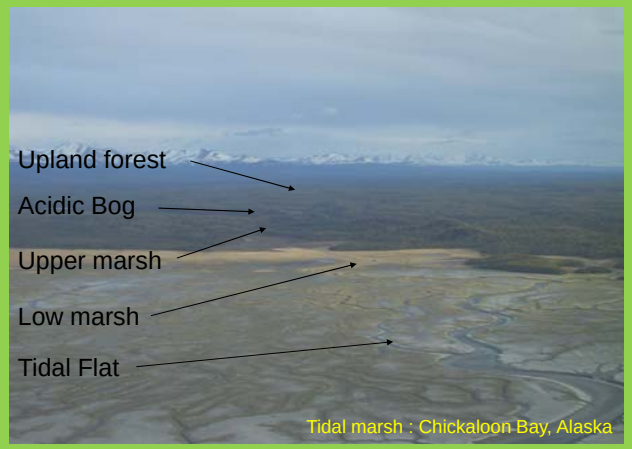
Lithostratigraphy, Biostratigraphy, Chronostratigraphy

A layer of sediment that is characterised by a combination of lithological/biological/chemical properties, distinguishable from other layers.

The vertical succession of sediment layers is produced by the progradation or lateral migration of one environment over another.

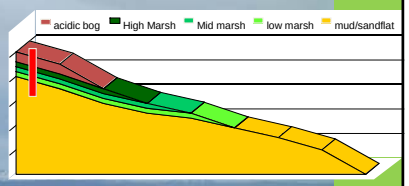
Therefore, sediment layers found one above the other in a core, without an **hiatus**, must have formed in environments found one after the other, or side by side.

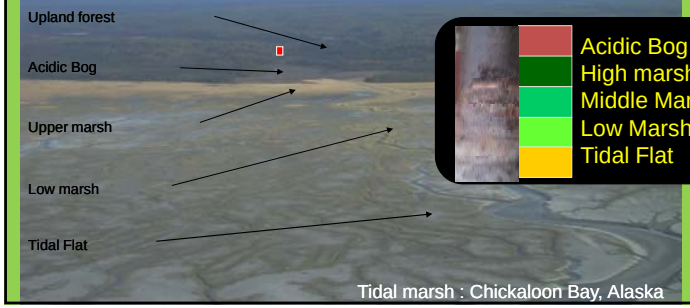
Spatial patterns of sedimentation



Environmental change expressed as sediment secessions

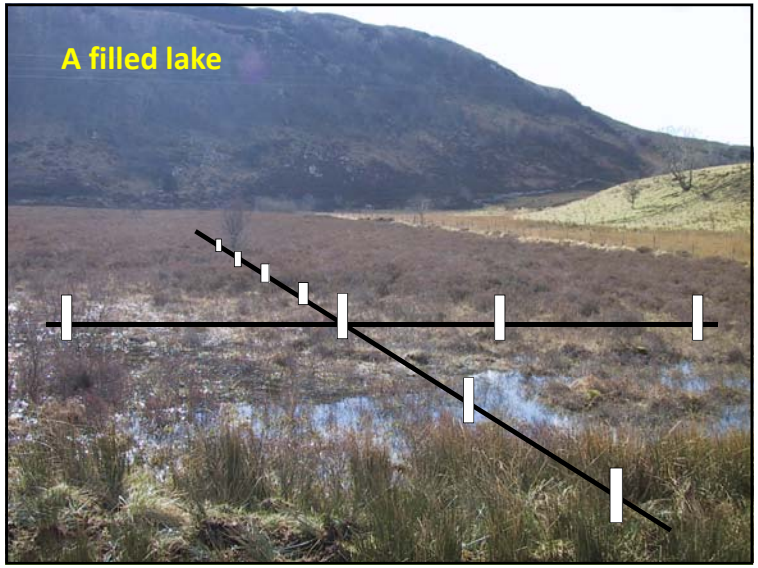
"The vertical succession of layers is produced by the progradation or lateral migration of one environment over another" - sediments found one above the other in a core, without an hiatus, must have formed in environments found side by side



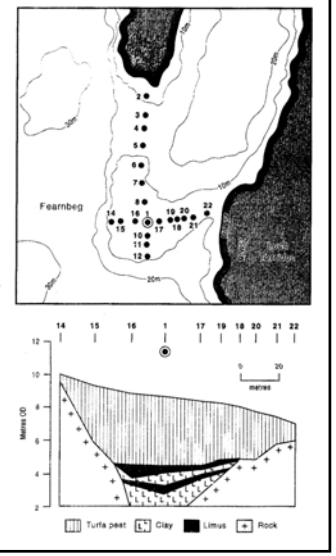


Tidal marsh : Chickaloon Bay, Alaska

Free-face sections



Transects of boreholes help us to understand the lithostratiphy of the site.



Climate change

What have changed? Temperature, precipitation, air pressure, wind

How can we measure changes that took place in the past?

We can only measure indirect evidence to meteorological parameters, which are called proxies.

Oxygen, hydrogen and carbon isotopes
Biological evidence (microfossils, coral, tree ring)

Ice cores
Sediment sequences (terrestrial or marine)

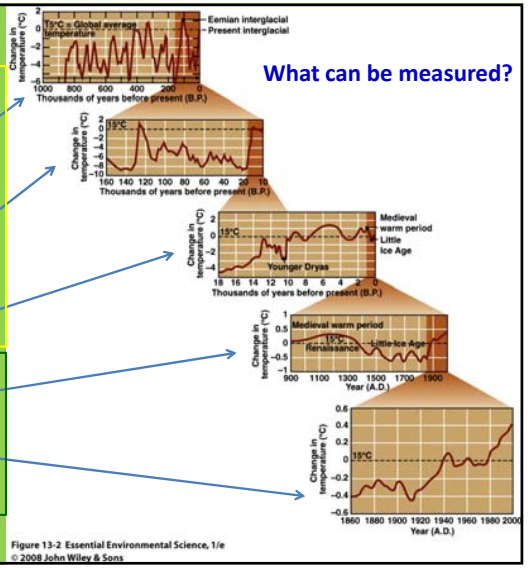
Marine sediment records:
$\delta^{18}O$ from foraminifera =
Sea surface temperature

Ice records:
$\delta^{18}O$, CO_2, methane, dust from air bubbles =
air temperature etc.

Pollen records from lakes:
Pollen assemblages =
Vegetation = climate

Historical records:
Cold, warm, dry and wet

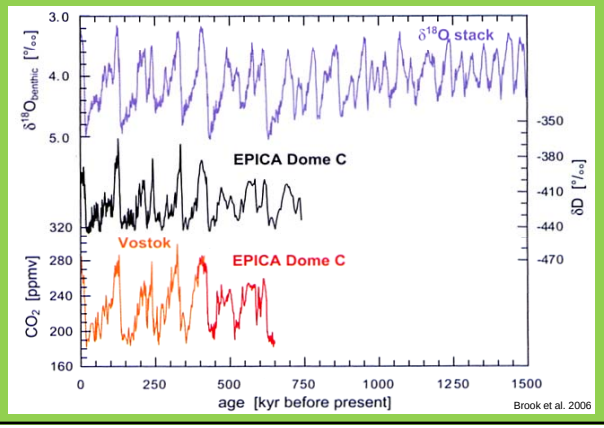
Instrumental records:
Temperature, precipitation, air pressure, winds



Oxygen ($d^{18}O$), Hydrogen (dD), carbon dioxide (CO_2), methane (CH_4) and dust

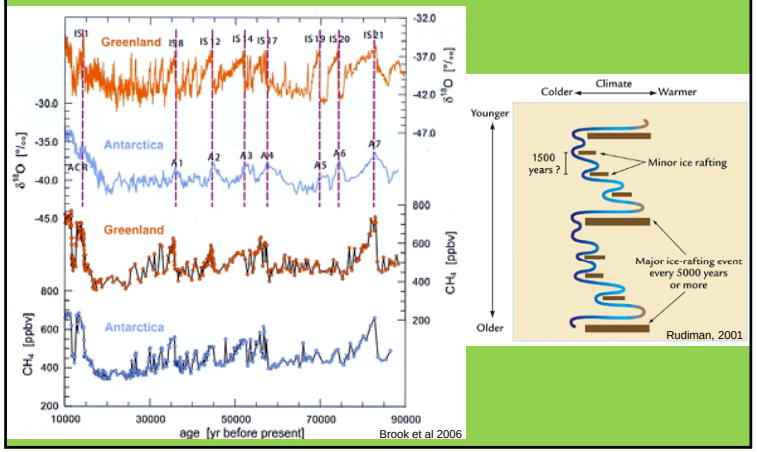
Pictures from NASA

Marine Records from the Atlantic and **Ice records** from Antarctica



Gradual cooling and rapid warming

Gradual growth and rapid collapse of northern ice sheets



Pollen records

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}

Mosses & Ferns: spores

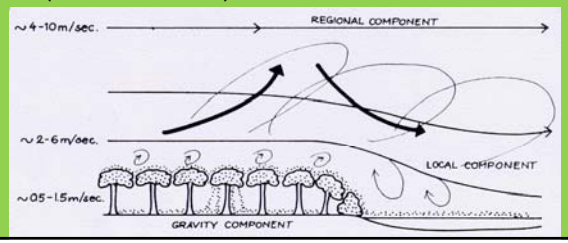
Spores perform a simpler process for reproduction – can germinate simply by arriving at a suitable site, e.g. soil surface.

Production, Disposal and Deposition:

Production – unquantifiable
hundreds thousands to several millions per tree

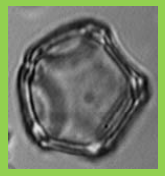
Dispersal routes (transportation) – indefinable
mostly by wind and rivers

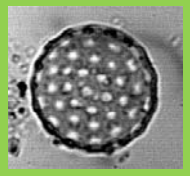
Deposition – various processes
on ground (grasslands and peat bogs)
in water (lakes and oceans)

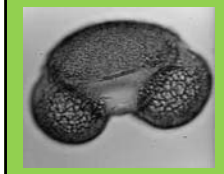


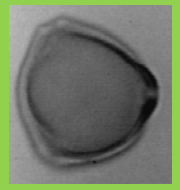
Pollen types


Grass (Poaceae)


Alder (*Alnus*)


Chenopodiaceae

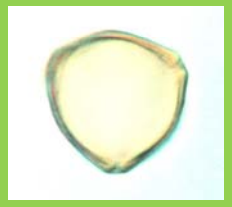
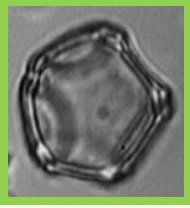
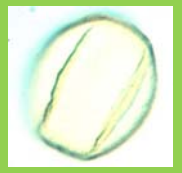

Pine (*Pinus*)


Hazel (*Corylus*)


Oak (*Quercus*)

Pollen grains under a microscope




Why is pollen analysis so useful?

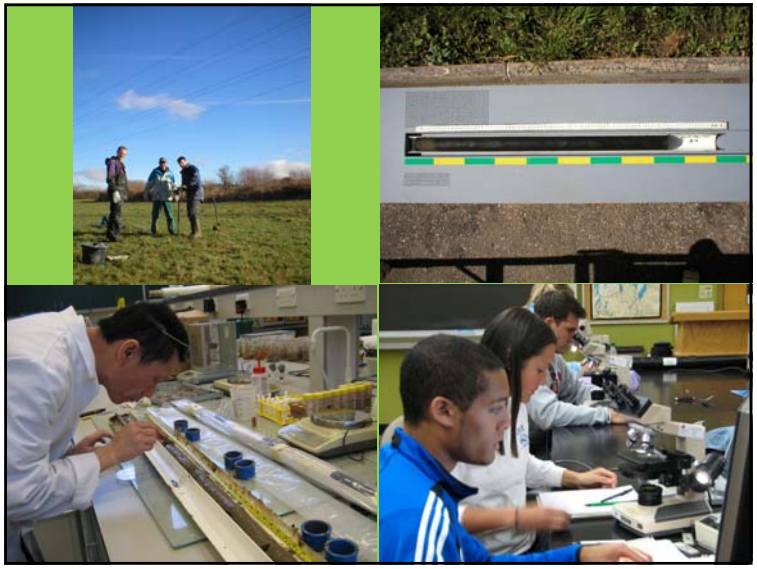
Pollen grains are extremely resilient and can be found in deposits in which other types of fossils have been destroyed.

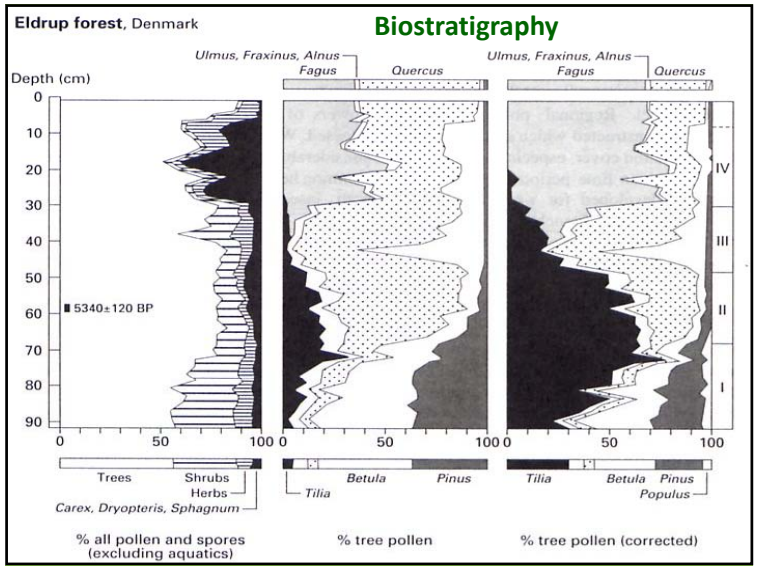
Pollen grains are produced in enormous numbers.

Pollen grains are more widely and more evenly spread than larger fossil.

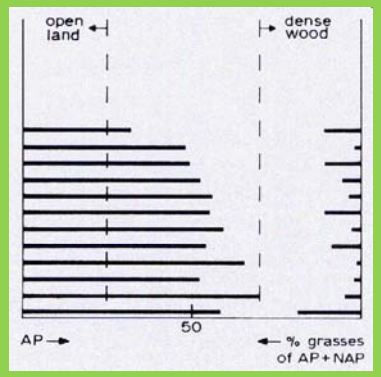
Pollen grains can be retrieved in great quantities, thus they can be treated statistically.

Vegetation = environmental conditions = climate



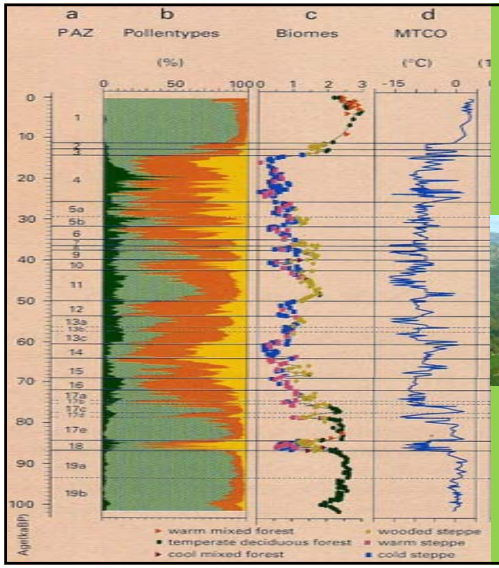


Changes between forest and grassland environments



Forest = warmer and/or wetter climate

Steppe (grassland) = cooler and/or dryer climate



Biostratigraphy

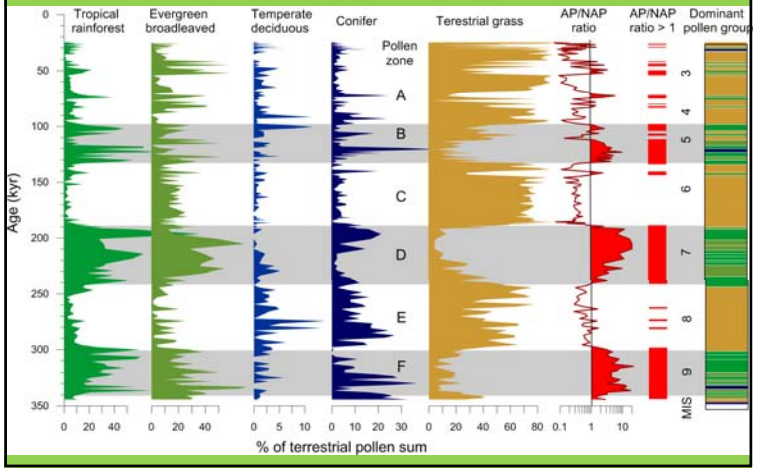
Pollen diagram from Italy
(Lake Grande di Monticchio)

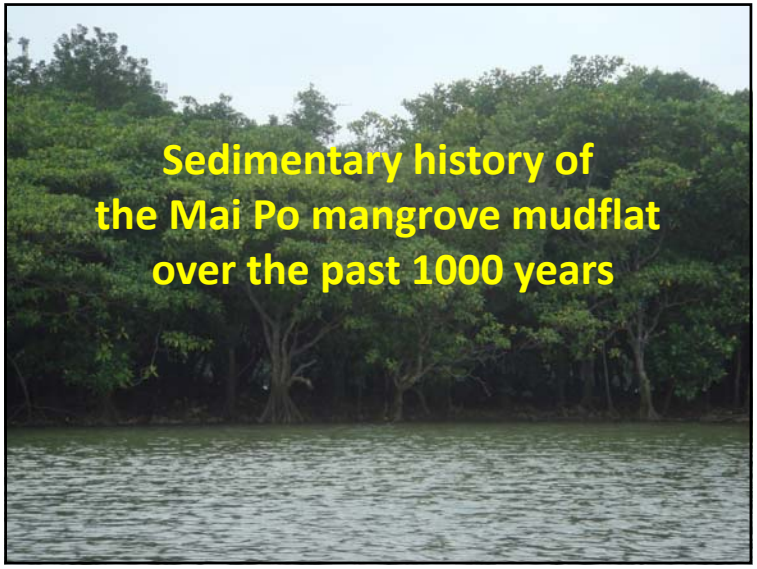
Dark/pale green – trees
Orange/yellow – grasses

Rapid changes in the tree/grass ratios reflect changes in precipitation and temperature

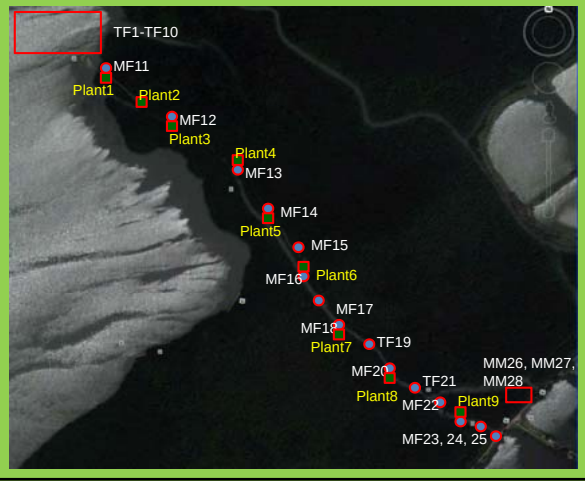
A pollen record from southern China

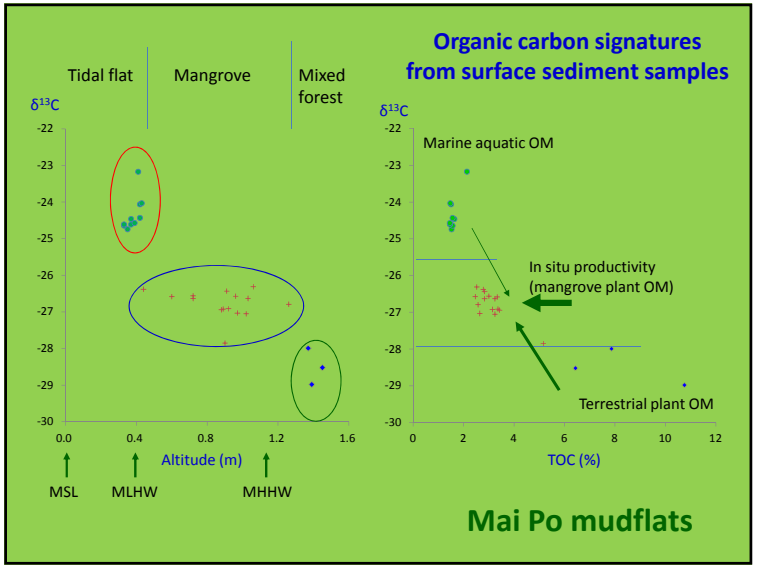
Showing glacial-interglacial changes





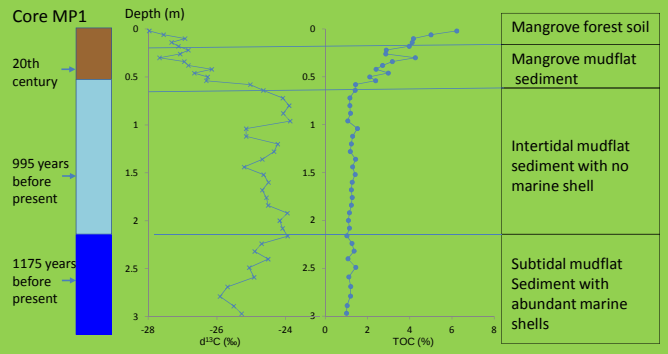
Surface sediment and plant samples were collected from mudflat and mangrove wetland



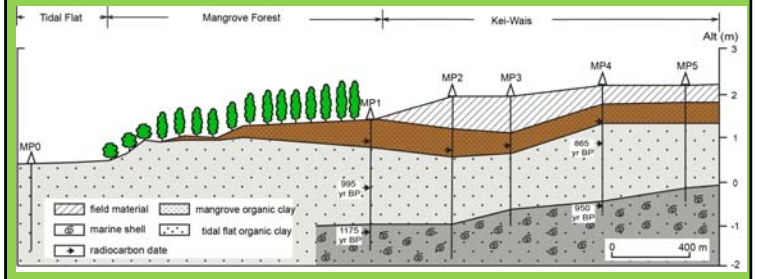


Sedimentary sequences were obtained from a number of locations using a Russian-type corer

Sedimentary history of Mai Po wetlands



Sedimentary sequences across Mai Po wetlands

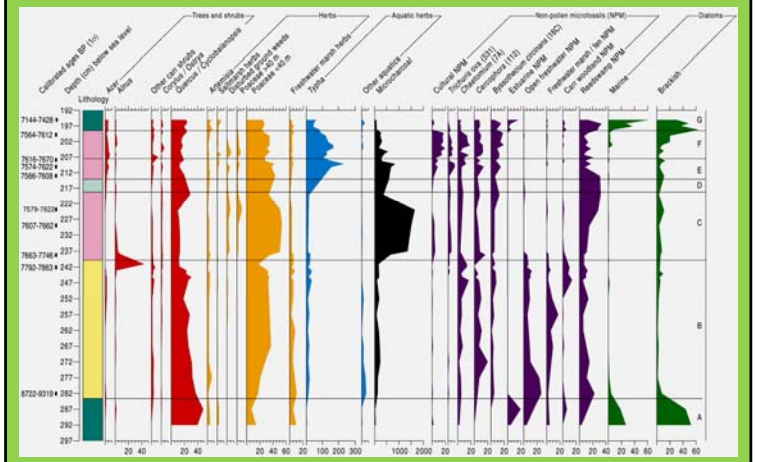


- Prior to 1000 years ago, Mai Po was under subtidal conditions.
  (when Castle Peak Peninsula was an island)
- By c. 800 years ago, a mudflat emerged, and soon after sedimentation reached its equilibrium state.
- Mangrove forest colonised seawards passing MP1 by late 19th century.
  (first major reclamation at Ping Shan Creek in 1920, and *kei wais* at Mai Po were constructed by c. 1950)

Human impacts – evidence of human activity

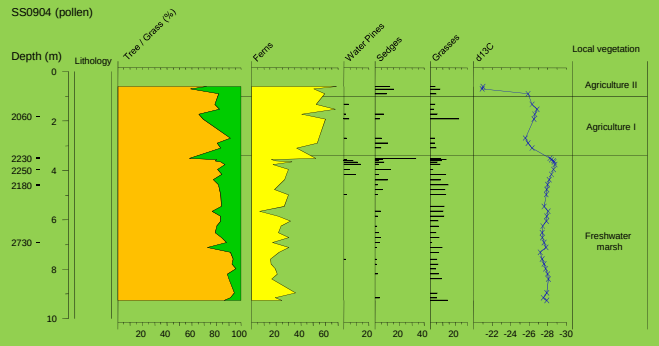
A profile from Tianluoshan, Zhejiang (south of Hangzhou Bay)

Kuahuqiao - Microfossils



$\delta^{13}C$ values

C3 plants	-27‰ to -30‰	(rice and many other crops)
C4 plants	-13.1±0.5 ‰	(sugarcane)



The tide was low, the wind was strong, but our spirit was high.

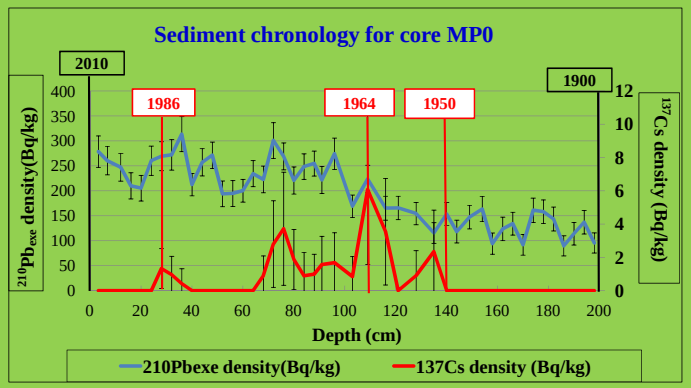
(Yongqiang, Deming and Chuen)
Sampling on Mai Po mudflat, March 20, 2011

The Russian-type corer and the undisturbed sediment

Laboratory methods:

Extract clay fraction
Digest trace metals out of solid sediment
Measure trace metal abundance

Result – ^{210}Pb and ^{137}Cs dating



Total Recoverable Metal concentration

Enrichment Factor

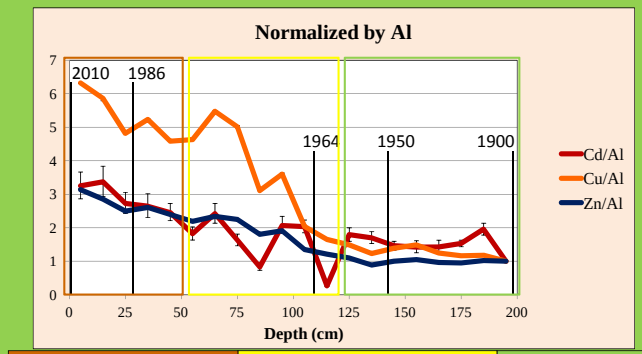
Application of naturally occurring metals as conservative tracers (Metal$_{ct}$) to compare enriched and background concentration of various metals

To determine the origins of metal input by:

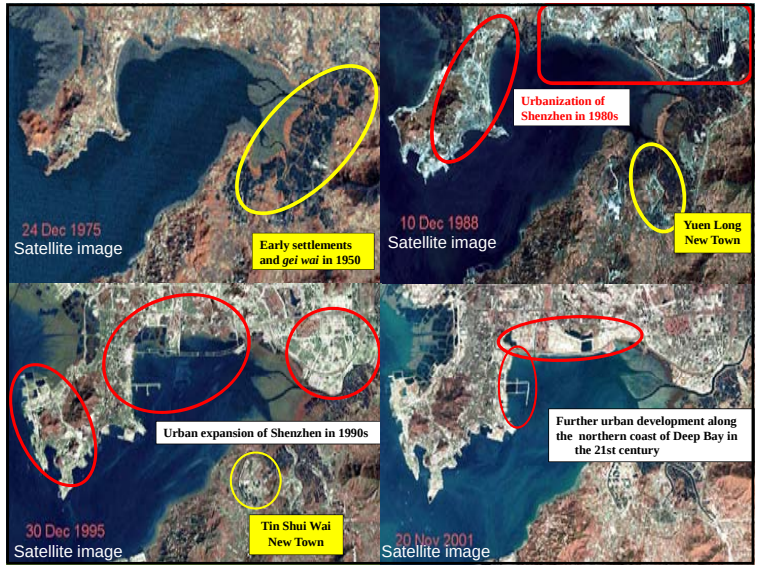
Industrial pollution / Natural geological background

Enrichment Factor	Implication
<1.0	*Depletion of that particular metal relative to background level*
=1.0	Natural (background) concentrations
1.0-1.5	*Enrichment but not necessarily from anthropogenic sources*
1.5-2.0	*An important portion of enrichment is from non-natural sources*
>2.0	Significant anthropogenic pollution

Metal Pollution in relation to economic development



Phase 3 – Industrial sources (1980 to present)	Phase 2 – Agricultural sources (1960-1980)	Phase 1 – Pre-industrial stage (before 1960)



Questions