

## Tracing of industrial emissions in an urban environment using Pb, Sr, Nd, and C isotopes (tree bark biomonitoring and aerosol sampling)

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The chemical composition of the atmosphere is affected especially in the northern hemisphere by increasing concentrations of heavy metals due to both natural and anthropogenic emissions. These pollutants are concentrated in submicrometer aerosols, which can be transported through the atmosphere over long distances before their deposition. Grousset and Biscaye (2005) showed in their review paper that combined Sr, Nd and Pb isotope ratios are most powerful tracers to identify natural dust sources and to identify their transport patterns. It has also been shown in many studies that Pb isotope ratios provide a very effective method of tracing anthropogenic atmospheric pollution. However Sr and Nd isotopes have very seldom been used for environmental studies. Only recently a first comprehensive study of trace metal pollution by a steel plant has successfully been performed using tree barks as biomonitors and Pb, Sr and Nd isotopes ratios ( $^{206}\text{Pb}/^{207}\text{Pb}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$ ,  $^{143}\text{Nd}/^{144}\text{Nd}$ ) as environmental tracers and shows that the combination of the three isotope systems is extremely powerful for tracing of an anthropogenic pollution (Lahd Geagea *et al.* 2007).

In the present study we can show that the combination of the three isotope systems is also extremely powerful for the distinction of different industrial atmospheric emissions sources in the same urban environment. This is of importance because Pb isotope ratios alone do not allow such distinction since industrial emissions like domestic waste incinerators, chemical waste incinerators or steel plant have very similar Pb isotopic compositions ( $^{206}\text{Pb}/^{207}\text{Pb}$ : 1.152-1.154) but very different Nd isotopic compositions ( $\epsilon_{\text{Nd}}$  values vary between -17 and -9.7). Similarly  $^{87}\text{Sr}/^{86}\text{Sr}$  isotopic compositions of soot particles from car exhausts (0.7087) are rather low compared to dust from steel plant (0.709) and domestic waste incinerators (0.7095). Thus the possibility of the identification of different industrial and anthropogenic emissions is given by the combined application of the 4 isotope systems and is based on the fact that significant difference exist between the Pb, Sr, Nd and C isotope ratios of the natural atmospheric background and pollutants containing Pb, Sr, Nd and C of industrial origin with likewise variable  $^{206}\text{Pb}/^{207}\text{Pb}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$ ,  $^{143}\text{Nd}/^{144}\text{Nd}$  and  $^{13}\text{C}/^{12}\text{C}$ .

### References

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## Re-Os systematics of Svecofennian Ni-Cu deposits in Finland

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Svecofennian magmatic Ni-Cu deposits are hosted by mafic-ultramafic intrusions that emplaced close to the peak of the Svecofennian orogeny (~1.89 Ga). These orogenic intrusions have a high potential for magmatic Ni-Cu sulphides and have been the main source of nickel in Finland. One mine – Hitura – is in current production. The studied intrusions are located in different areas of the Svecofennian domain; Vammala and Hyvelä are a part of the Vammala nickel province in SW Finland, while Kotalahti, Rytty and Hitura belong to the Kotalahti Ni-belt close to the craton margin in eastern Finland. Previous studies have emphasized the significant role of crustal contamination, but the nature of the assimilation and timing of the magma-country rock interaction has remained controversial.

We report Re-Os results from these five deposits in order to constrain the origin of the ores in more detail. Eighteen whole-rock samples and five sulphide fractions were analyzed, all but one from the mineralized parts of the intrusions. Os and Re contents in the whole-rock samples range from 0.012 to 57 ppb and 0.24 to 654 ppb respectively, and in the sulphide fractions from 14.6 to 5580 ppb and 92.1 to 1187 ppb respectively. The Re/Os-ratio ranges between 1.4 and 37.3 with an average of 13.9. The Re-Os variation shows very little secondary disturbance and the samples from all intrusions define a Re-Os isochron giving an age of  $1993 \pm 29$  Ma and an initial  $^{187}\text{Os}/^{188}\text{Os}$  value of  $0.32 \pm 0.10$ . The radiogenic composition of the ores indicate crustal contamination, which is supported by low  $\epsilon_{\text{Nd}}$  (1900 Ma) values (-1.4 – 0.4) indicated by the analysis of four samples. Importantly, these Re-Os systematics show no notable variations between the different nickel provinces or between the deposits. Given the similar isotopic composition for the intrusions, *in situ* contamination seems unlikely, since this would have required roughly the same amount of assimilation of a similar contaminant for each intrusion.

Our results imply that crustal contamination led to the sulphide saturation in these Svecofennian orogenic magmas, and that this was not an *in situ* process, but occurred at deeper crustal levels. Sulphides have probably been transported in suspension to their present location.