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# Ice Core Archives of Natural and Anthropogenic Lead (Pb) and Cadmium (Cd) enrichment on Devon Island Ice Cap, Nunavut, Canada

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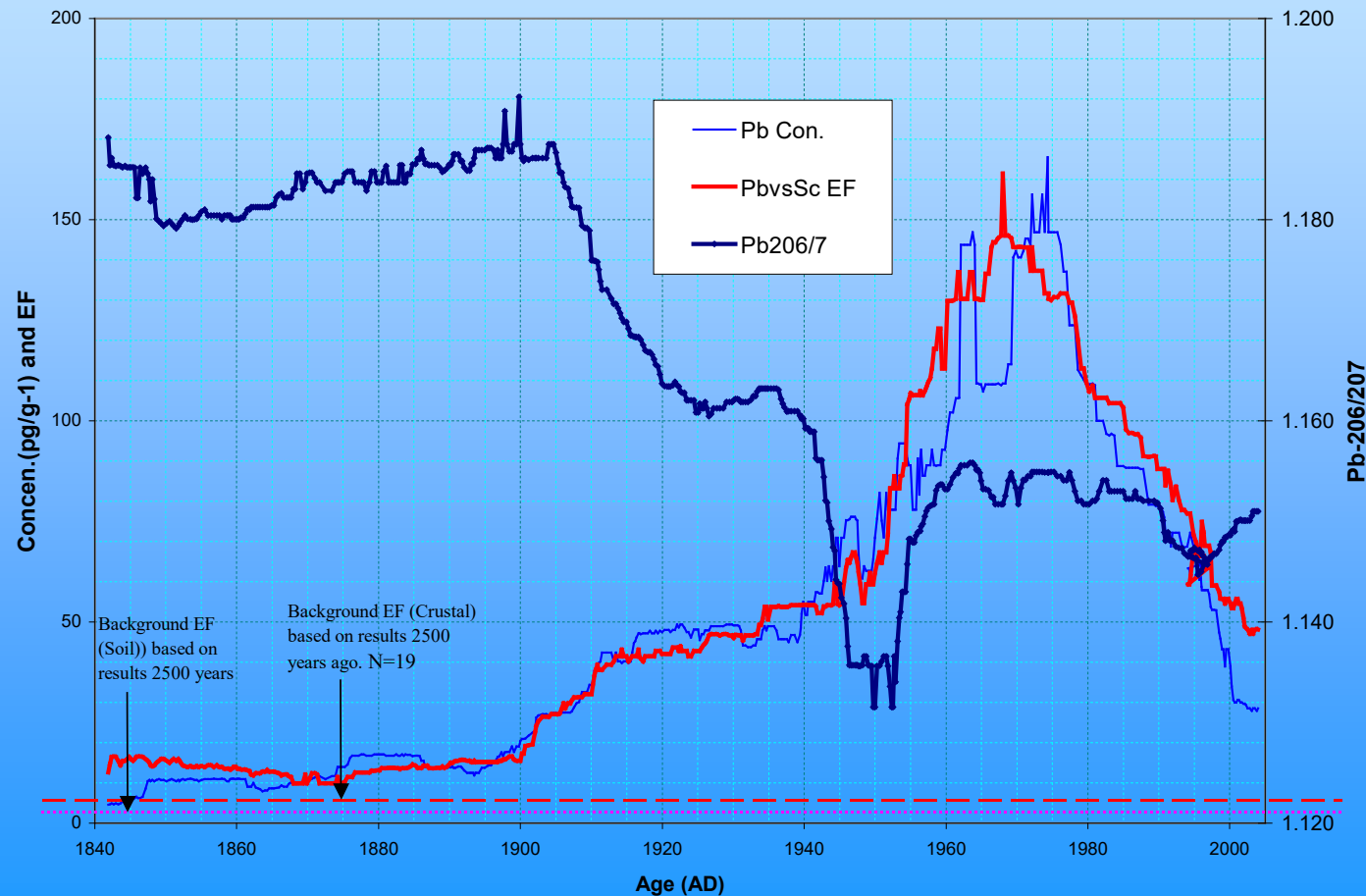
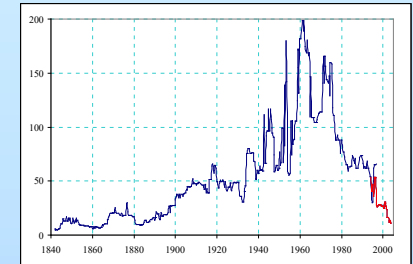
## Purposes of this work:

1. To develop a methodology for retrieving “contamination-free” ice cores;
2. To develop a methodology to process ice core samples for ultra low level concentration analyses (sub  $\text{pg g}^{-1}$  level)
3. To retrieve archives of Pb and Cd for the past 150 years (since industrial revolution in 1850s)



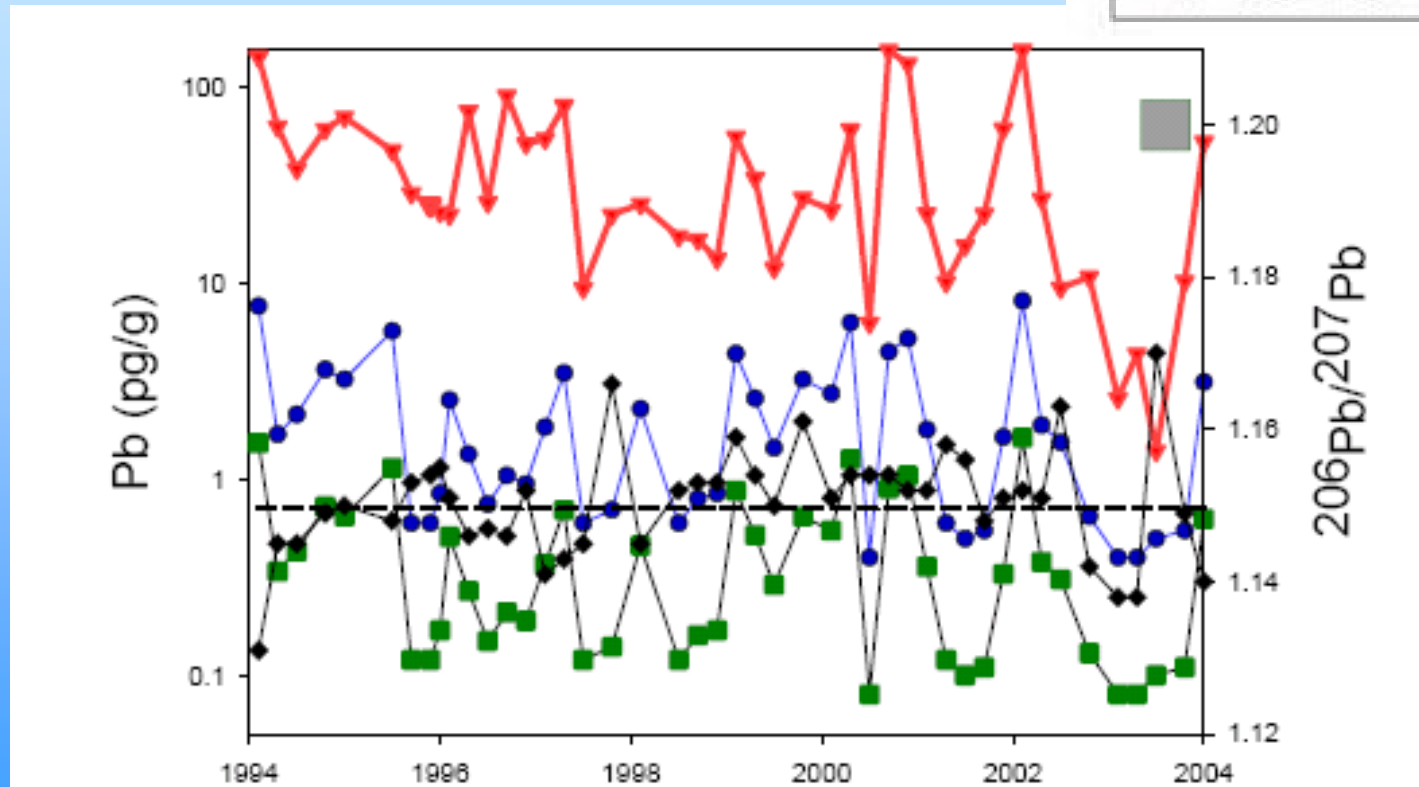


## Pb in ice core from 1940s to 2004: Concentration, Enrichment Factor and Pb206/207 Isotopic ratio





## Pb source apportionment for recent 10 years

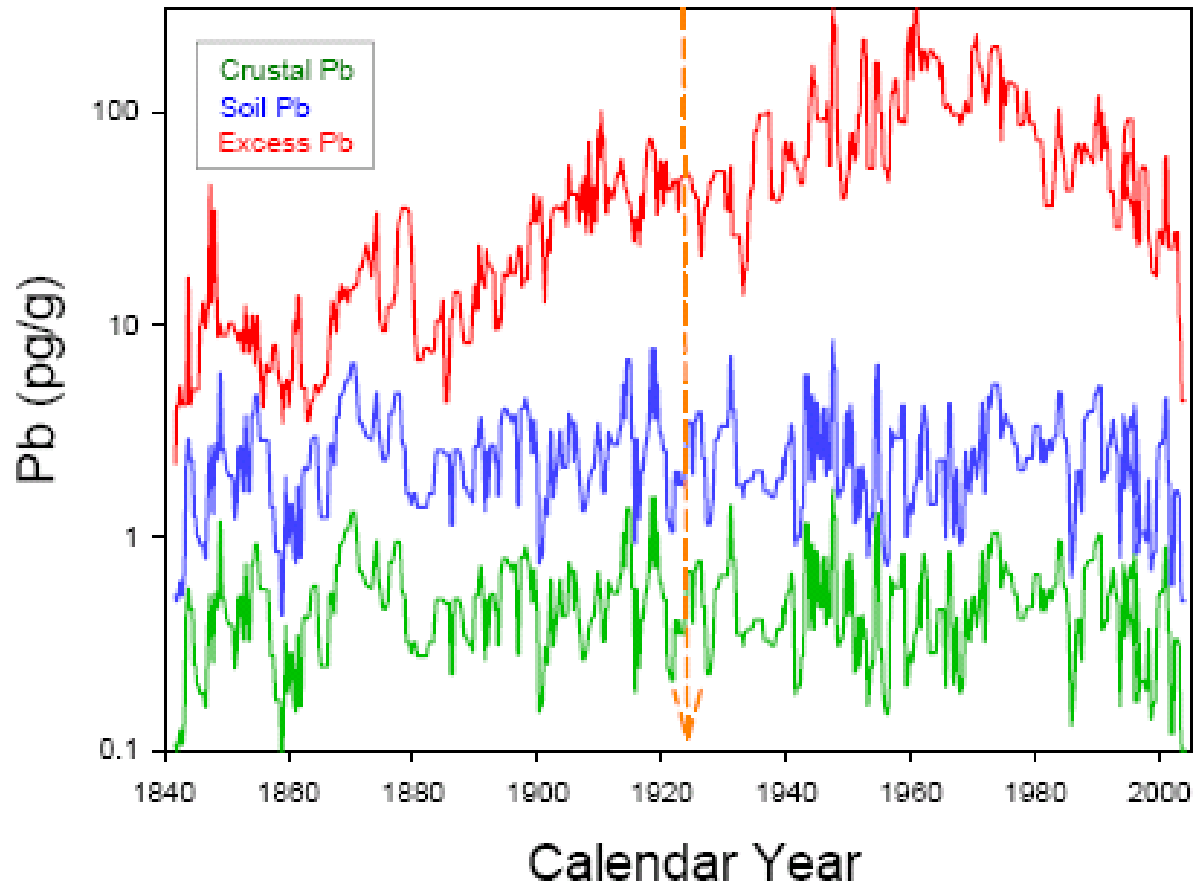


Quoted from Shotyk et al., 2005.





## Pb apportionment for the recent 160 years



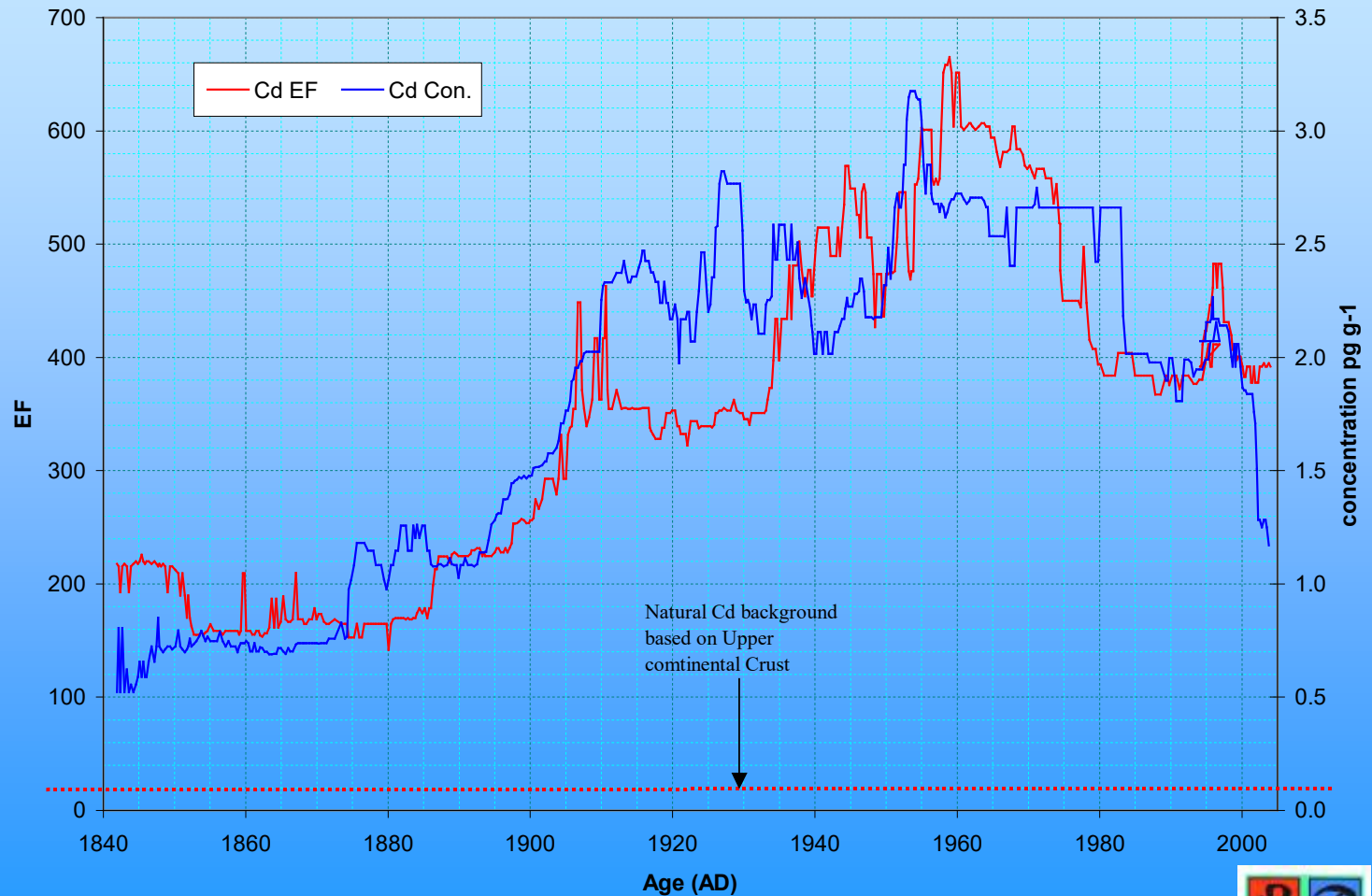
Quoted from Shotyk et al., 2005.





## Cd concentrations in Devon ice core from 1940s to 2004

Cd EFs calculated using Upper Continental crust Cd/Sc ratio.



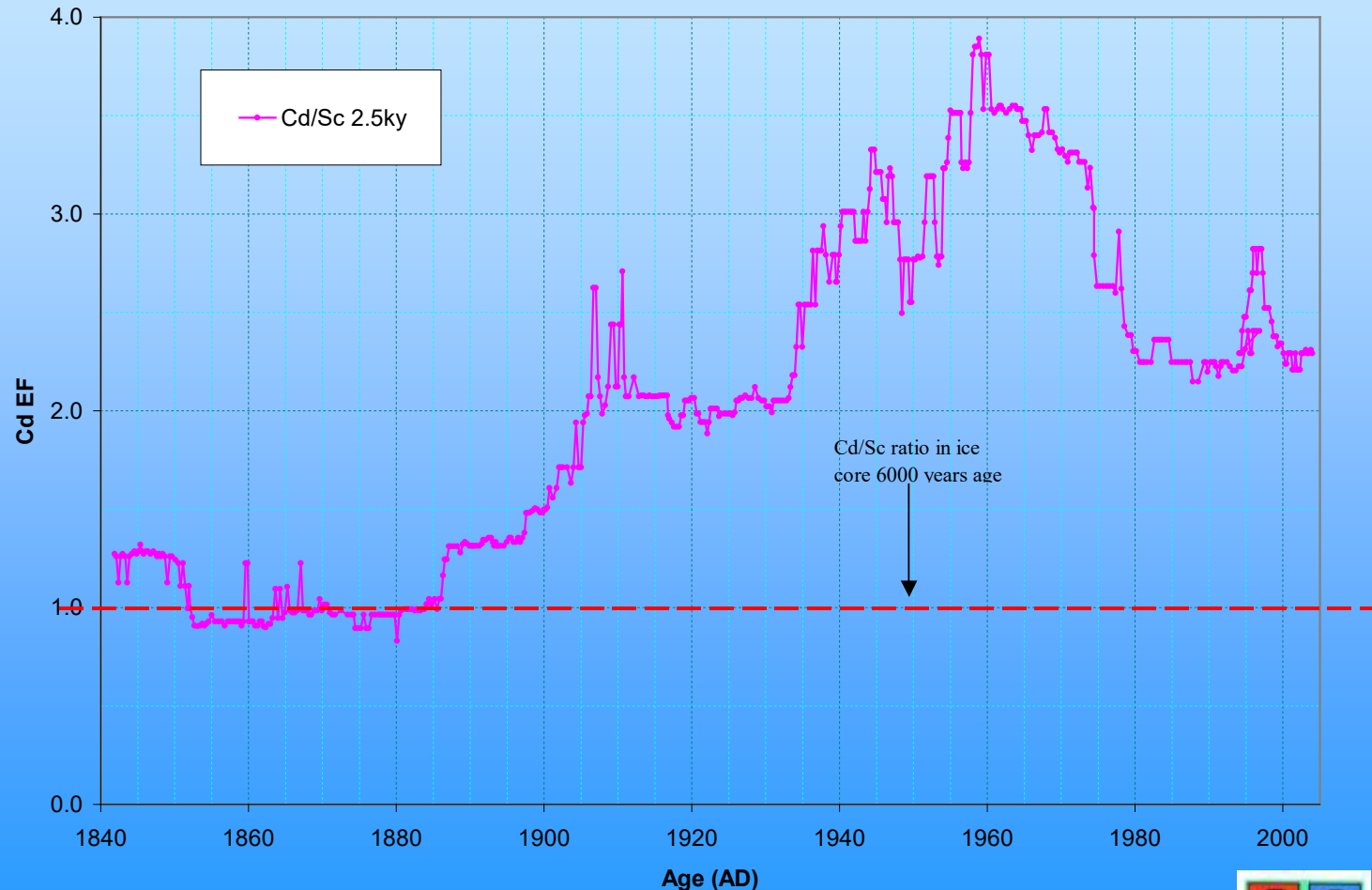


**Is this enrichment factor sound?  
If not, how to properly estimate it?**





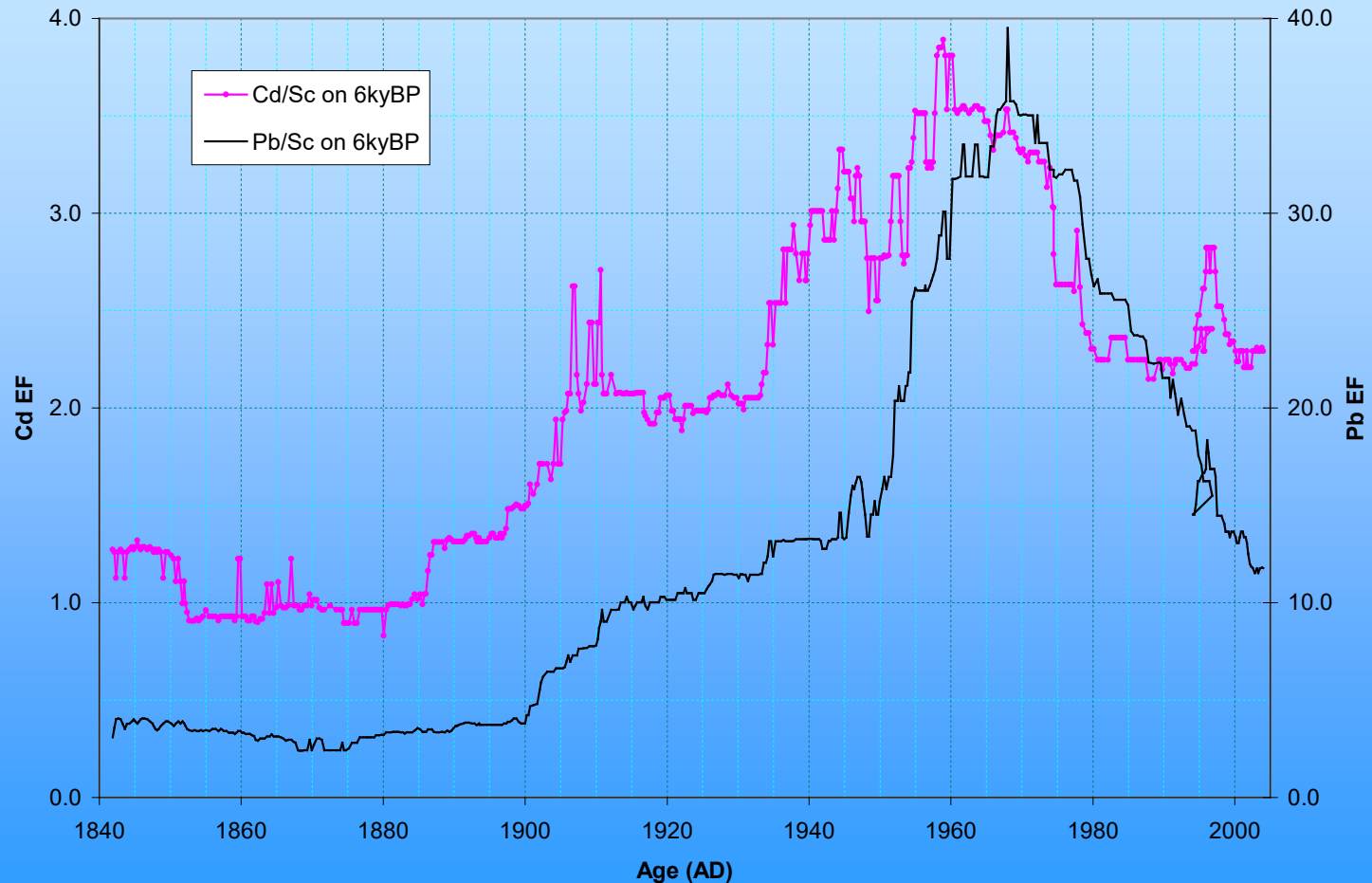
## Changes of Cd EFs from 1940s to 2004 based on natural background calculated between 6000 BP and 15500 BP







## Changes of Cd EFs from 1940s to 2004 based on natural background calculated between 6000 BP and 15500 BP





## Publications:

1. An ultra-clean firn core from Devon Ice Cap, Nunavut, Canada, retrieved using a specially-designed titanium drill for trace element studies. Zheng, J., Fisher, D., Blake, E., Hall, G., Vaive, J., Krachler, M., Zdanowicz, C., Lam, J., Lawson, G. and Shotyk, W. *Journal of Environmental Monitoring*. (in press)
2. Increasing atmospheric antimony contamination in the northern hemisphere: snow and ice evidence from Devon Island, Arctic Canada. Krachler, M., Zheng, J., Koerner, R., Zdanowicz, C., Fisher, D. and Shotyk, W. *Journal of Environmental Monitoring* 7, 1169-1176. (2005)
3. Predominance of industrial Pb in recent snow (1994-2004) and ice (1842-1996) from Devon Island, Arctic Canada. Shotyk, W., Zheng, J., Krachler, M., Zdanowicz, C., Koerner, R. and Fisher, D. *Geophysical Research Letters* 32, doi:10.1029/2005GL023860. (2005).
4. Direct determination of lead isotopes ( $^{206}\text{Pb}$ ,  $^{207}\text{Pb}$ ,  $^{208}\text{Pb}$ ) in Arctic ice samples at picogram per gram levels using inductively coupled plasma-sector field MS coupled with a high-efficiency sample introduction system. Krachler, M., Zheng, J., Fisher, D. and Shotyk, W. *Analytical Chemistry* v. 76: 5510-5517 (2004).
5. Novel Calibration procedure for improving trace element determinations in ice and water samples using ICP-MS. Michael Krachler, James Zheng, David Fisher and William Shotyk. *Journal of Analytical Atomic Spectrometry*, 2004, 19, pp. 1017-1019.
6. Analytical procedures for improved trace element detection limits in polar ice from Arctic Canada using ICP-MS. Michael Krachler, James Zheng, David Fisher and William Shotyk. *Analytica Chimica Acta* 530(2005) pp. 291-298.
7. A new 155-yr record of Pb pollution from Devon ice cap, Canada. Zheng, J., Zdanowicz, C., Fisher, D., Hall, G. and Vaive, J. *Journal de Physique IV*, v. 107: 1405-1408 (2003).





## Conference/workshop presentations/posters

- Lead background before anthropogenic effect and its recent 10-year trend. Society of Environmental Toxicity and Chemistry, Hague, Netherlands. May 7 to 11, 2006. (will attend)
- Importance of ice cores as Hg pollution archives and its geochemistry researches. NCP Hg workshop in Toronto. August 29 to 31, 2005.
- Recent trends and source(s) of atmospheric Pb deposition in the Canadian High Arctic documented from ice cores and lake sediments. Northern Contaminants Program Results Workshop, Victoria, B.C. (2005).
- Distribution and trend of cadmium (Cd) pollution in the high Arctic. Presented at “Northern Contaminants Program workshop” at White Rock, BC, Canada, Sep. 28<sup>th</sup> to Oct. 1<sup>st</sup> 2004.
- XII International Conference on Heavy Metals in the Environment, Grenoble, France, May 25 to 31, 2003.
- A Pb pollution history record since pre-industrial revolution (poster). NCP symposium, Ottawa, April 2003.





## Conclusions

1. Expectation or target of this work has been fulfilled;
2. The Titanium ice core drill, field sampling and lab sample processing procedures developed with this work are effective and sound;
3. Anthropogenic Pb is still existing in Arctic (Devon Ice Cap) and dominating the Pb deposition in ice/snow (over 90%);
4. **\*Cadmium contamination on Devon Island Ice Cap could be less than 4 times of its natural background.**





## Future plans:

- Further source of origin apportionment
- Climate driven lithogenic element variation
- Other anthropogenic elements in ice cores related to our modern life, such as PGEs and Hg, Sb, As et al.
- Long term Cd trend study





# Acknowledgements

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