Sedimentation rates by the ^{210}Pb method

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Introduction

Age of sediment – it's age of sediment expressed as number of years elapsed from deposition till time of collecting.

Sediment dating – establishing age of a given sediment layer

Methods of sediments dating:

1. **The methods based on known sequence of events:**
   - pollen dating
   - composition of sediment
2. **Radiometric methods:**
   - radiocarbon method
   - uranium-thorium method
   - **lead method**
   - potassium-argon method
   - rubidium-strontium method

The lead method

Application:

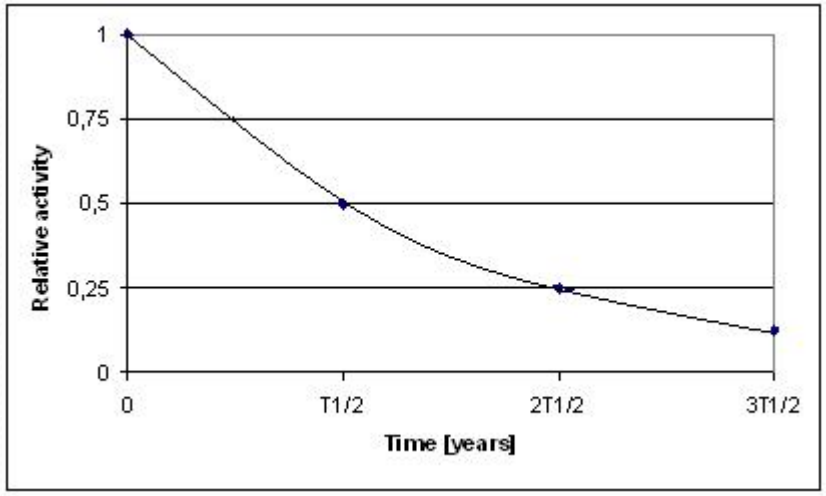
- material balance
- determination of sediment accumulation rates
- sediments dating

The lead method is widely used to determine the ages of sediments in coastal marine, estuarine and lacustrine environments.

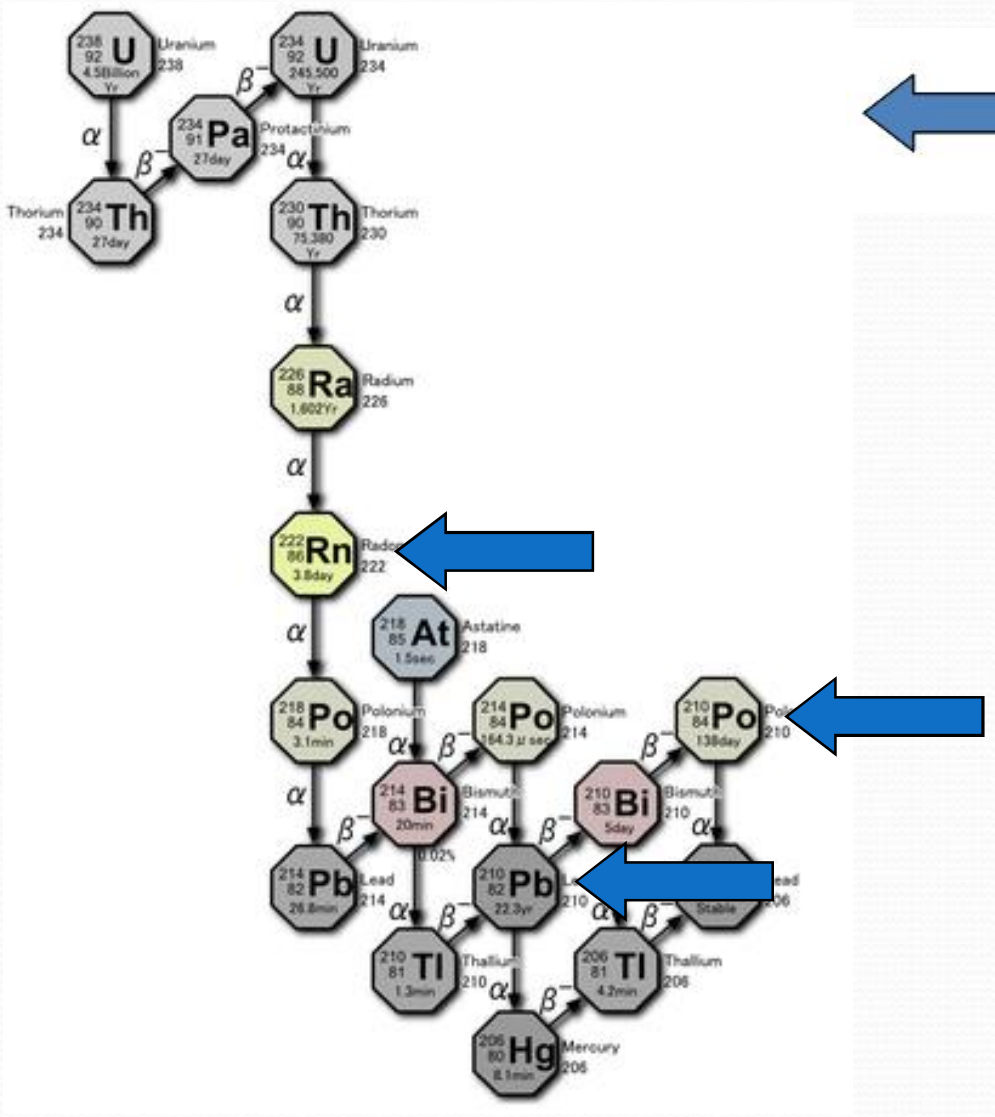
Lead method is based on measurements of ^{210}Pb activity– ^{210}Pb is the end product of the ^{238}U decay series.

^{210}Pb

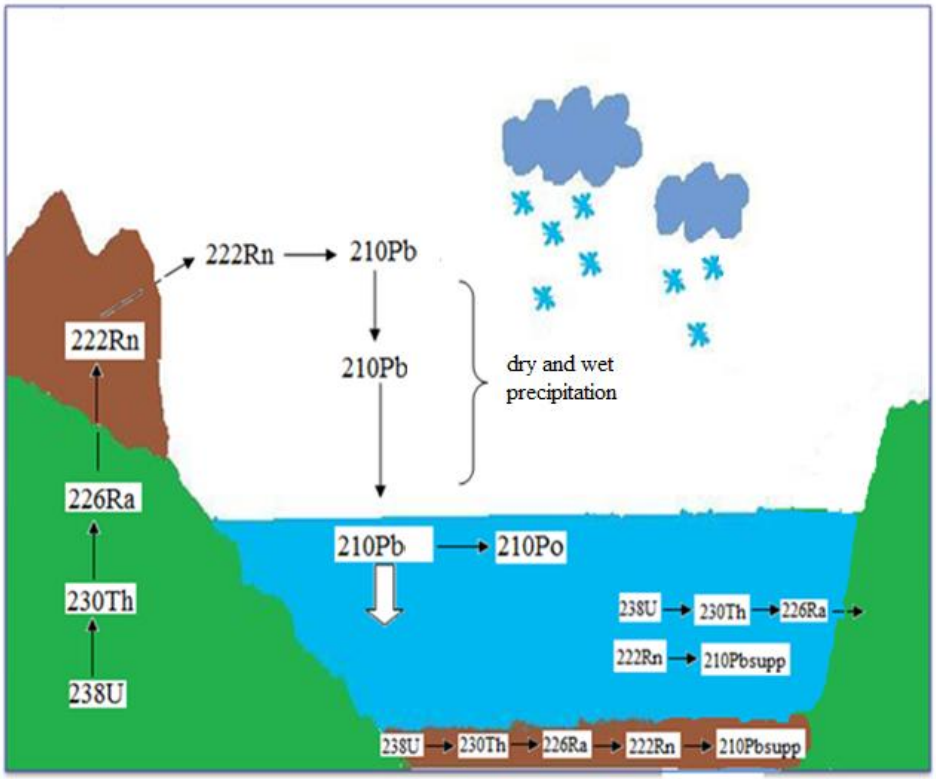
- Member of the uranium series (^{238}U – half life $4{,}47*10^9$ years)
- Natural radionuclide
- Half life – $T_{1/2}$ = 22,3 years



Uranium series



Lead cycle



The ^{210}Pb activity has two components:

- $^{210}Pb_{supp}$ – supported – deriving from ^{222}Rn decay within the sediment column
- $^{210}Pb_{ex}$ – excess – deriving from the atmospheric fallout of ^{210}Pb

$$^{210}Pb_{total} = {}^{210}Pb_{ex} + {}^{210}Pb_{supp}$$

Analytical procedure

0,1 g dry sediments

add 100ml ^{209}Po, 2ml $HClO_4$ 3ml HF, heat at 130-140 ^{0}C/5h

Digested sediment

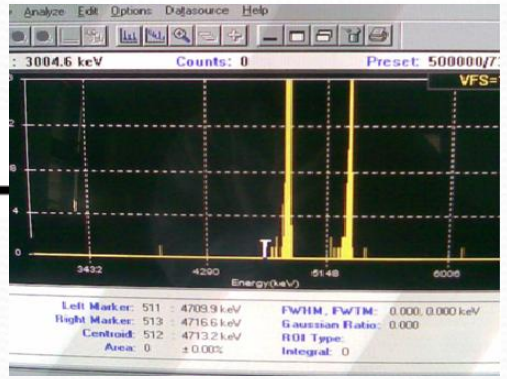
move by 6M HCl to evaporating dish and evaporate to dryness

Dry sediment

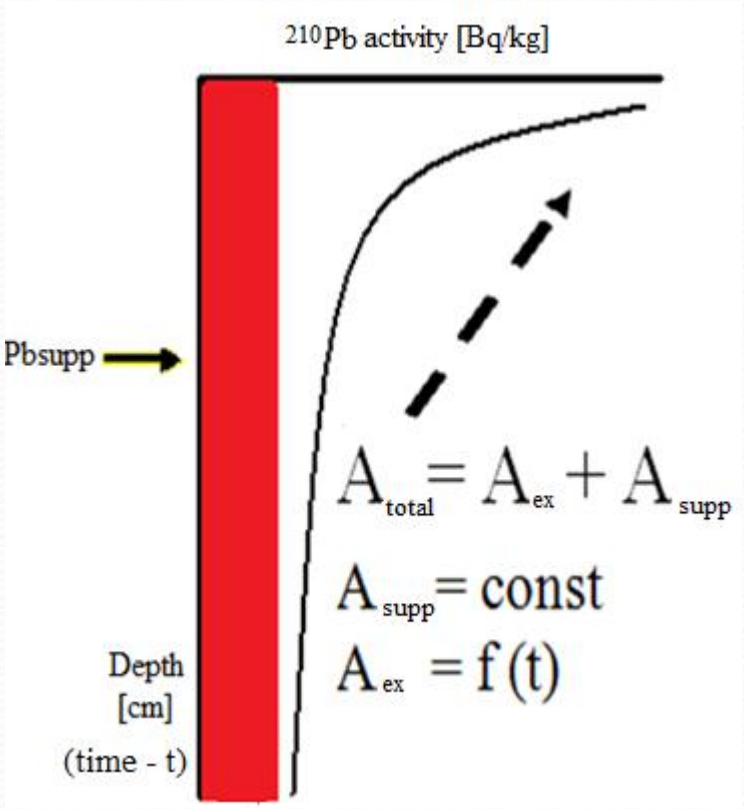
move by 0,5M HCl, deposition onto silver disks, 70^0 C/4h

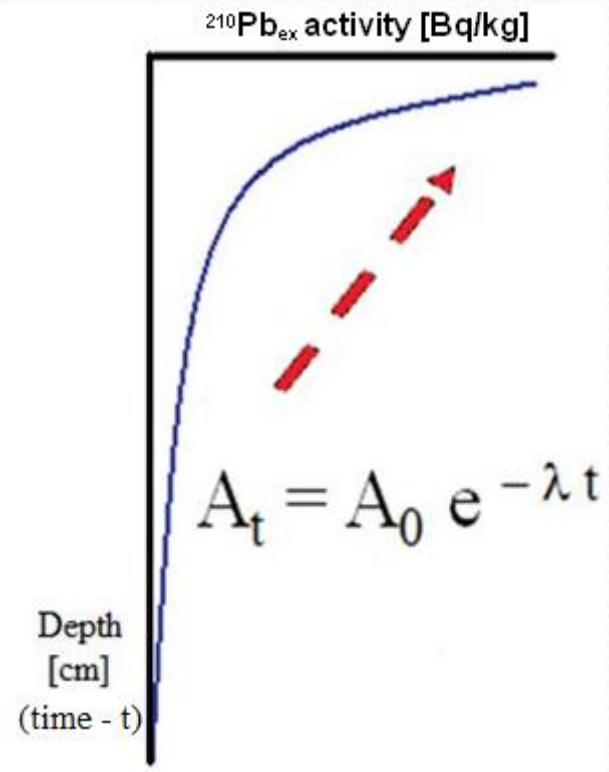
solution after deposition

spektrometr alpha



The ^{210}Pb lead profiles in surface sediments





T (time) – Z (depth) in sediments relationship

$$A_t = A_o\, e^{-\lambda t}$$

A_t – activity of $^{210}Pb_{ex}$ at time t

A_o – activity at time o

λ – radionuclide decay constant

$$t = z/\nu$$

z – depth

ν – sedimentation rate

$$A_t = A_o\, e^{-\lambda z/\nu}$$

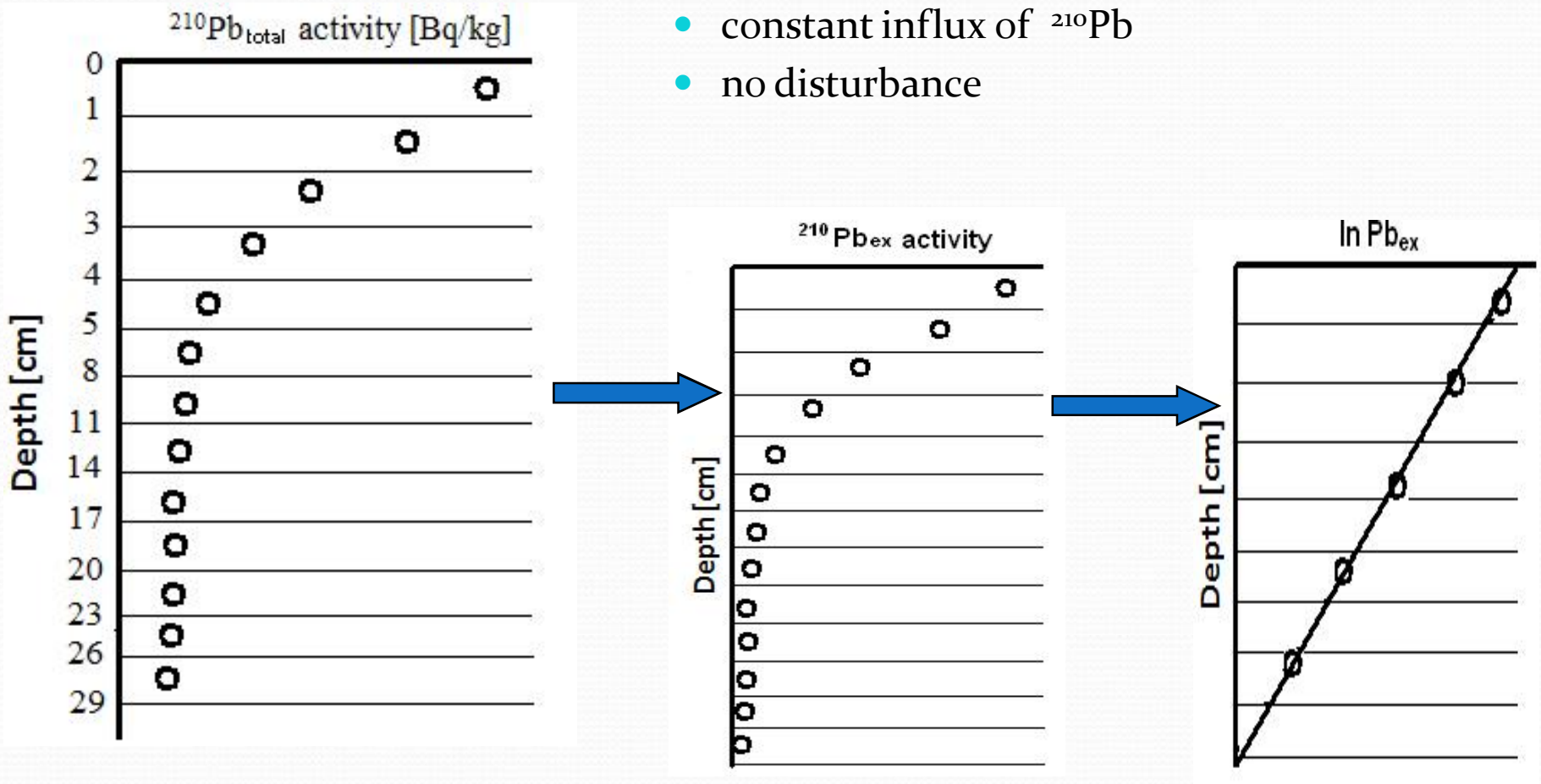
$$\ln A^{210}Pb_{ex}(z) = \ln A^{210}Pb_{ex}(o) - (\lambda/\nu)z$$

$$\nu = -(\lambda * z)/(\ln A^{210}Pb_{ex}(z) - \ln A^{210}Pb_{ex}(o))$$

Realistic Profiles I

Conditions for „ideal" profile:

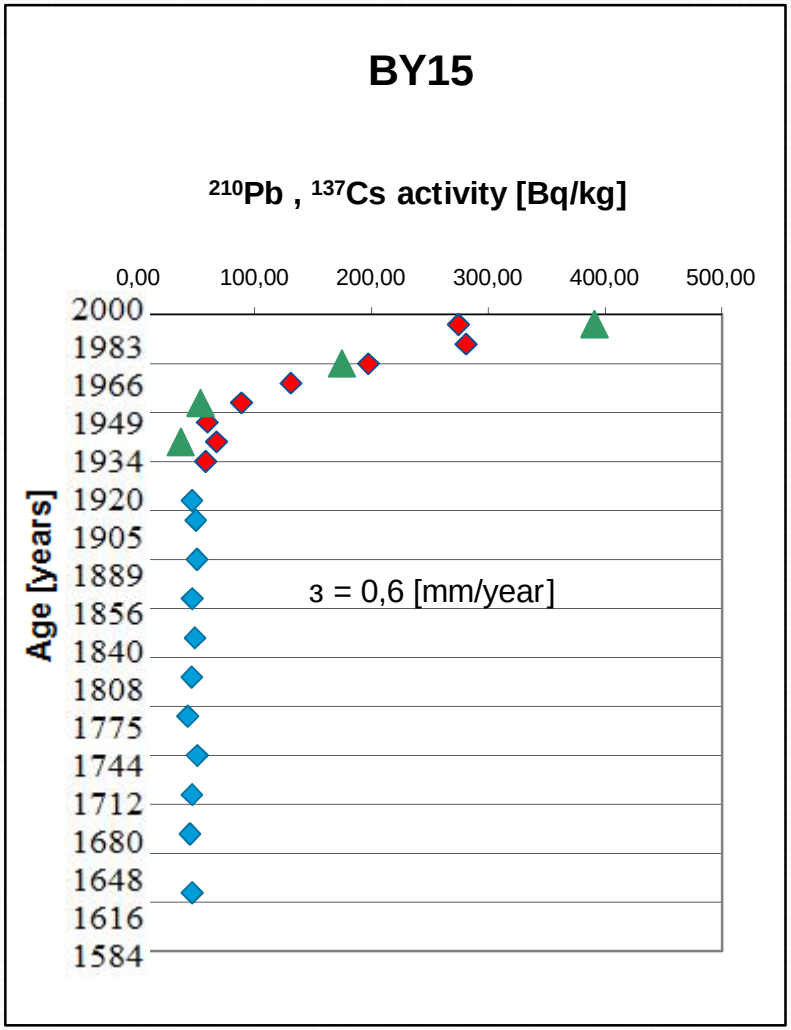
- constant sedimentation rate
- constant influx of ^{210}Pb
- no disturbance

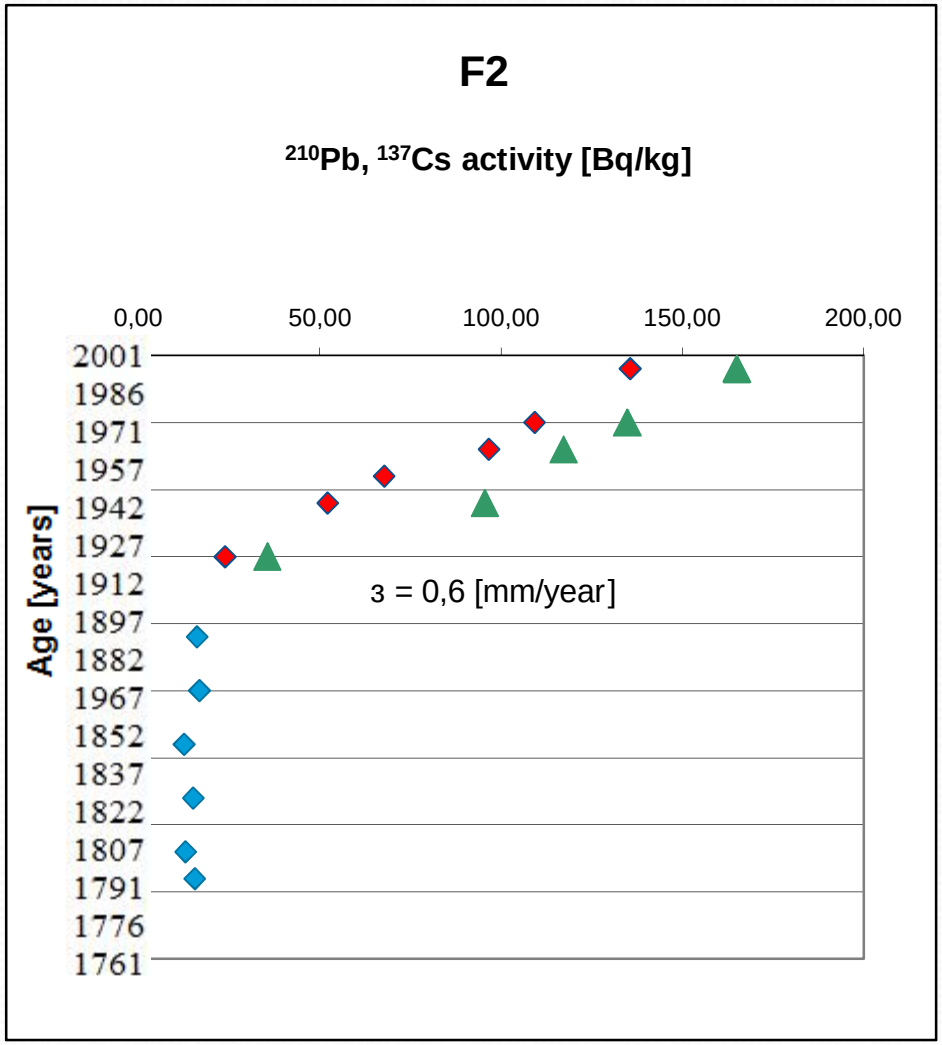


^{137}Cs validation

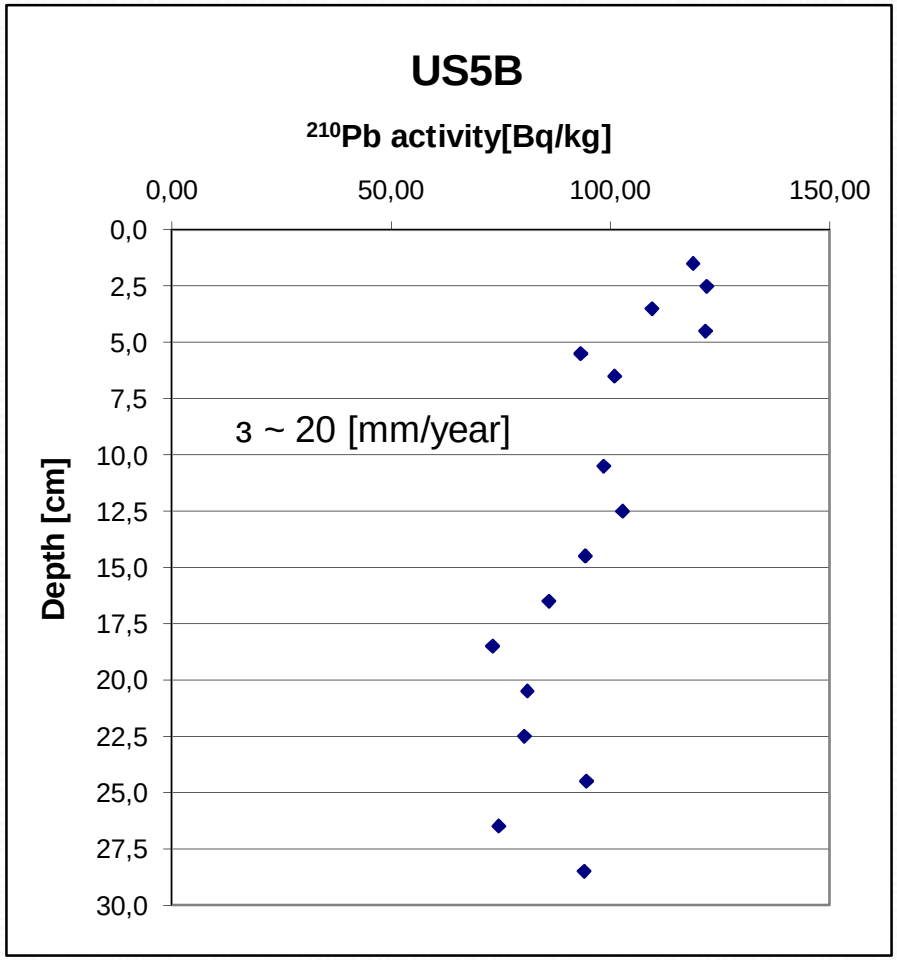
- Man-made radionuclide (half life 30,2 years)
- ^{137}Cs was introduced to environmental as a consequence of nuclear weapons tests from 1945-1976
- 1986 – Czernobyl
- ^{137}Cs method is used commonly for validation of ^{210}Pb results (confirm results obtained from ^{210}Pb geochronology)

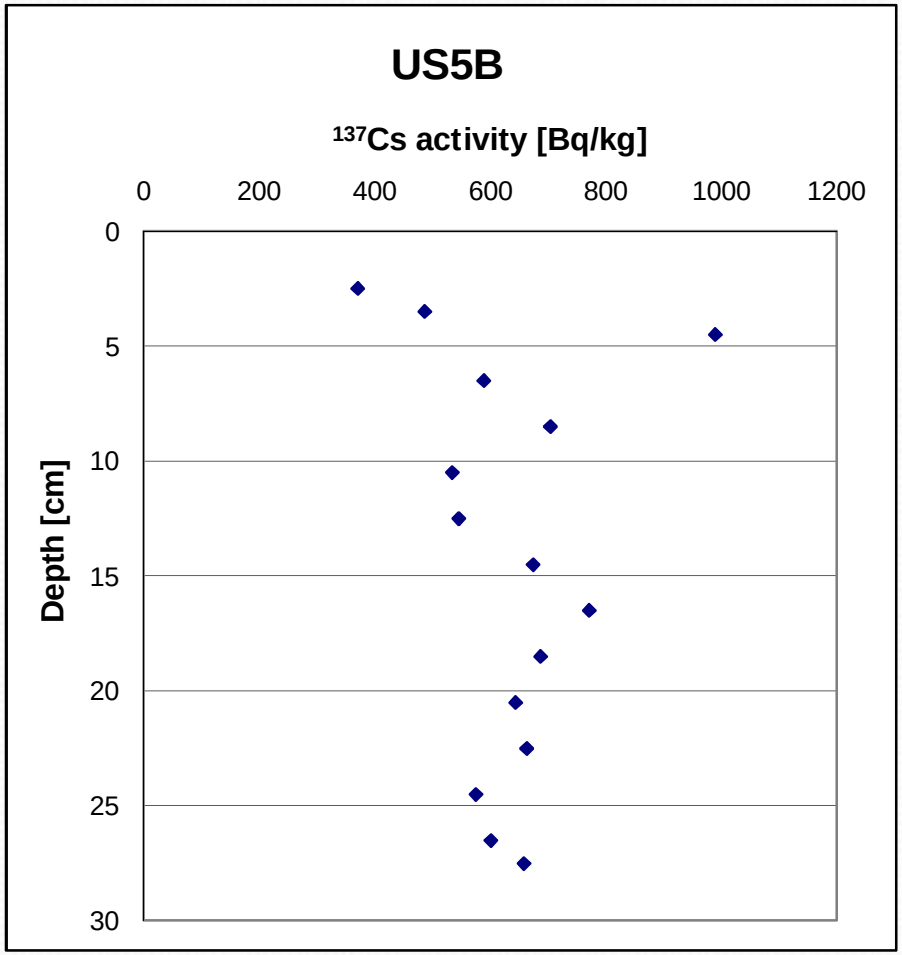
Profiles





Profiles





Conclusions

1. Lead method allowed to determine the ages of sediments within the last 150-200 years.

2. Determine the sediment accumulation rates using models (CRS and CIC models).

3. ^{137}Cs validation.

What's next ?

1. Determination the sediment accumulation rates and ages of sediments at different locations.

2. Establish recent sediment accumulation budget over the Baltic.

3. Determine carbon flux to sediments.

4. Use sediment ages and carbon profiles to establish kinetics of minerazlization.

Data mining