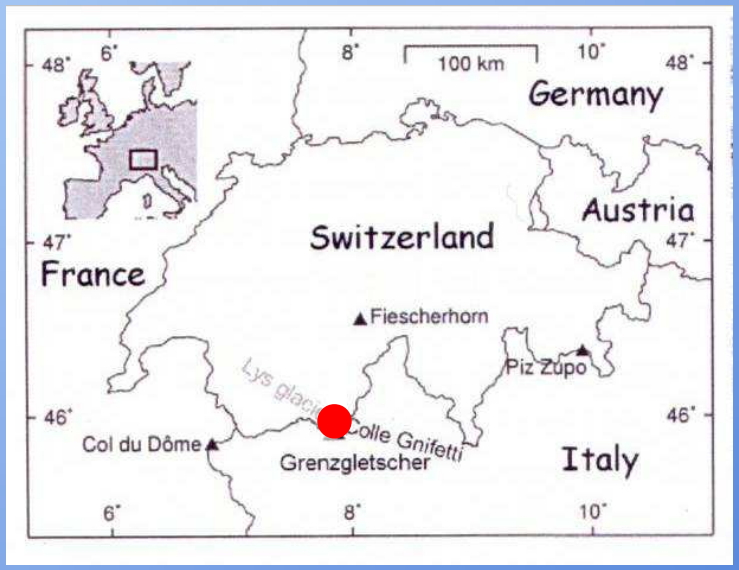
Trace elements and Polycyclic Aromatic Hydrocarbons (PAHs) in snow and ice sampled at Colle Gnifetti, Monte Rosa (4450 m), during the last 10,000 years: Environmental and climatic implications

Venezia - November 28th 2008

The Colle Gnifetti drilling site



What we have done in Villigen (PSI)

Storage, visual stratigraphy, density calculations, log, first processing

Discontinuous analysis

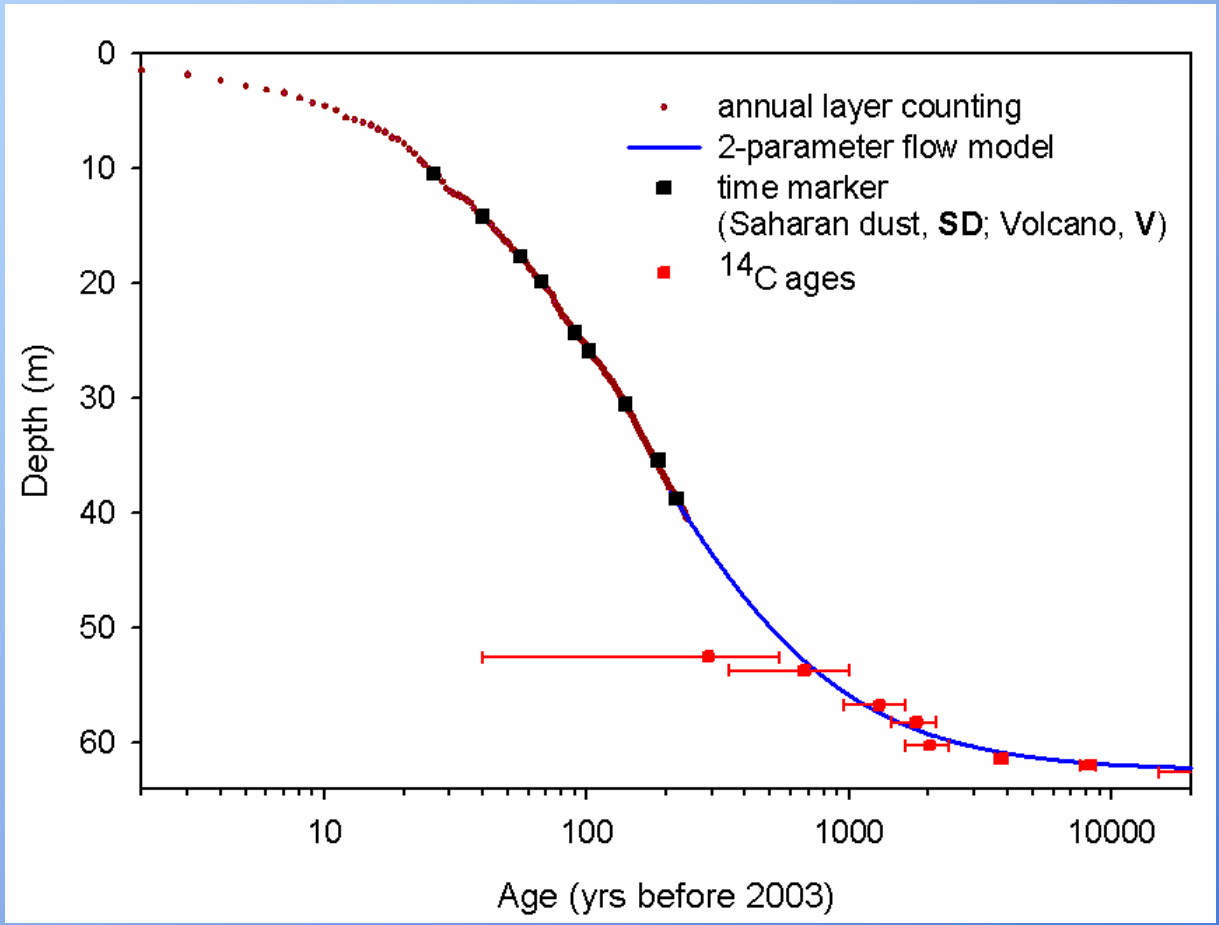
- *Major ions*
- *Stable H, O isotopes*

Dating

- *Volcanoes*
- *Saharan dust depositions*
- *Annual Layer Counting*
- *^{3}H, Pu, ^{210}Pb (core2)*
- *^{14}C*

Analysis carried out at PSI

What we have done in Villigen (PSI): dating



What we have done in Venezia

Designing, building and testing of a new melting system for continuous decontamination and on-line analysis of alpine ice/firn core

On-line continuous analysis

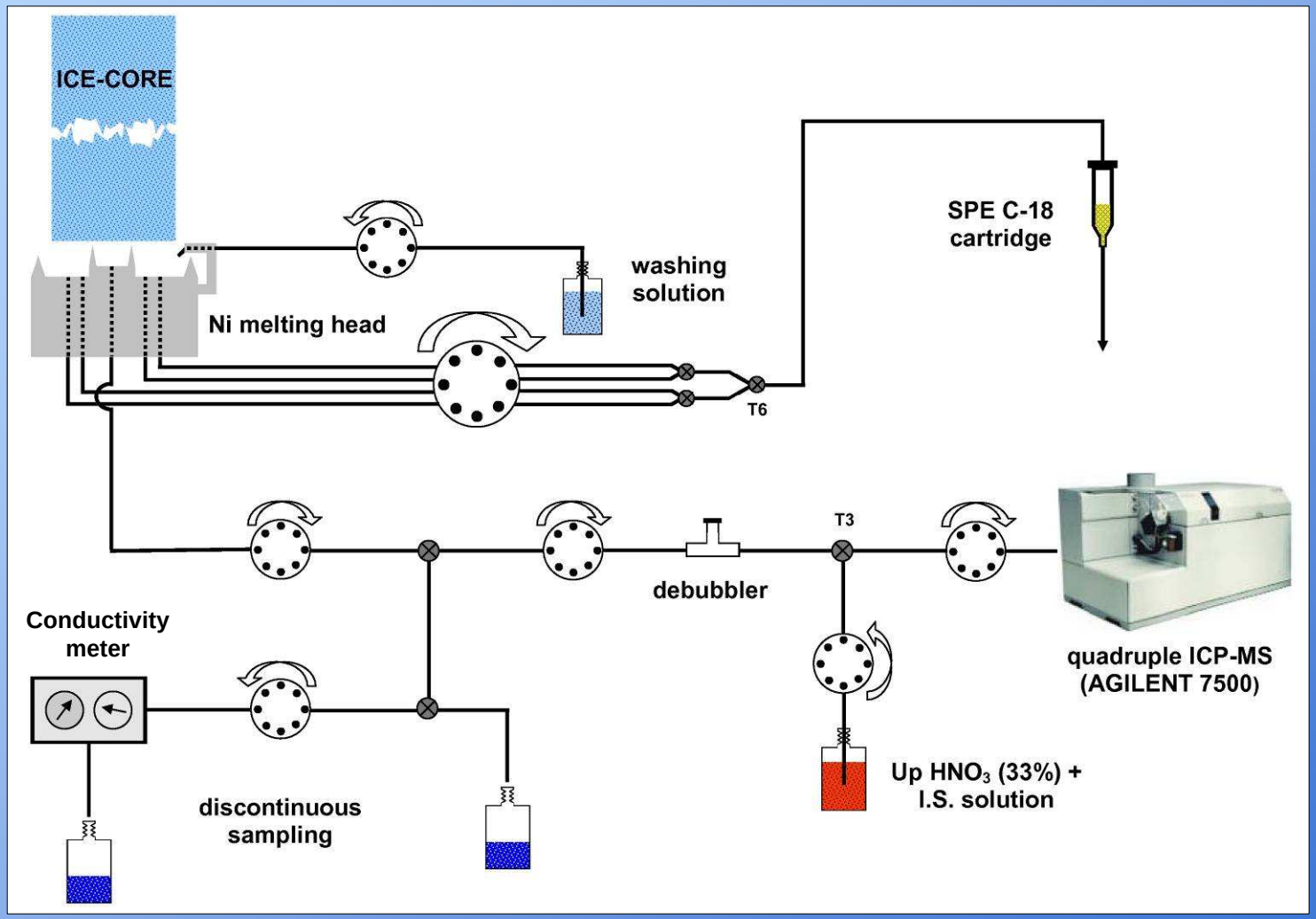
- ***Trace elements by ICP-QMS***
- ***Conductivity***

On-line solid-phase extraction for semi-continuous PAHs analysis

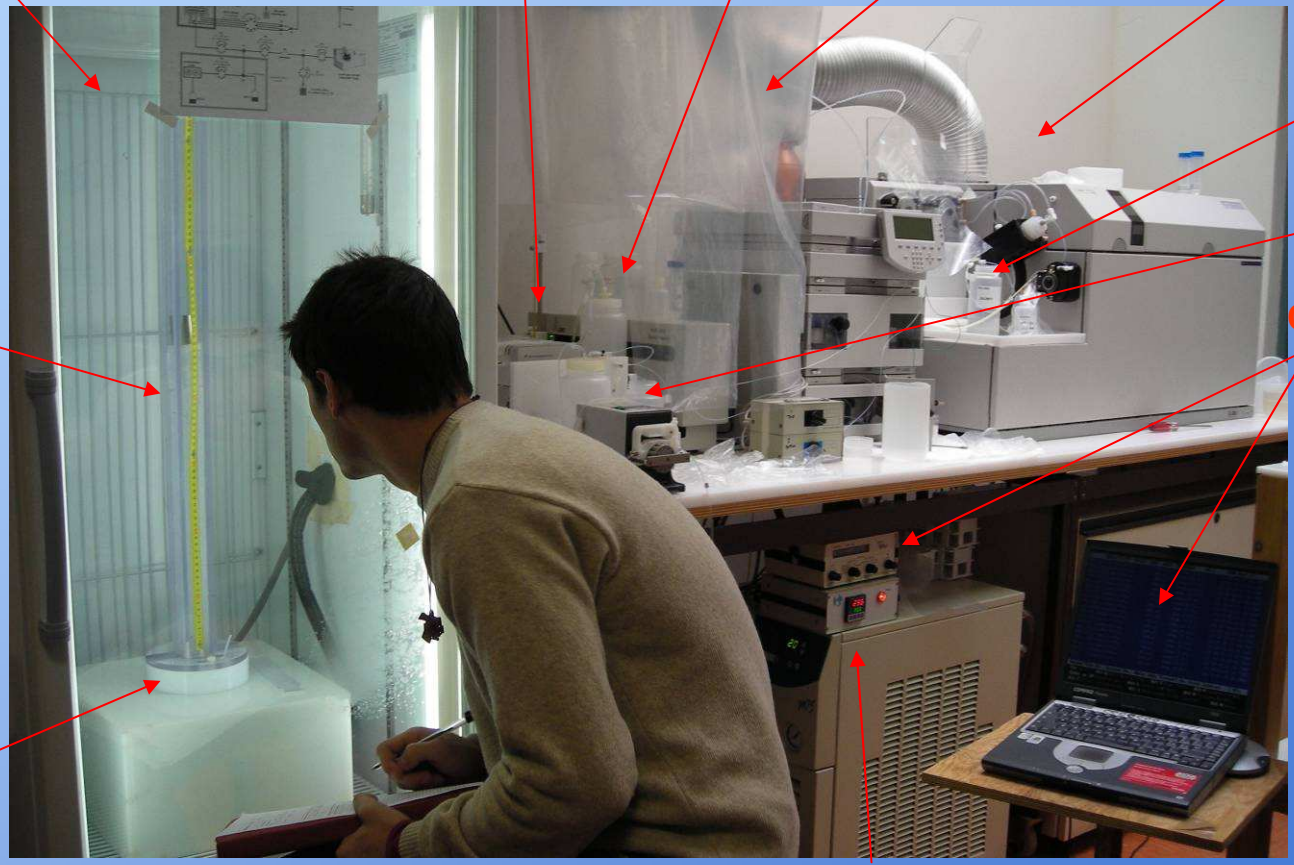
Discontinuous analysis

- ***Trace elements by ICP-SFMS***
- ***Trace elements by ICP-OES***
- ***Pb isotopes***
- ***^{239}Pu***

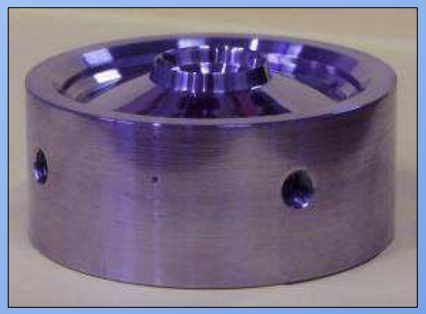
The "Venetian" melting system draft

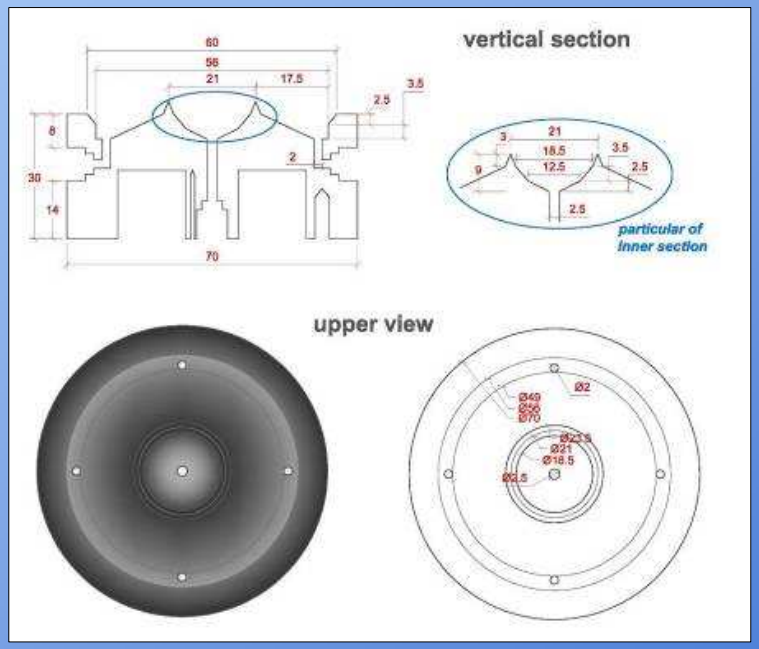


The "Venetian" melting system picture

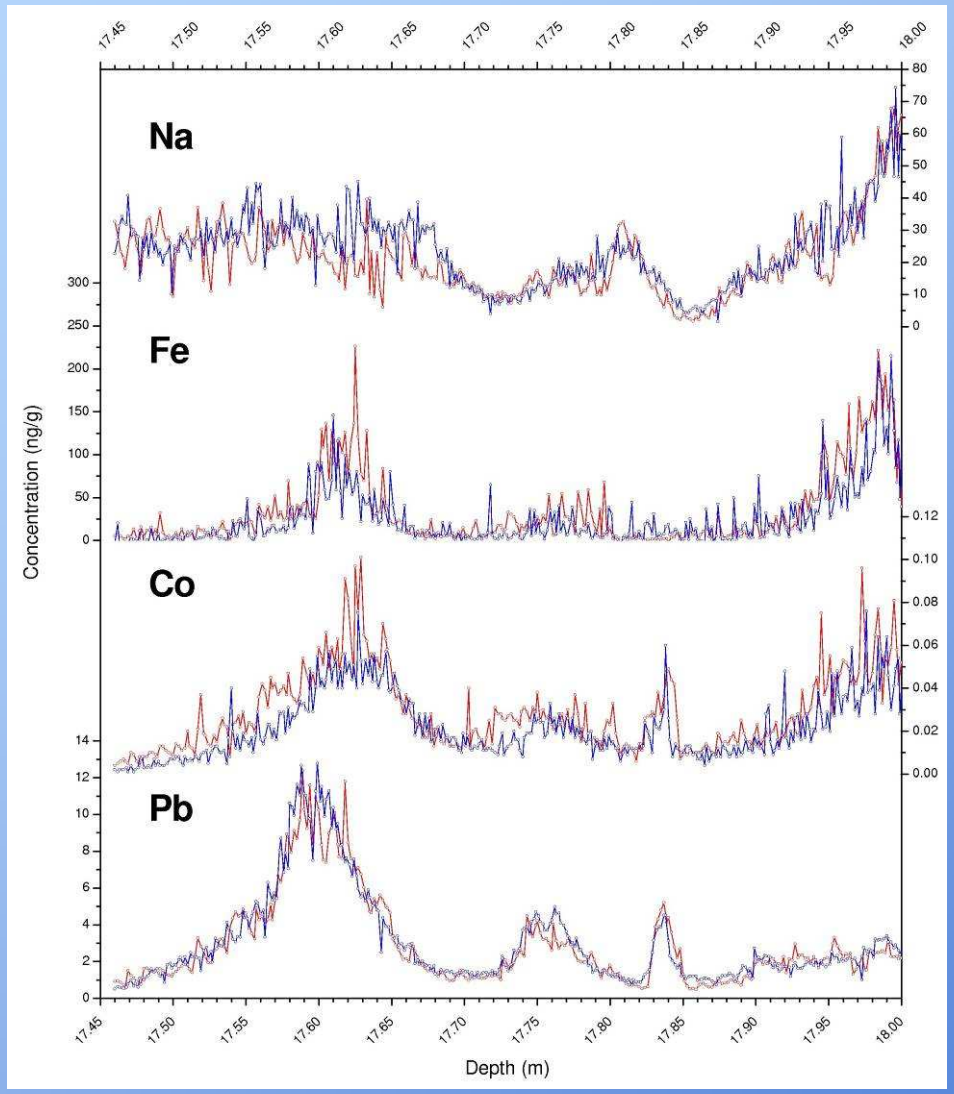


The "Venetian" melting heads





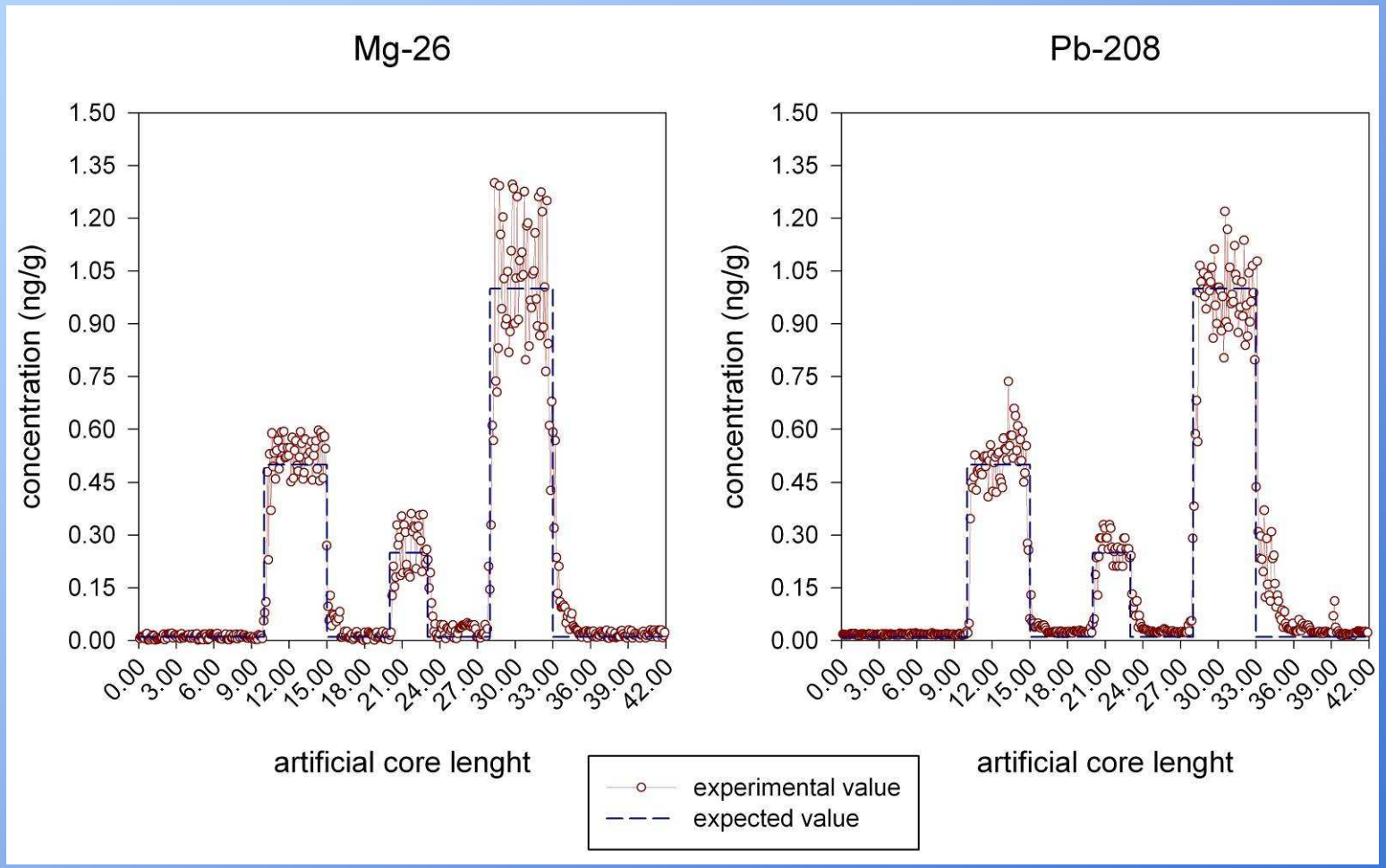
Continuous ICP-QMS analysis: reproducibilty test



Analysis of parallel ice and firn sections during different analytical sessions

Very good fitting except for Zn which is strongly affected by external contaminations

Continuous ICP-QMS analysis: recovery test




Tofana di Rozes - Dolomites

Continuous and discontinuous trace elements analysis

21 elements by continuous ICP-QMS → 42,000 measurements
900,000 concentration data

→ Resolution 0.9 – 2.5 mm (interpolation 10 mm)

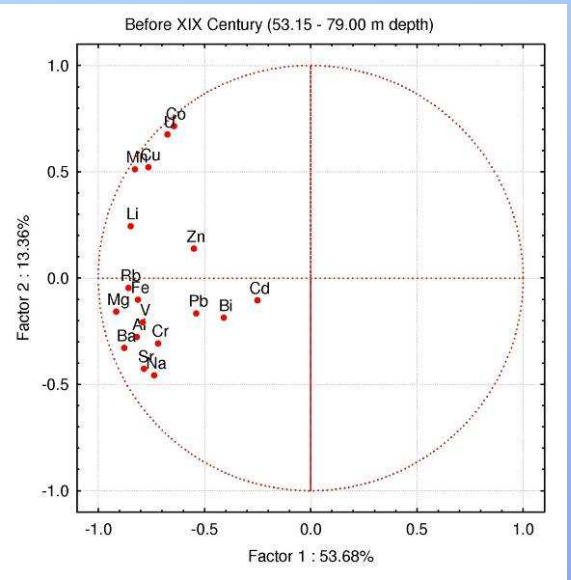
22 isotopes by ICP-SFMS

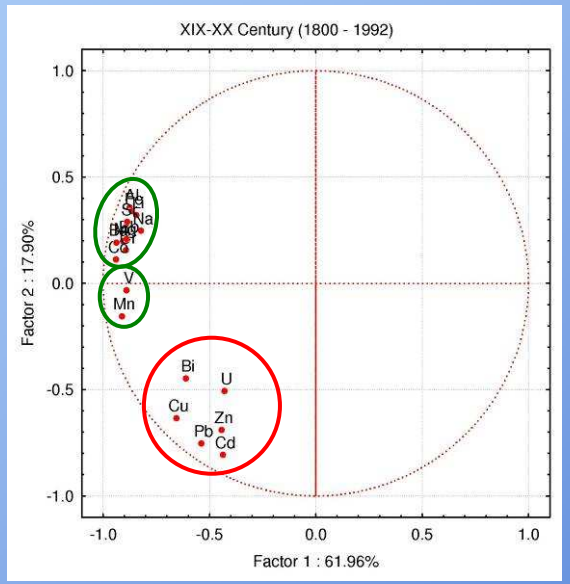
6 elements by ICP-OES (Ca, Mg, Na, K, Fe, Al)

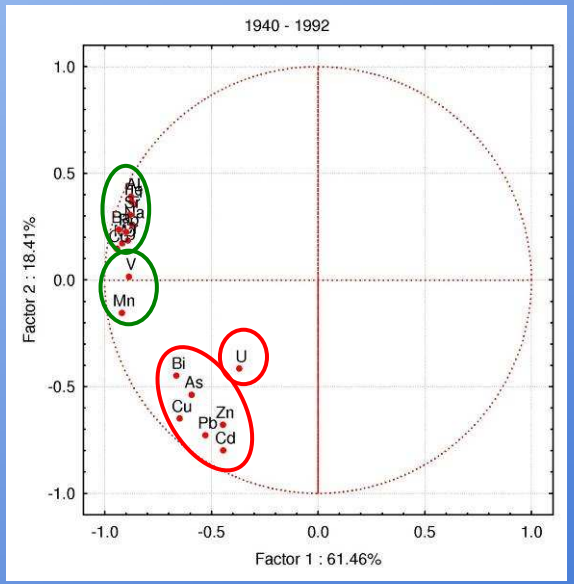
} 214 measurements

→ Resolution 20 - 30 cm

Principal component analysis

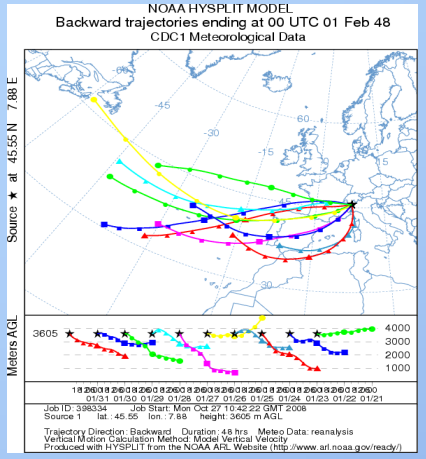




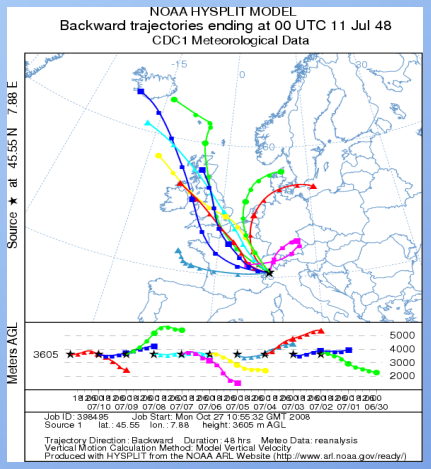


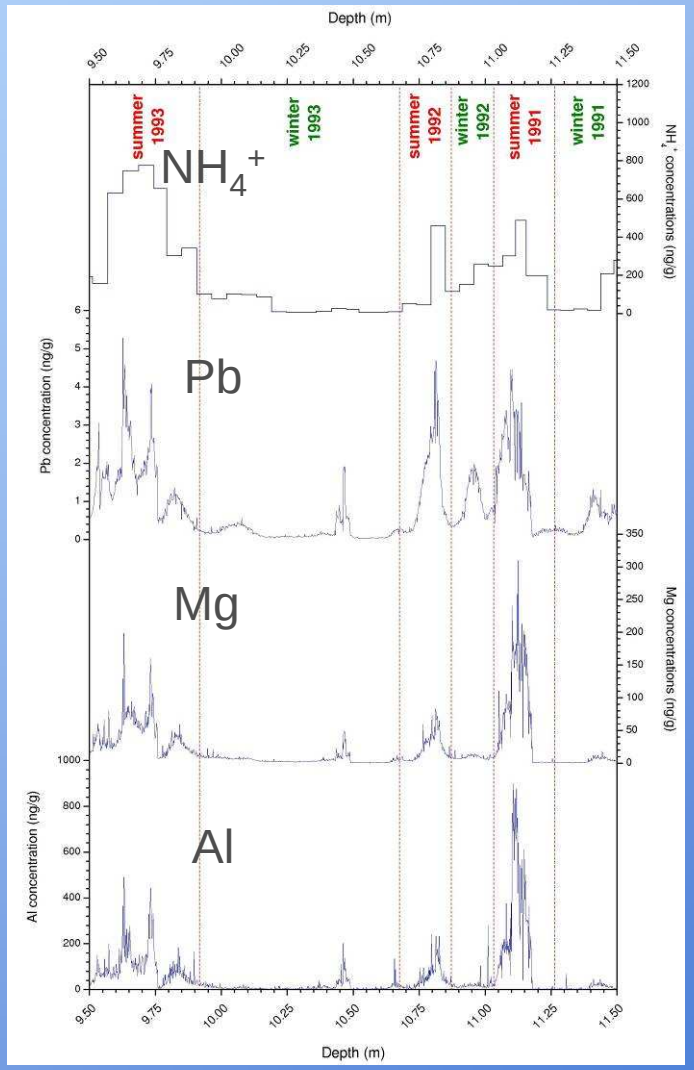
Short-term variations

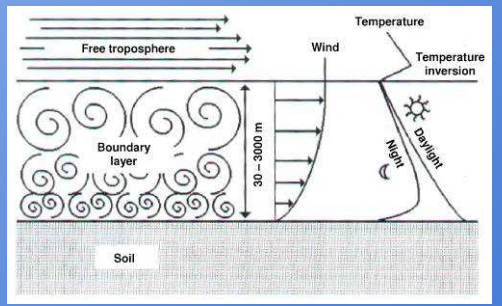
winter



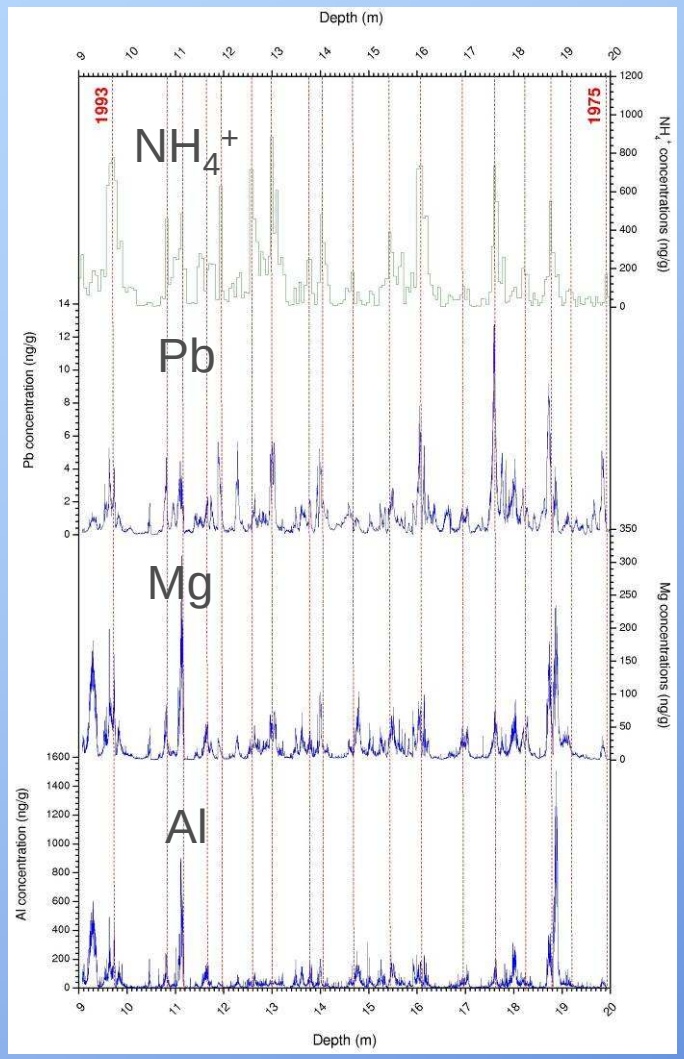
summer







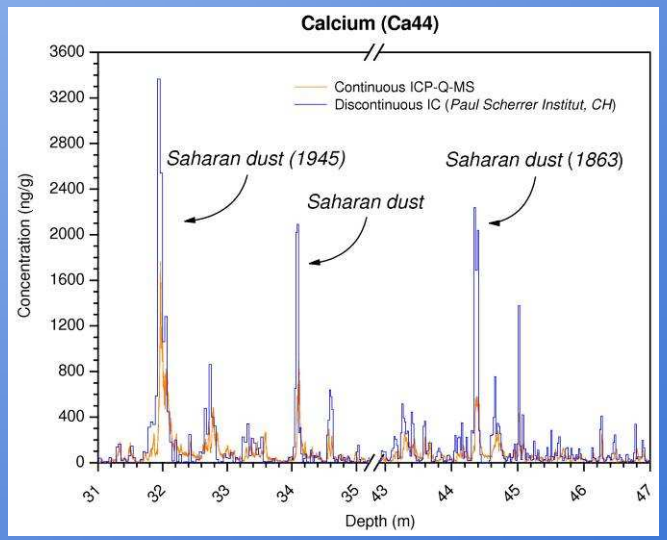
Short-term variations



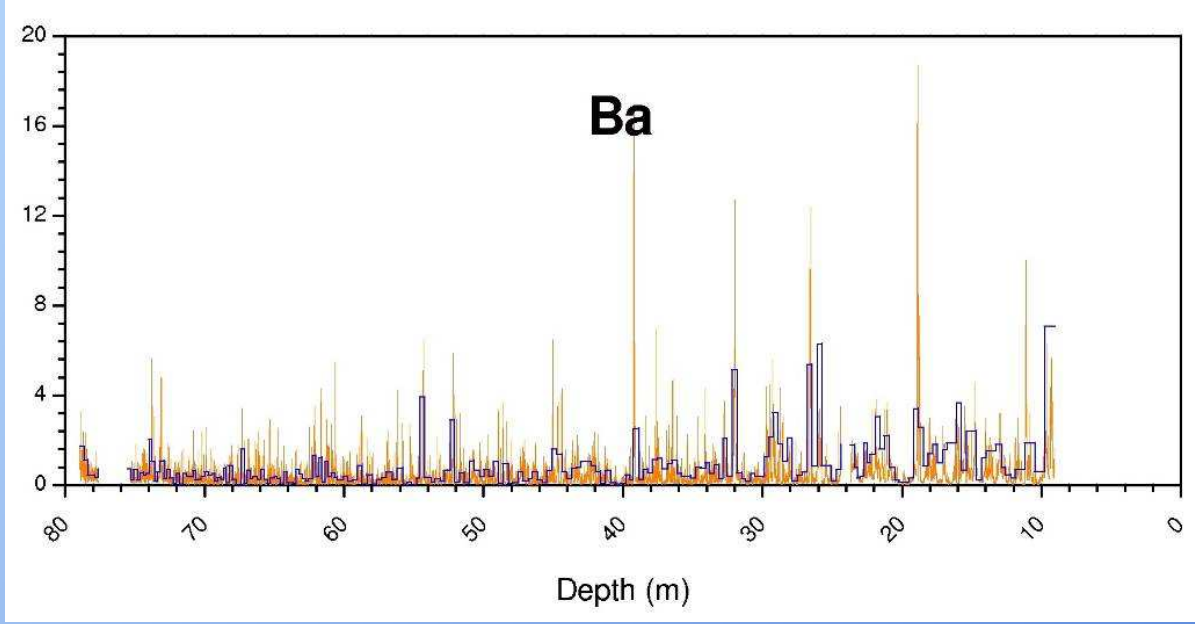
ALC from 1200 (~) to 2003 AD

Not consistent with ^{14}C dating

1200 AD { 66.45 m (ALC) / 71.10 m (^{14}C)

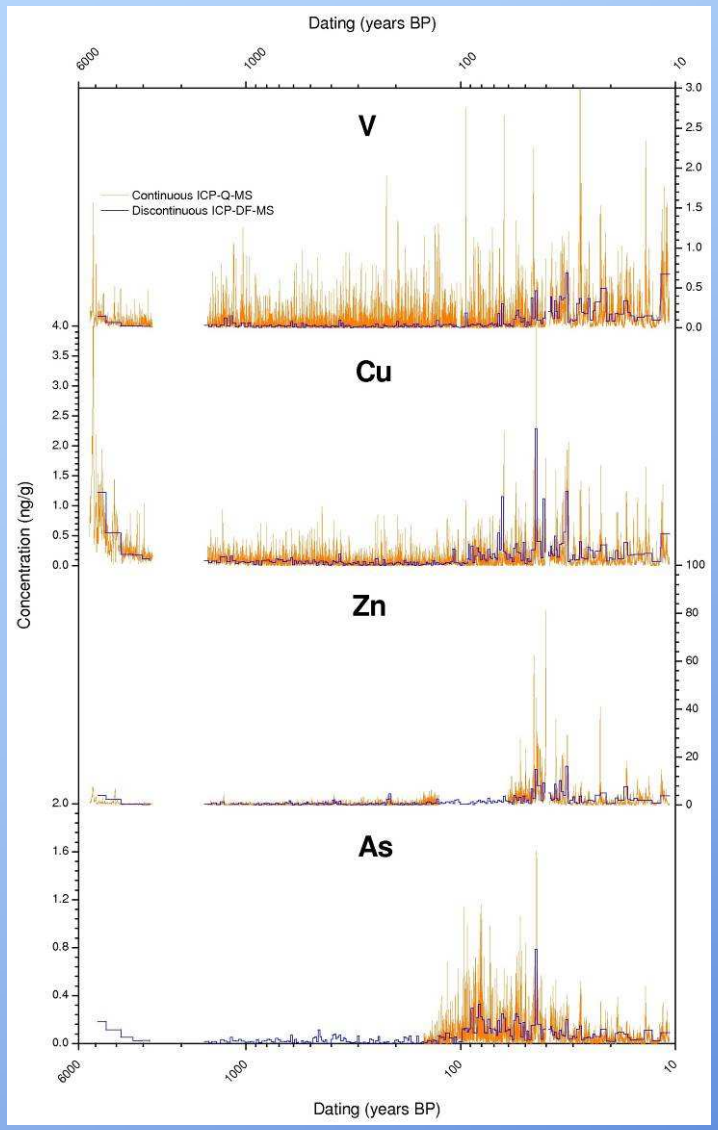


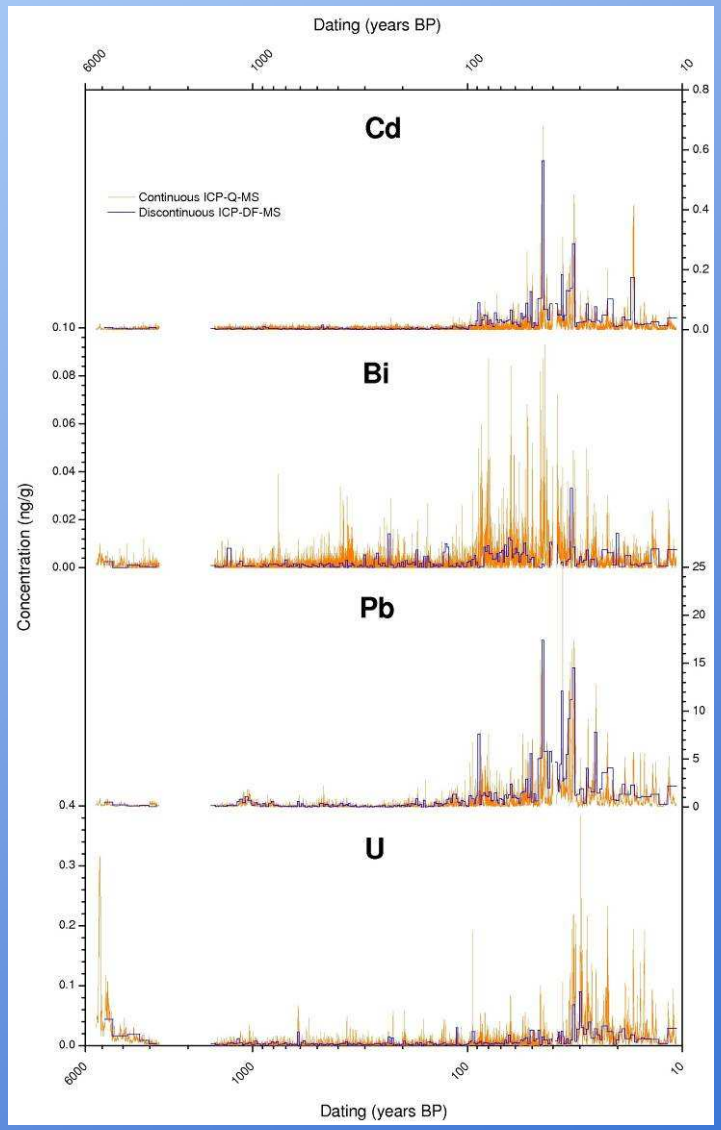
Long-term variations: crustal elements



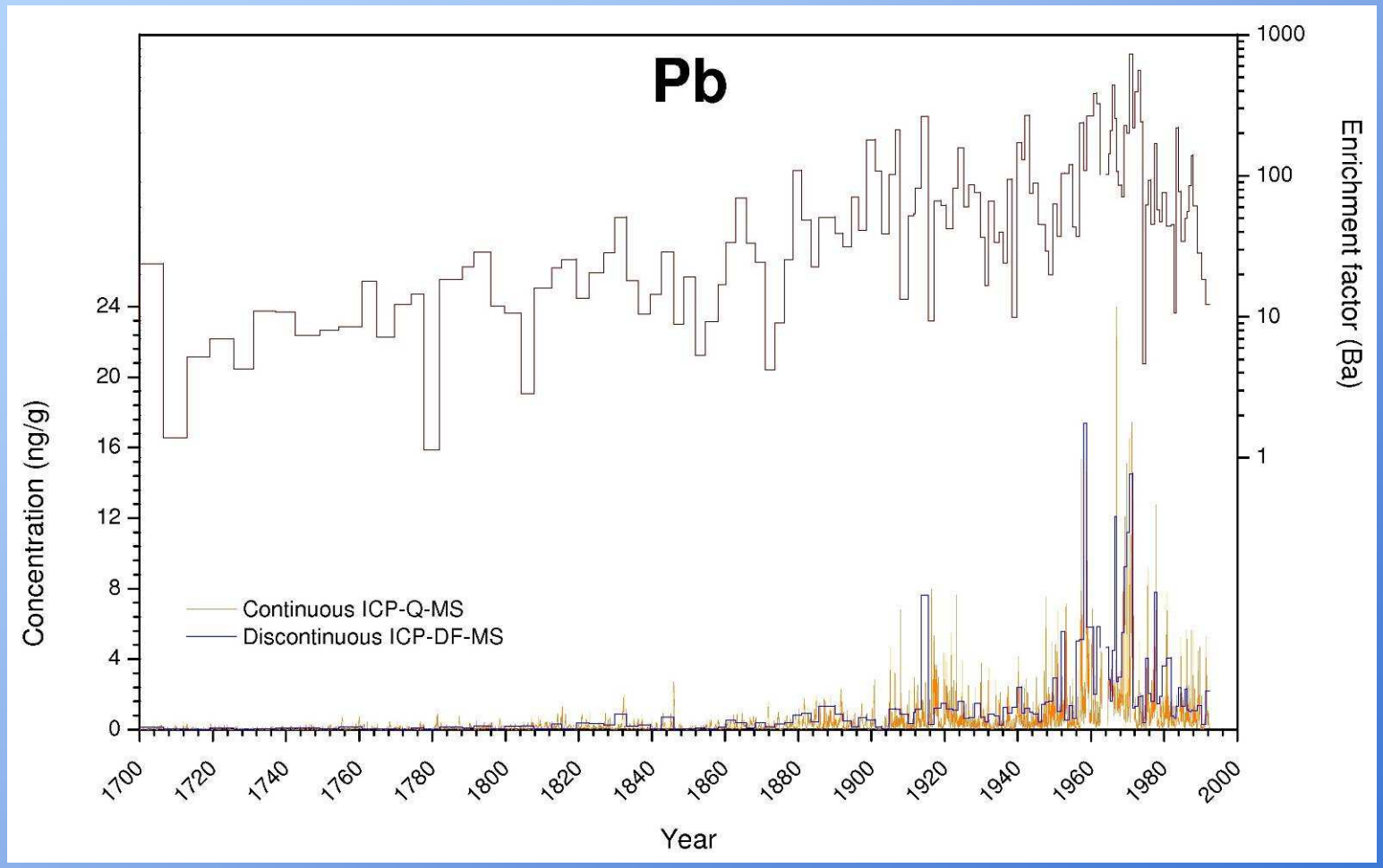
	XX Century			Pre-XX Century			Increase factor
	mean	median	max	mean	median	max	
Li	0.045	0.018	1.6	0.034	0.015	1.3	1.2
Na	28	17	725	24	12	477	1.4
Mg	19	10	236	16	10	266	1.0
Al	38	15	1258	28	11	682	1.4
Sc	0.015	0.011	0.098	0.0098	0.0085	0.052	1.3
Ti	0.20	0.10	1.6	0.094	0.067	0.70	1.4
Cr	0.085	0.040	2.2	0.060	0.038	0.92	1.1
Mn	1.3	0.70	17	0.79	0.50	35	1.4
Fe	26	9.7	807	24	13	479	0.7
Co	0.029	0.021	0.42	0.016	0.013	0.179	1.5
Rb	0.089	0.041	2.8	0.064	0.034	0.97	1.2
Sr	0.75	0.34	17	0.56	0.35	11	1.0
Ba	0.59	0.28	15	0.36	0.21	5.3	1.3

Long-term variations: anthropogenic elements

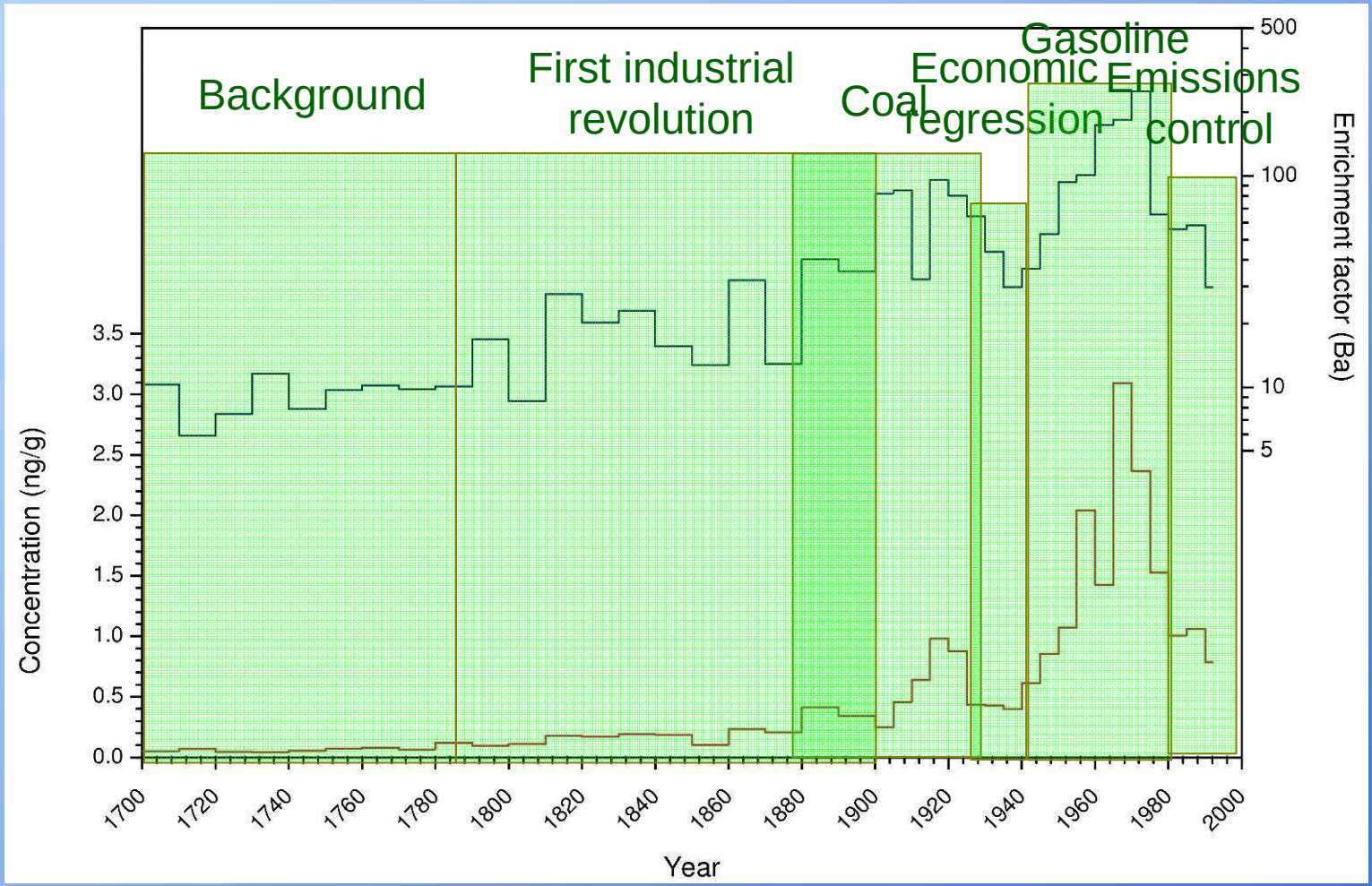




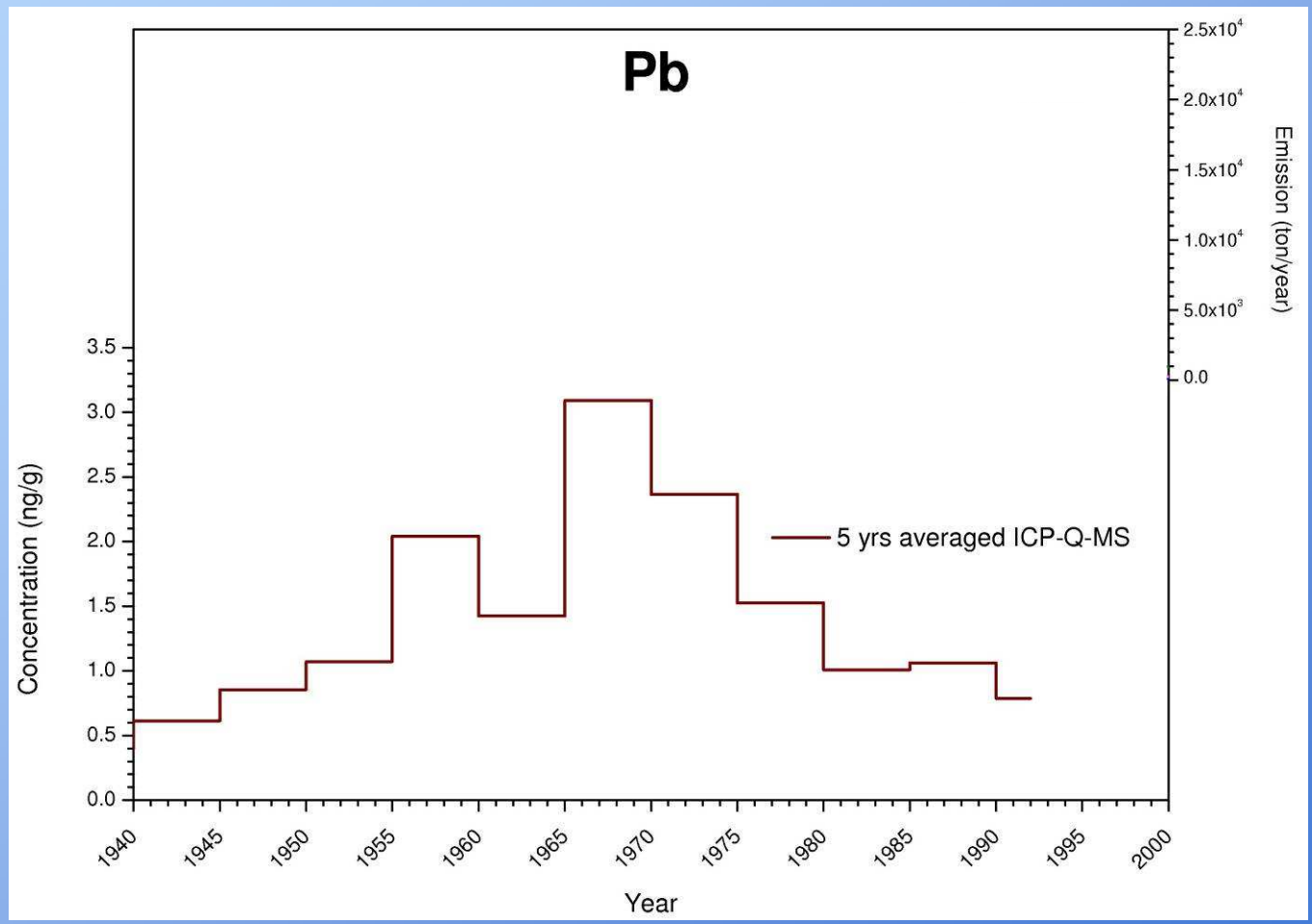
Anthropogenic metals: Pb



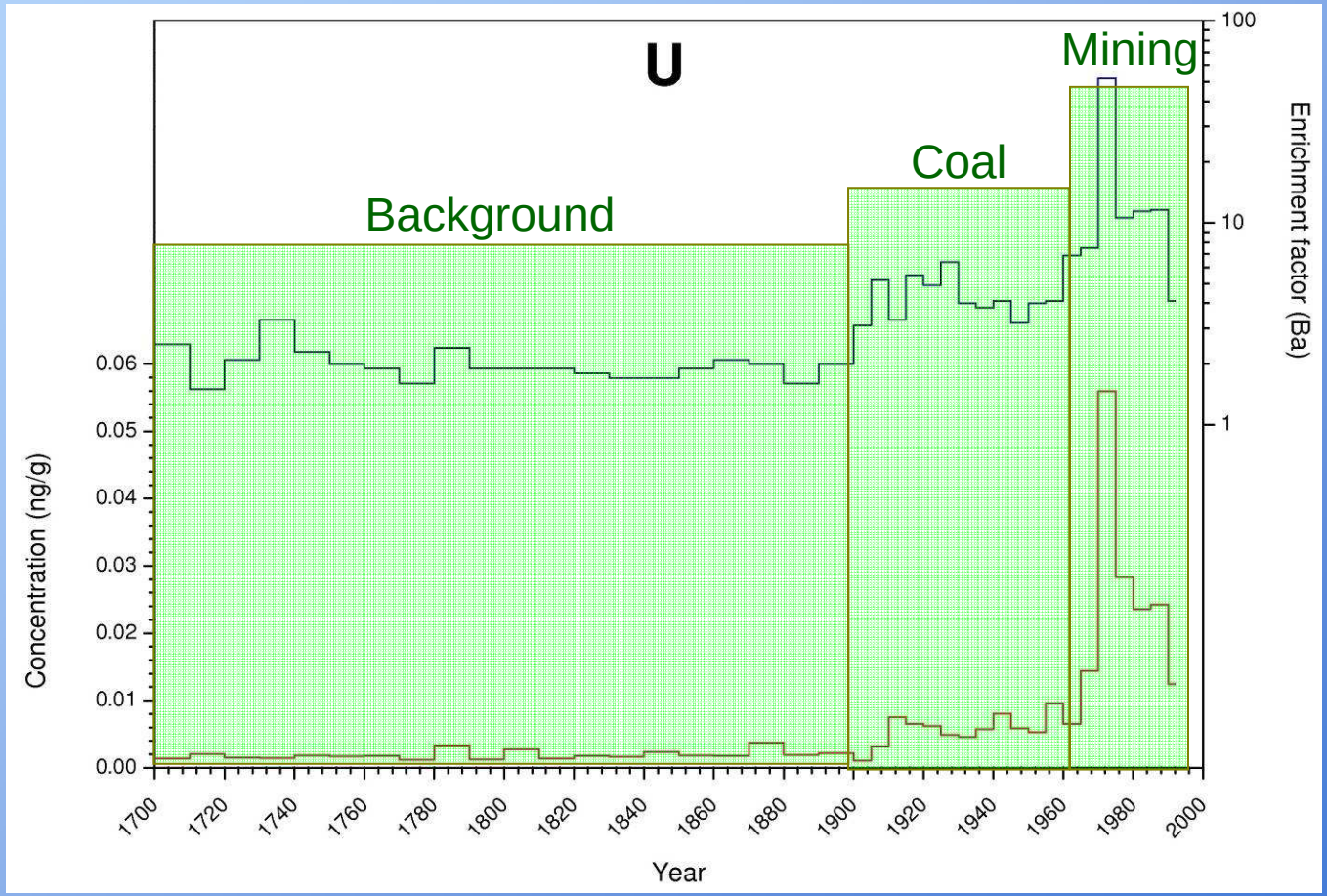
Anthropogenic metals: Pb



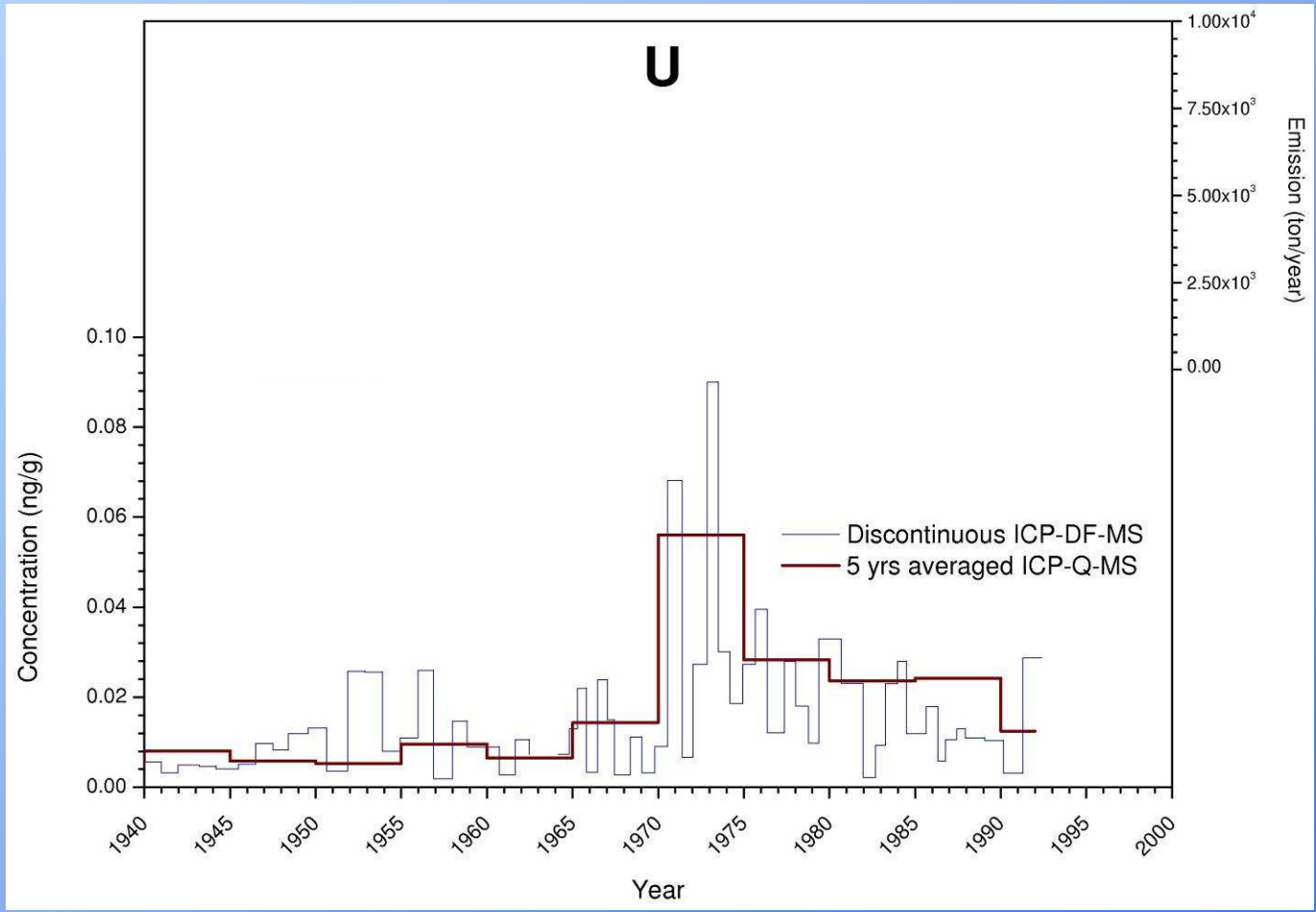
Anthropogenic metals: Pb



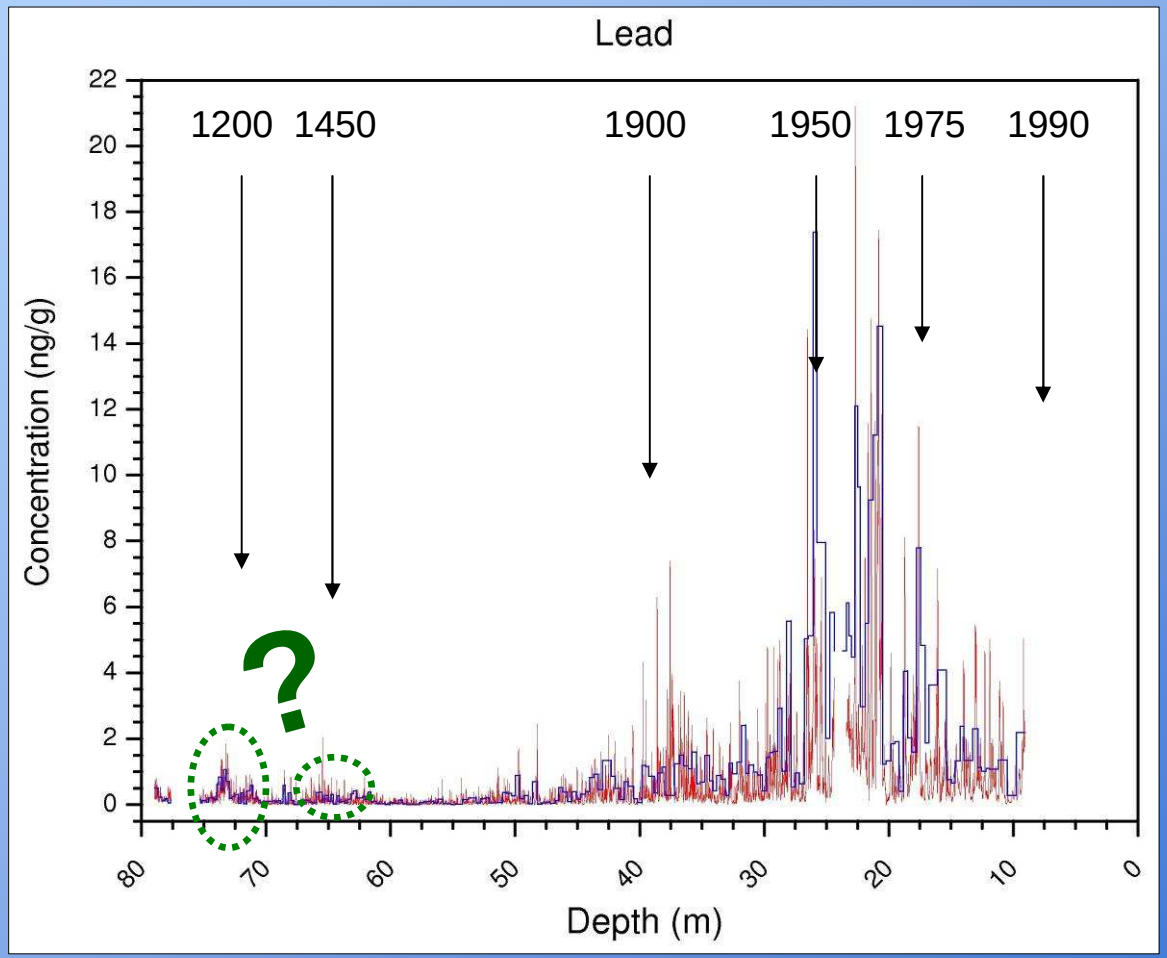
Anthropogenic metals: U



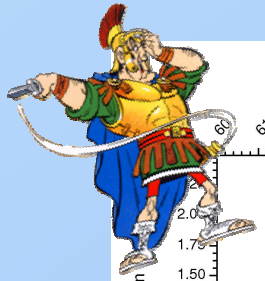
Anthropogenic metals: U

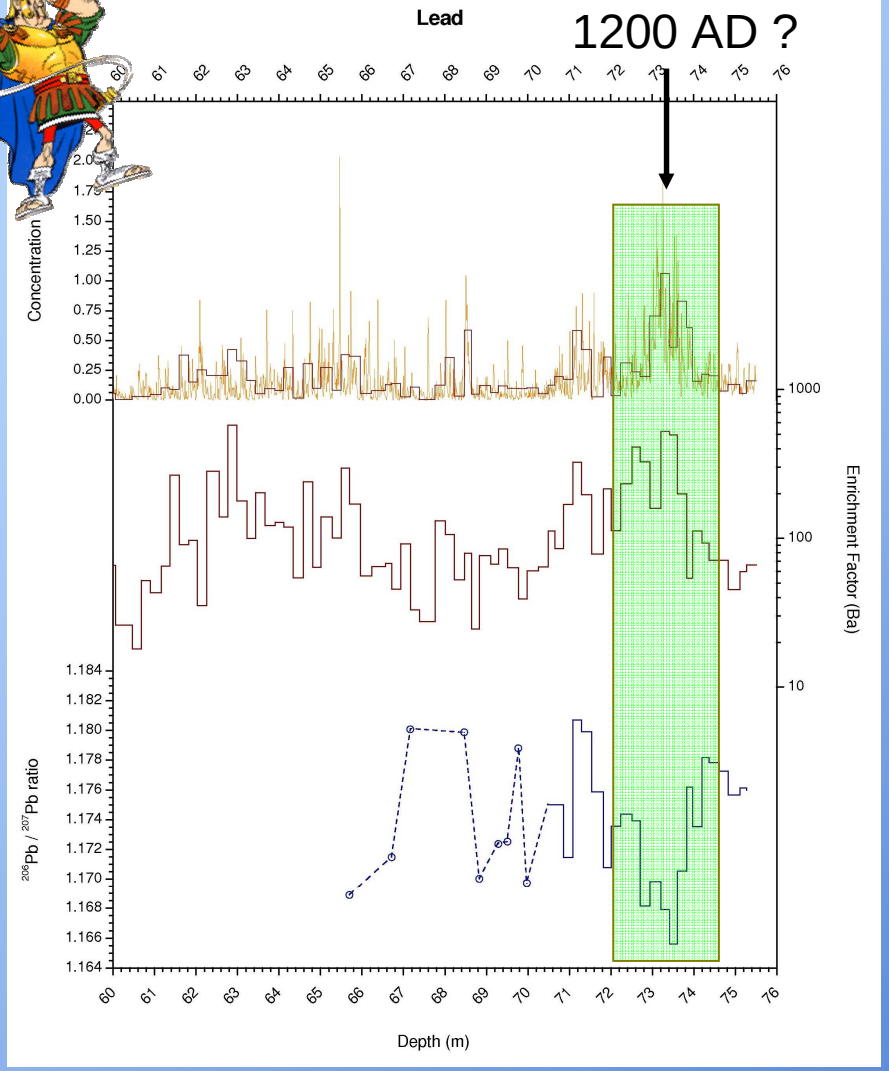


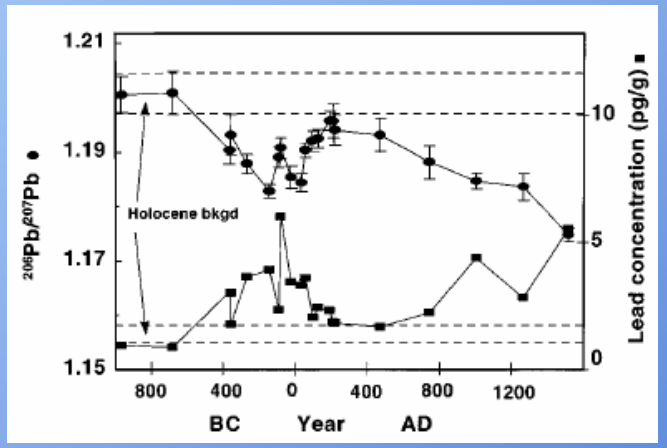
Pb: a useful tool for dating validation?



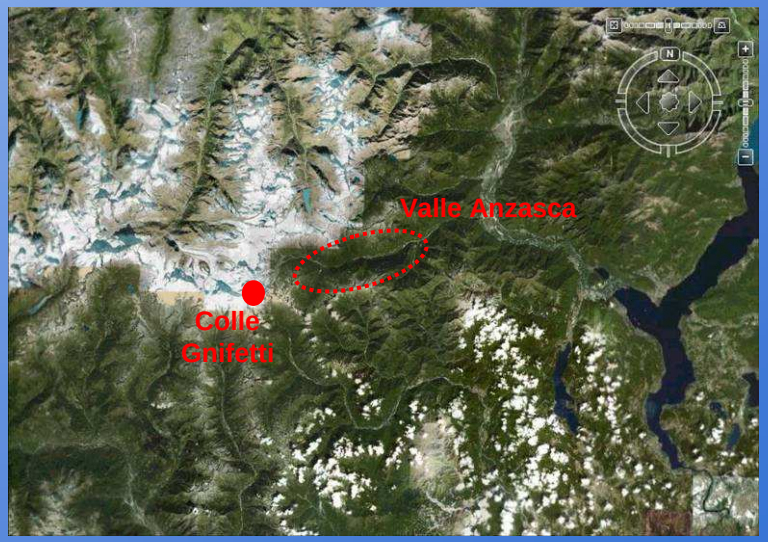
Pb profile: a tool in dating validation?



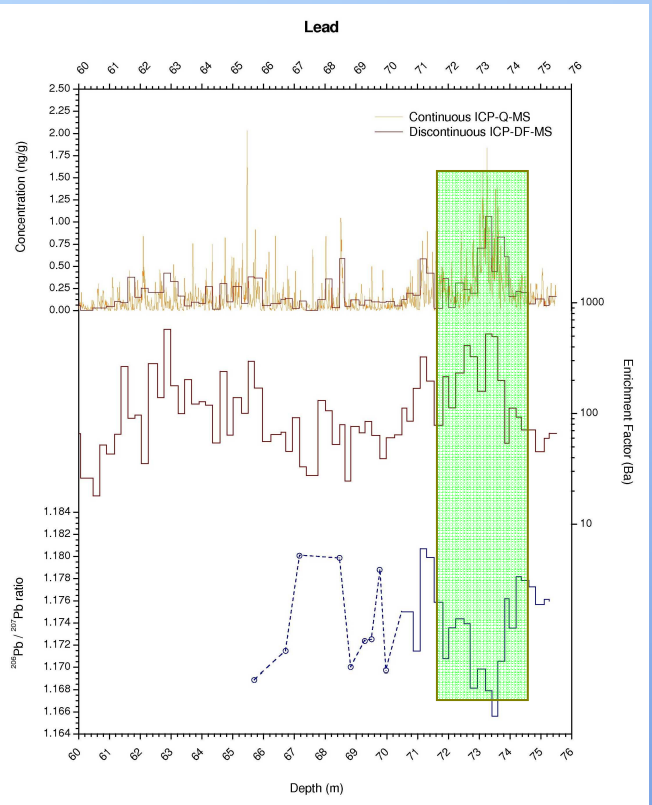


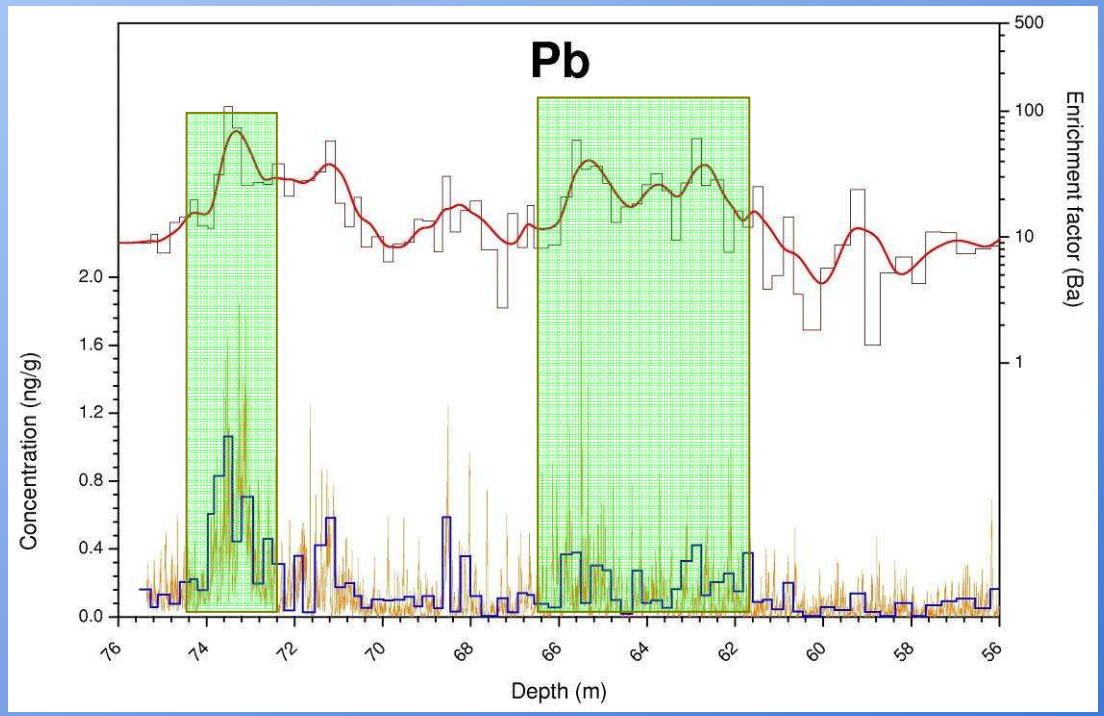


Rosman, 1997



Pb: a useful tool for dating validation?



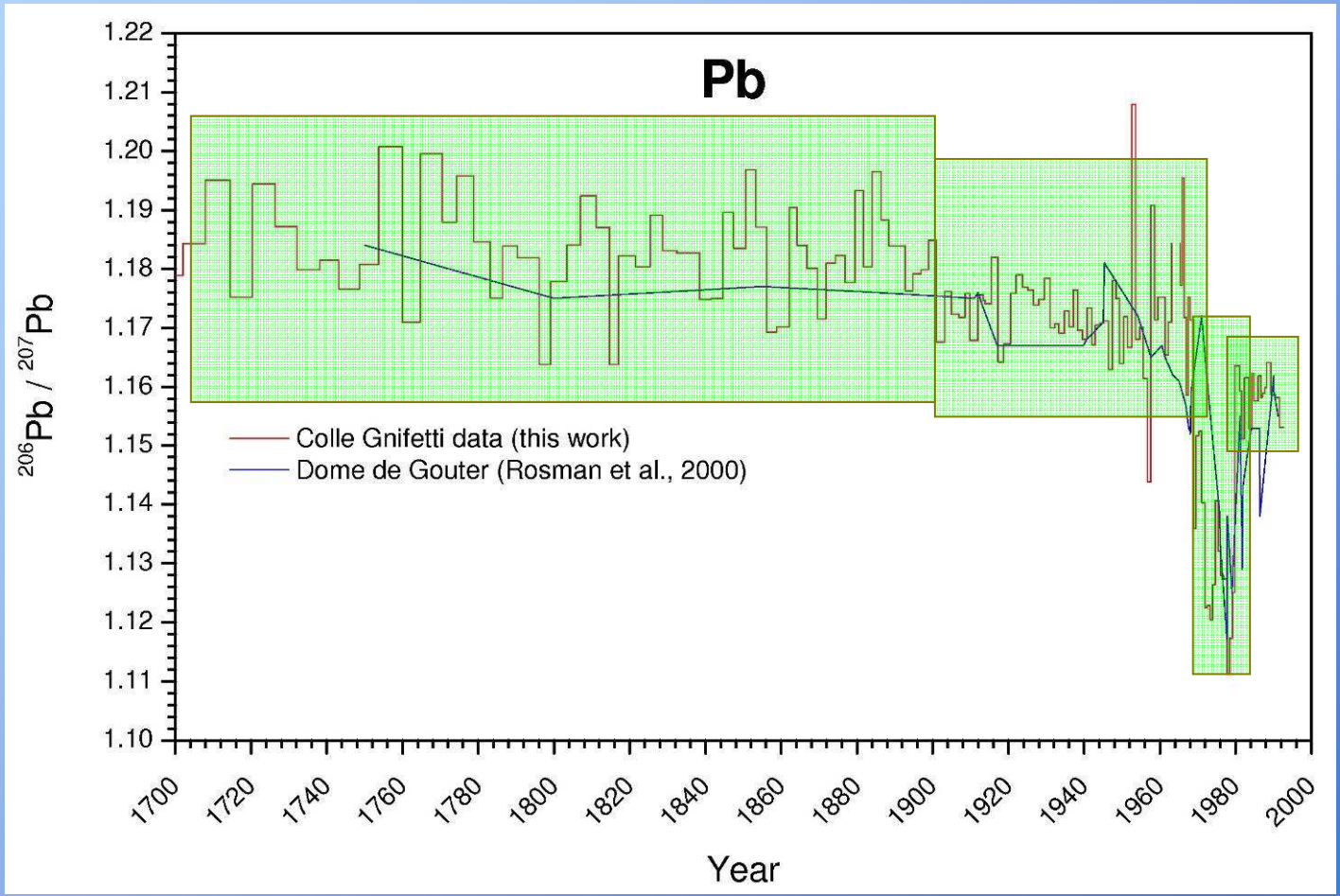


Roman Empire

Middle Ages

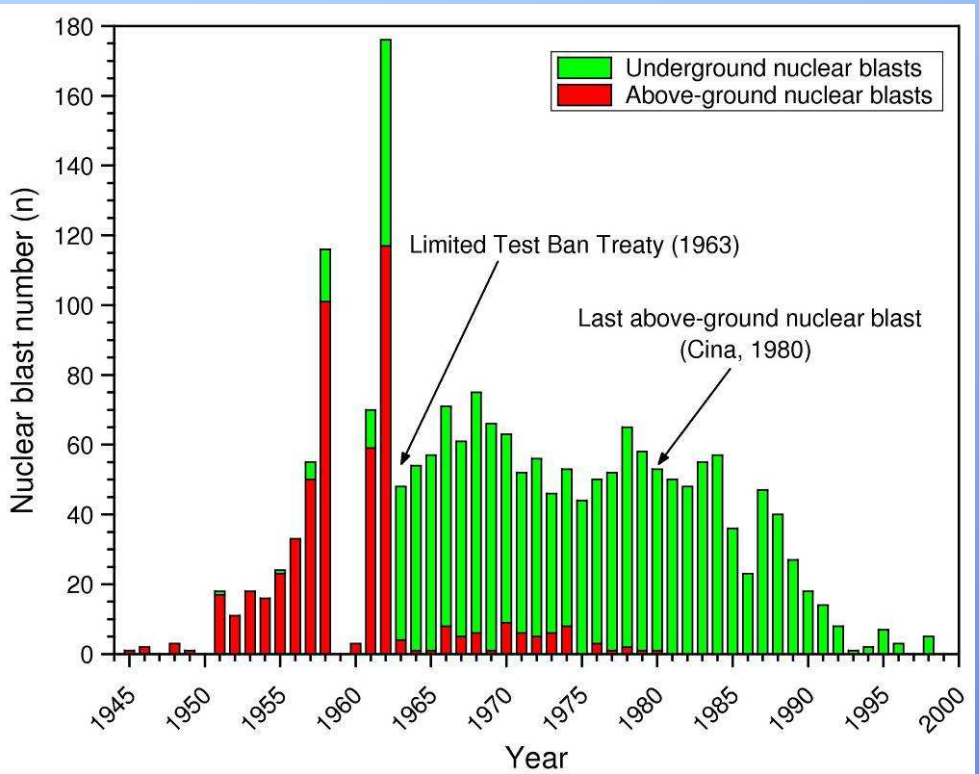
(ALC 1200 AD at 66.5m)

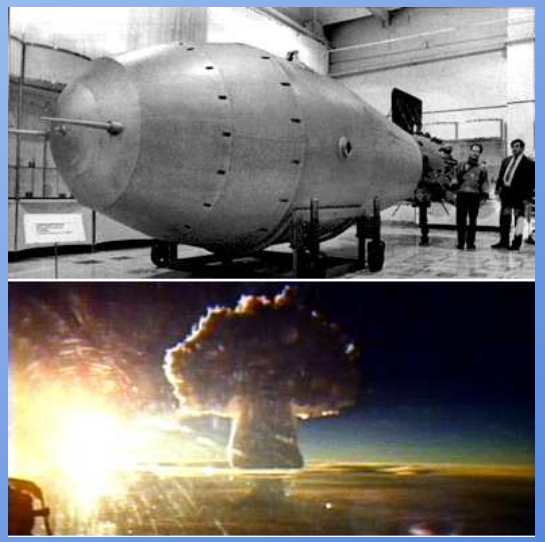
Lead isotopes in industrial period



Pb isotopic ratio profile

Pu: a worldwide "cold war" pollutant





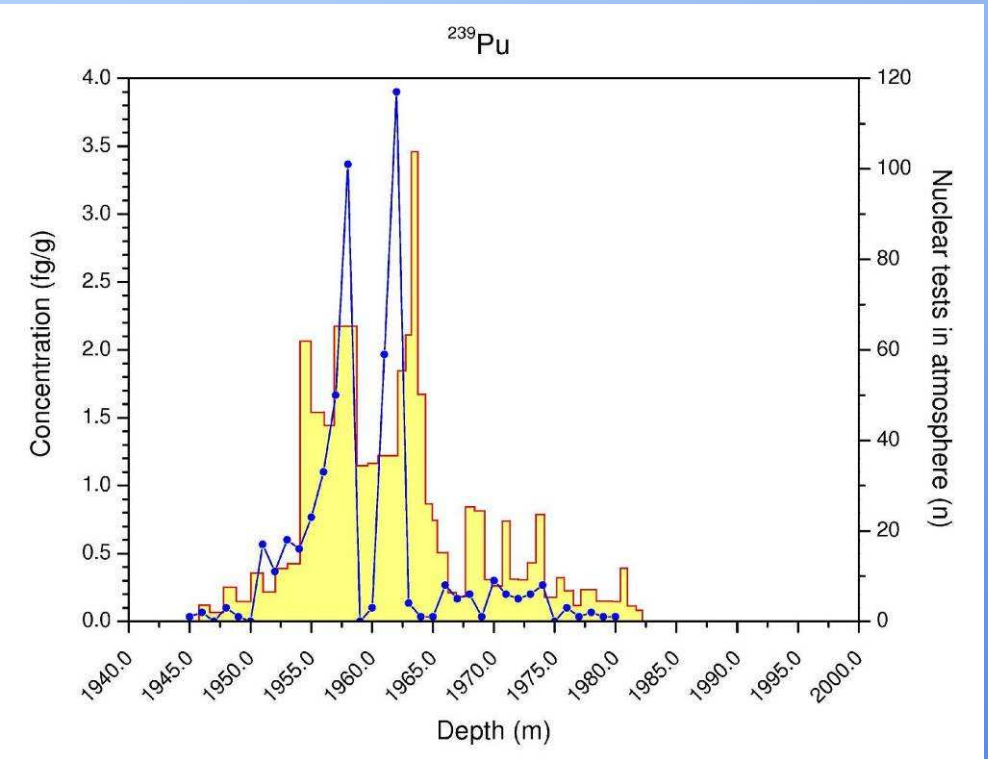
Tsar bomb, Arctic Siberia; 30 October 1961

57 Mton (more than 5 times the total amount of traditional explosives during 2°World War)

Blast at 4000 m a.s.l.; nuclear mushroom cloud high about 60 km

Pu profile in CG firn core

Semi-quantitative determination



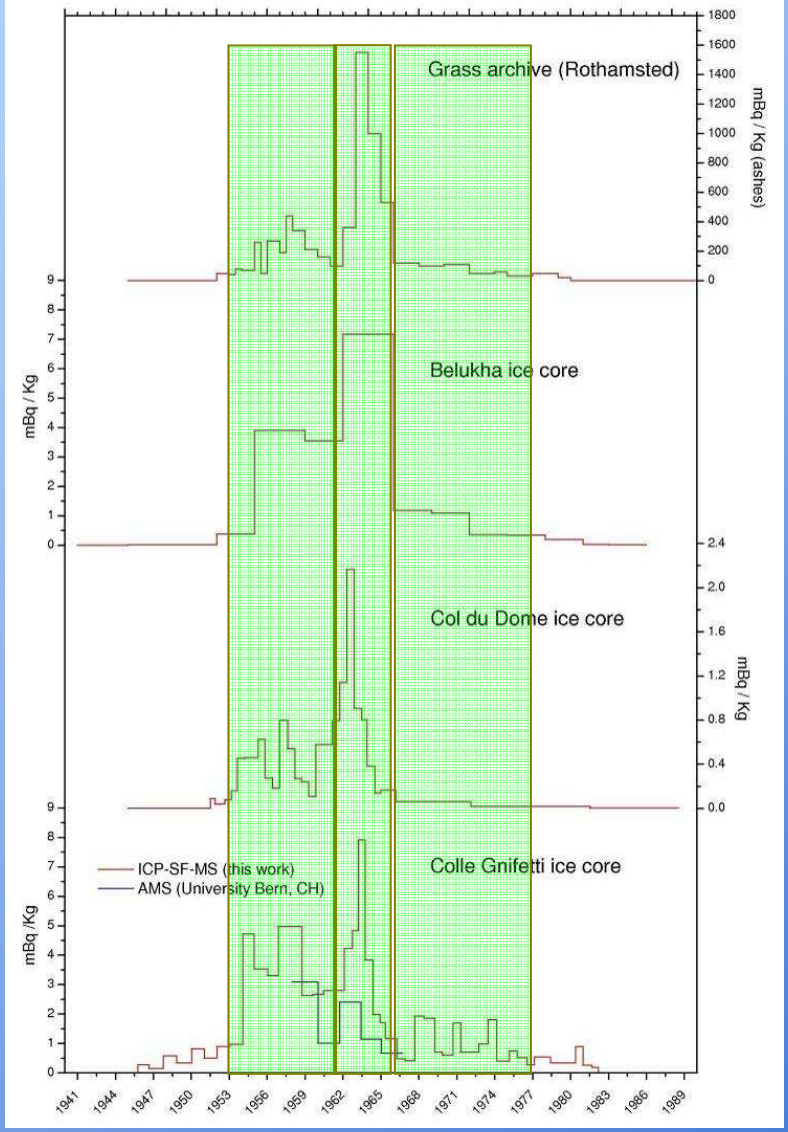
Without external calibration and/or IS spiking (^{241}Pu) only semi-quantitative analysis

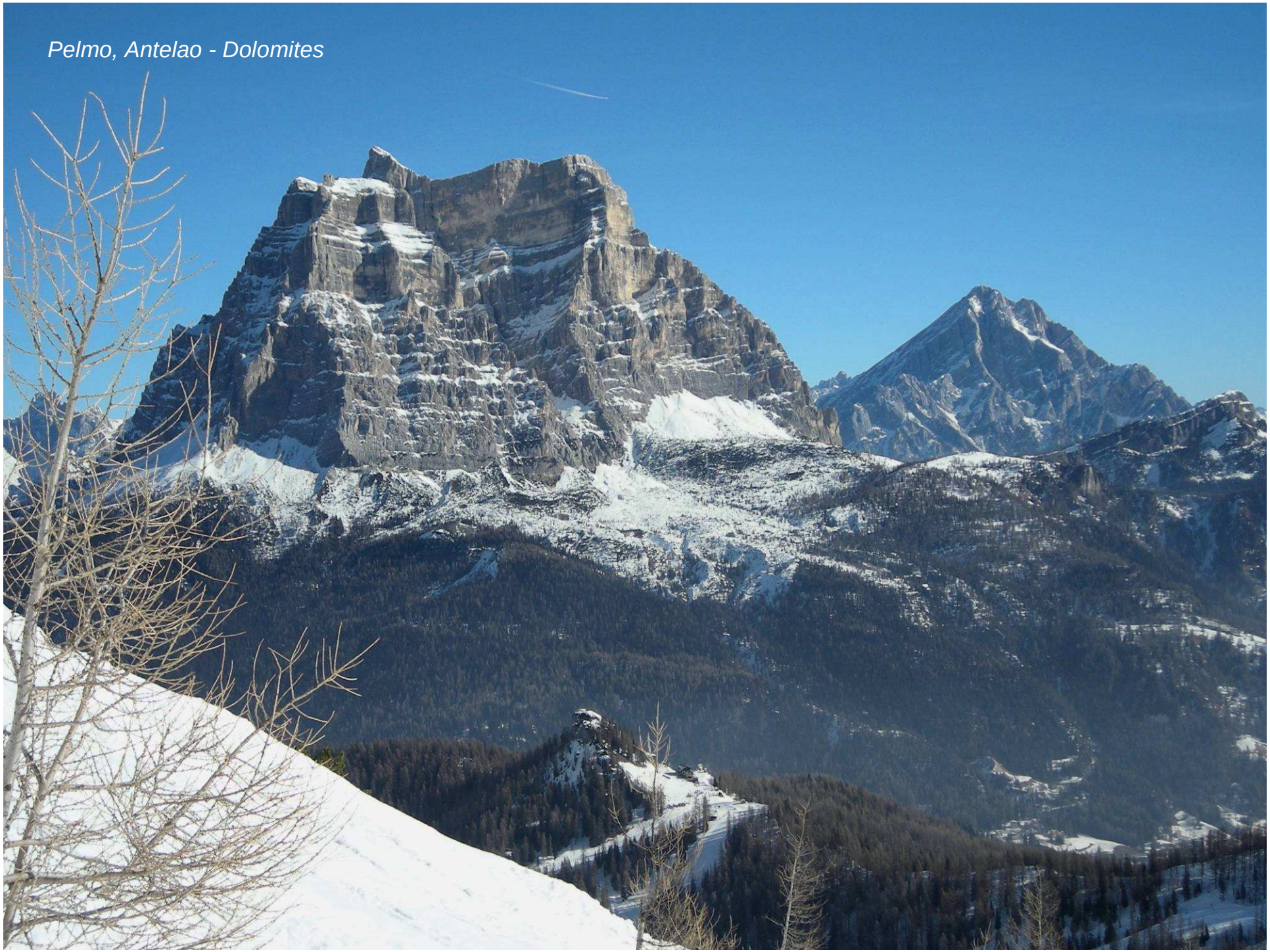
Calibration using ^{238}U linear regression parameters

UH^+ interference doesn't affect the method for [U] < 50 pg/g

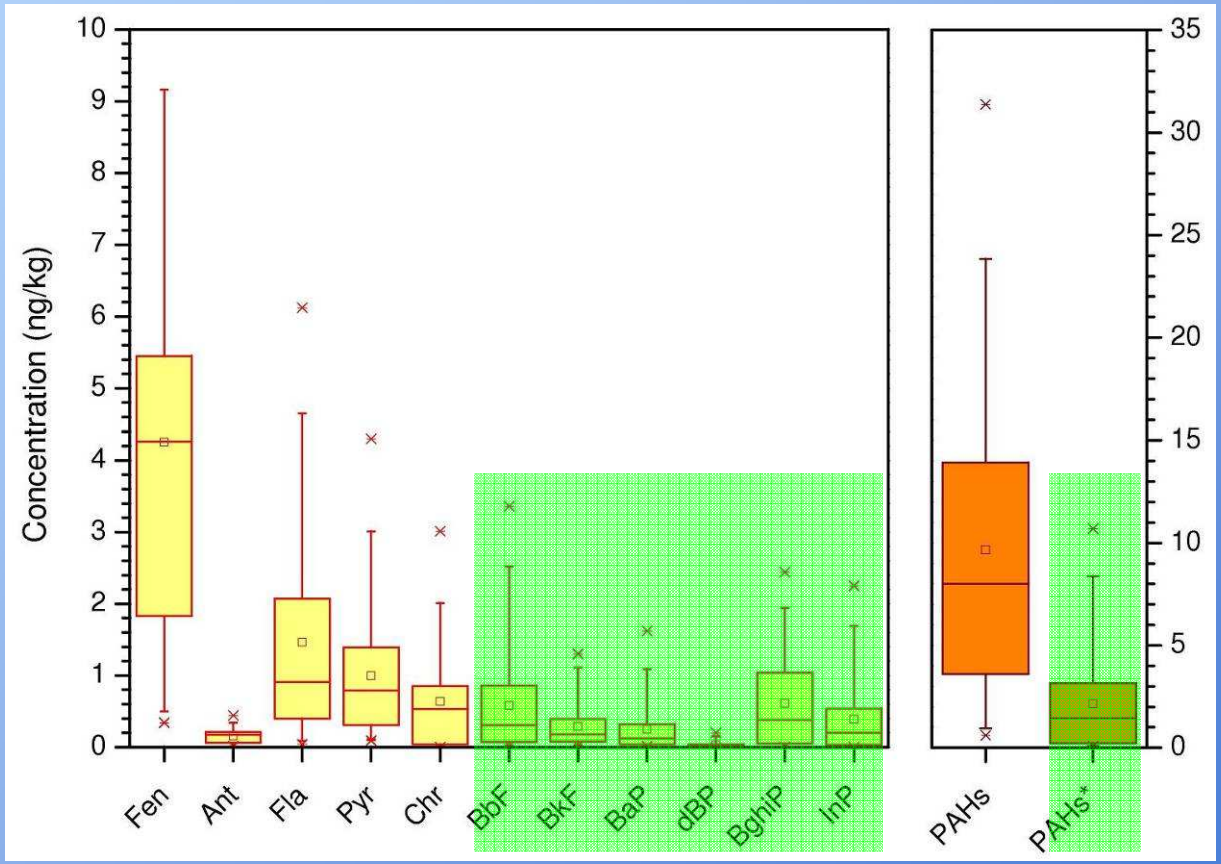
Fast screening method for "clean" matrix analysis; not appropriate for complex samples (soil, sediments, biological) without a purification step

Pu profile in CG firn core

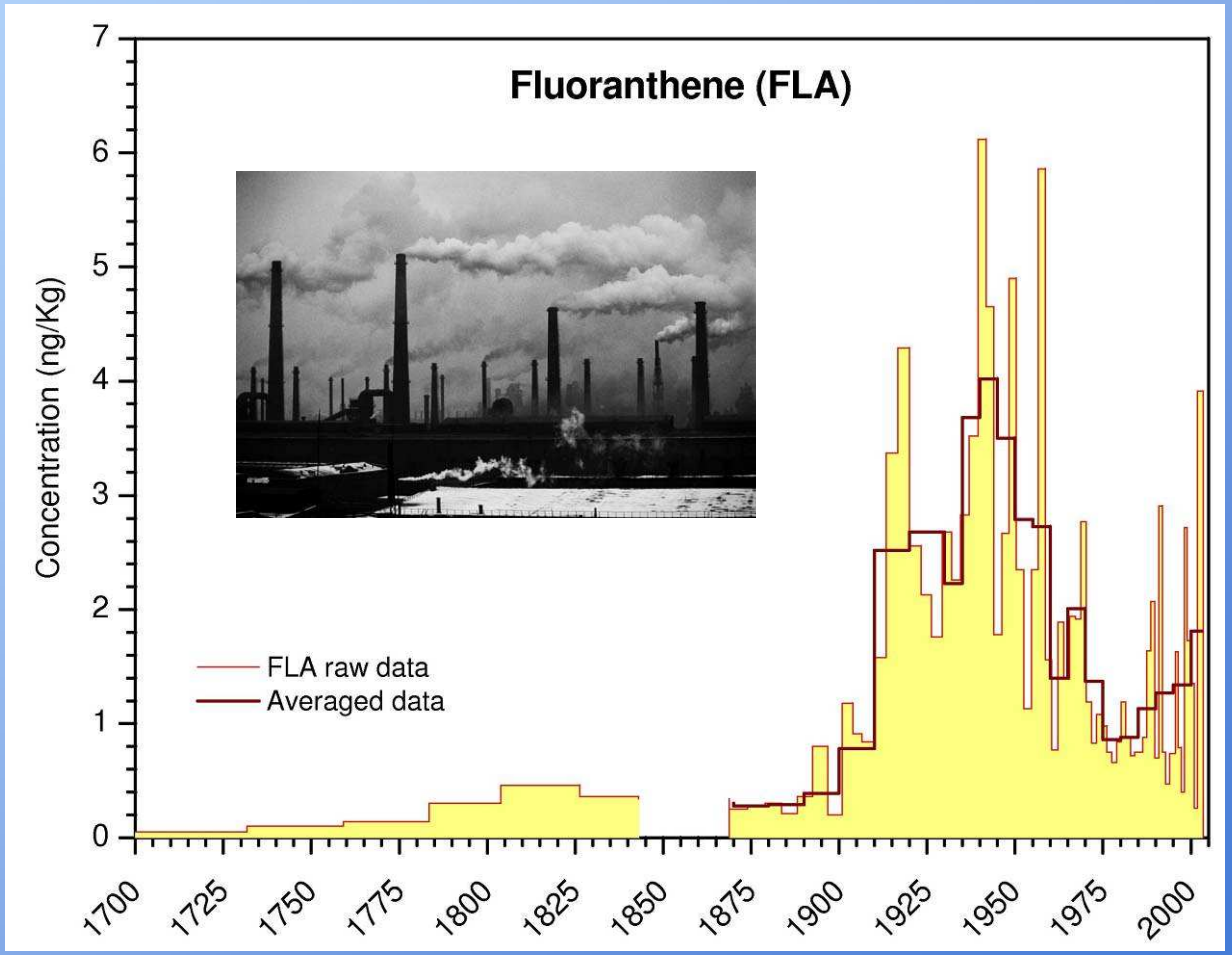



Pelmo, Antelao - Dolomites

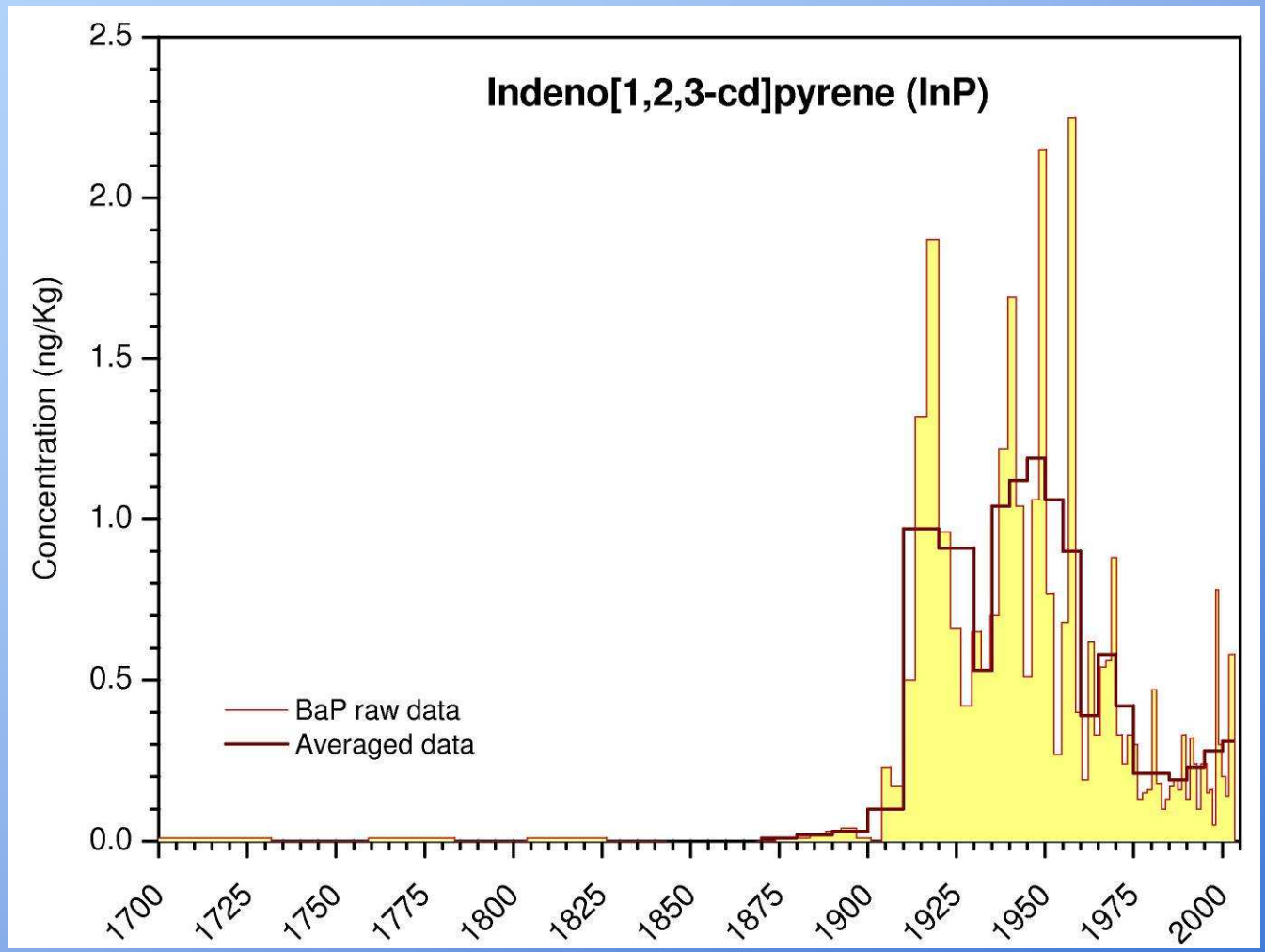
PAHs pattern



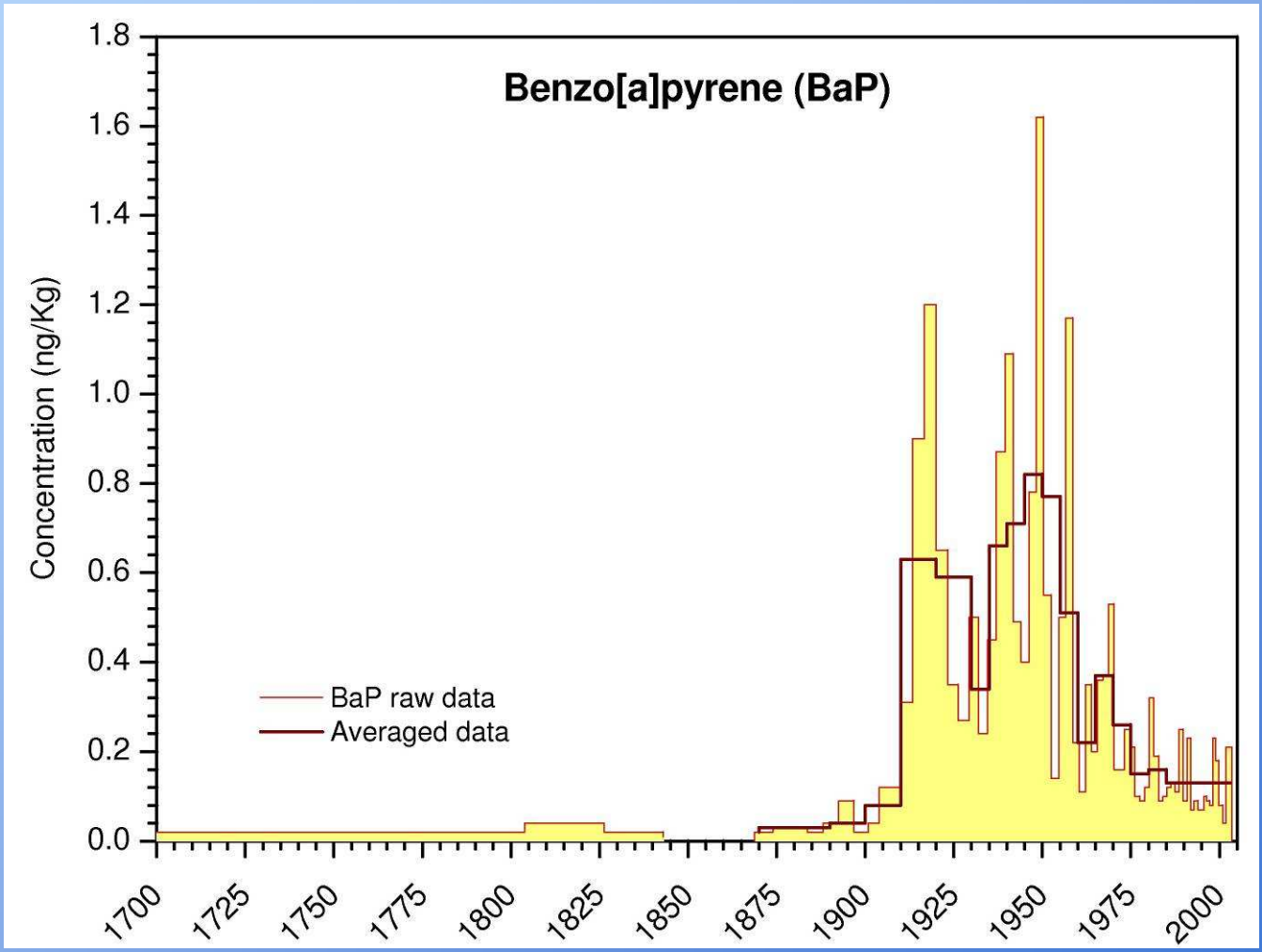
Fluoranthene



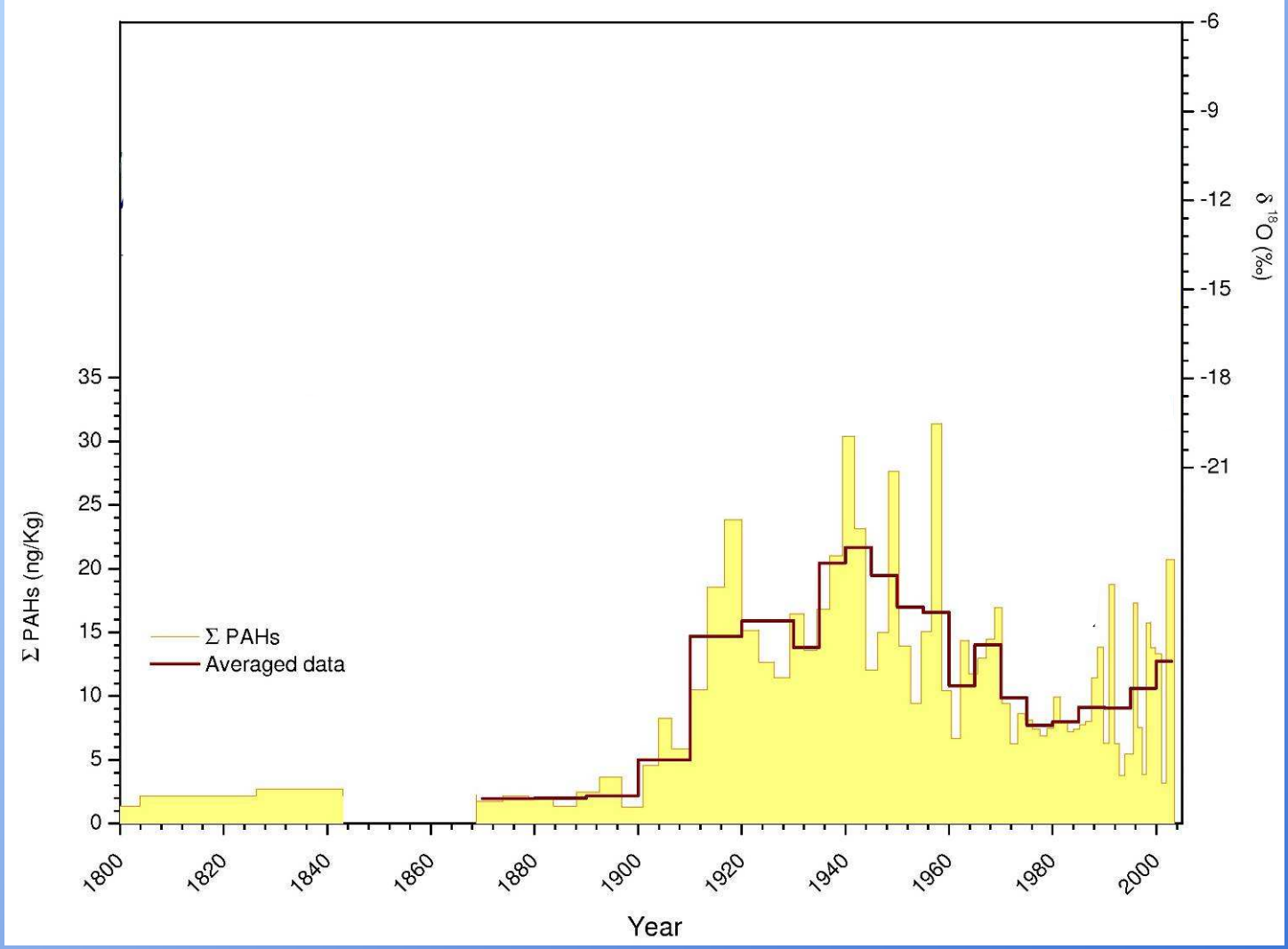
Indeno[1,2,3-cd]pyrene



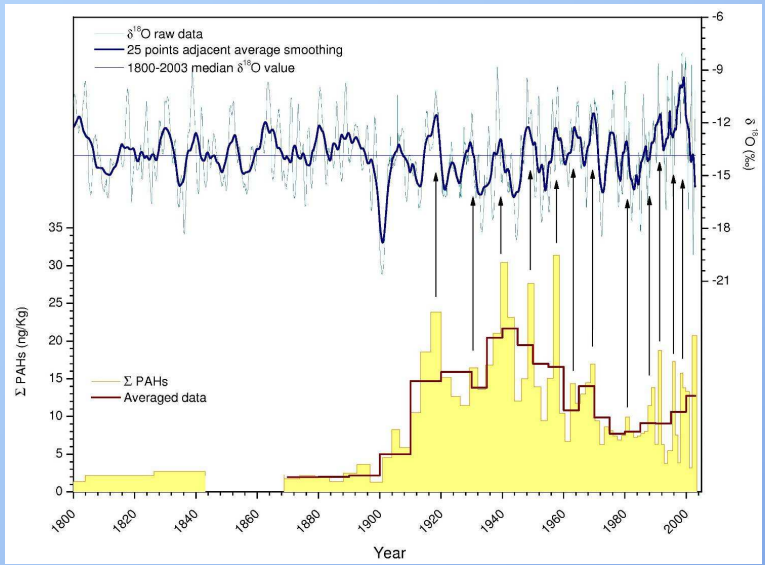
Benzo[a]pyrene

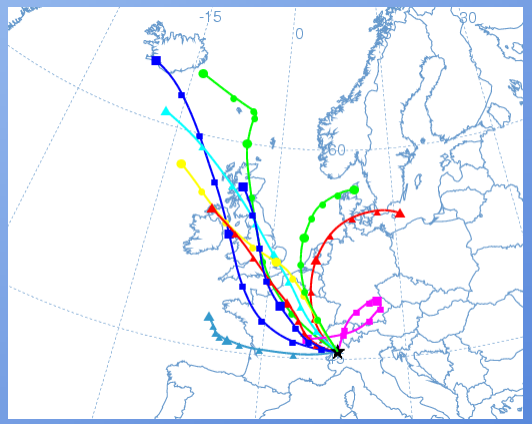


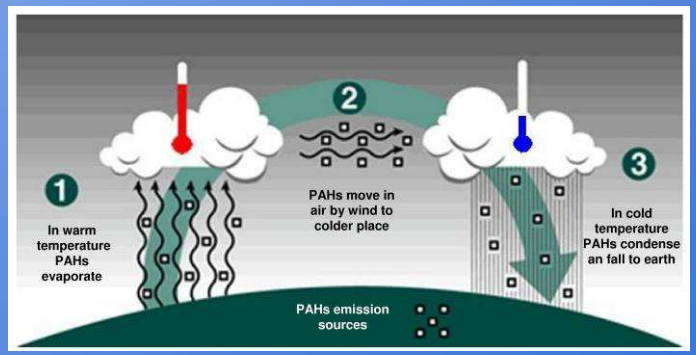
PAHs short-term variation and temperature



PAHs short-term variation and temperature








Marmolada, South Face - Dolomites

Conclusions

Designing, building and testing of a new melting system for continuous decontamination and on-line analysis of alpine ice/firn core

Continuous trace elements (ICP-QMS) and conductivity determination; semi-continuous solid phase extraction (SPE)

Discrete sampling and discontinuous analysis of trace elements, Pb isotopes and ^{239}Pu (ICP-SFMS)

Trace elements profiles

Short-term variations due to boundary layer and air masses trajectories seasonal changes; ALC implications

Increase of crustal TE concentrations during warm periods

Variations of anthropogenic TE concentrations during industrial revolution consistent with emission inventories in Europe

Conclusions

Polycyclic Aromatic Hydrocarbons profiles

First high-resolution PAHs record in ice and firn core

Long-term depositions influenced by anthropogenic emissions

Short-term PAHs profiles as function of climatic conditions: higher concentrations in warm periods

^{239}Pu profile reflects main periods of nuclear testing in atmosphere

High resolution profile

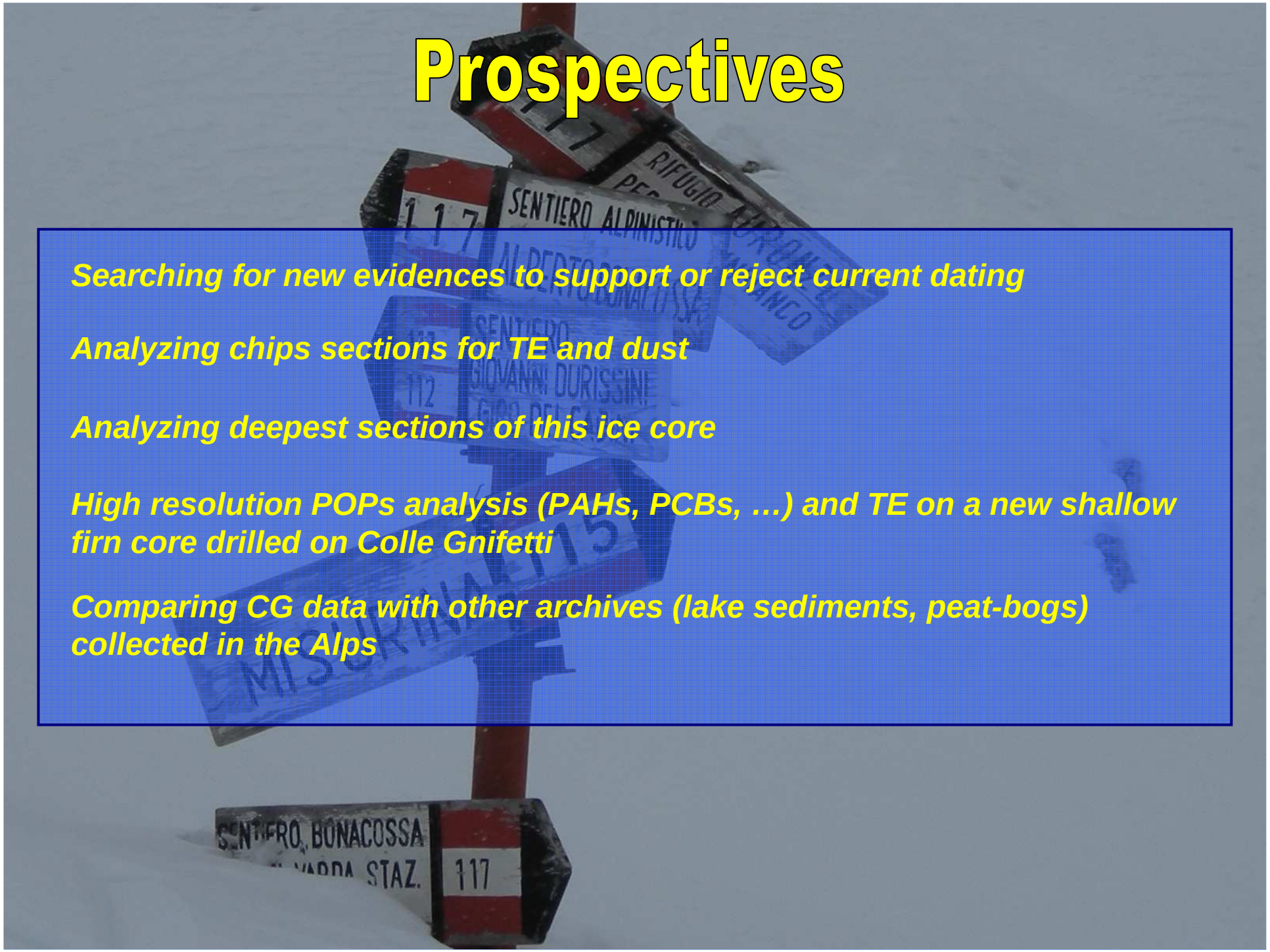
Validation of a rapid semi-quantitative method

Pb isotopes profile

High resolution profile

Evidences of "Turin isotopic experiment"

Prospectives



Searching for new evidences to support or reject current dating

Analyzing chips sections for TE and dust

Analyzing deepest sections of this ice core

High resolution POPs analysis (PAHs, PCBs, …) and TE on a new shallow firn core drilled on Colle Gnifetti

Comparing CG data with other archives (lake sediments, peat-bogs) collected in the Alps

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Dr. Theo Jenk

Dr. Barbara Delmonte


thanks for your attention!