Investigating Heavy Metal Contamination of the Puget Sound Environment with New Isotopic Tracers

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Tacoma Smelter Background

The Tacoma Smelter operated for approximately 100 years at the southern end of Puget Sound and is a known source of heavy metal contamination to the local environment.

Previous studies confirm significant local contamination based on a dramatic increase of metal concentrations in sediments deposited in the Puget Sound following commissioning of the smelter, shown to the right in Figure 1.

These metals, such as lead, copper, and zinc, are toxic to the environment and pose a potential regional health hazard.

The extent of regional contamination, mechanisms of dispersal, and chemical form of metal contamination in the environment are not well known.

Image 1. Tacoma Smelter Stack, 1986.

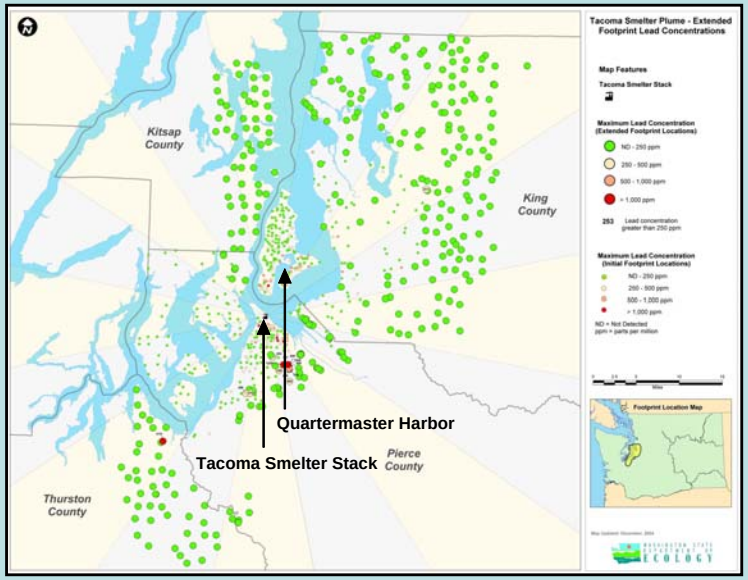
Goals

The main goal of our study is to analyze lead, copper, and zinc isotope ratios in contaminated sediments in order to calibrate isotopic tracers of heavy metals emitted by the Tacoma Smelter.

Preliminary data from lead isotope analyses of a sediment core from Quartermaster Harbor identify a clear isotopic fingerprint diagnostic of smelter-derived lead, as shown to the right in Figure 2.

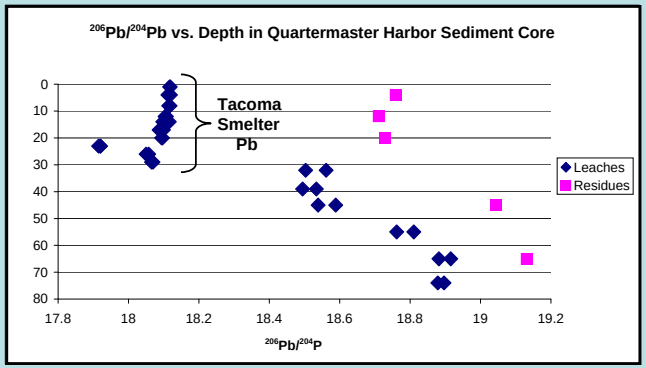
We will do a more thorough analysis of lead isotope ratios in the sediment core from Quartermaster Harbor, as well as, for the first time, test the use of copper and zinc isotope ratios as a fingerprint of smelter derivation for these metals. Pb is a radiogenic system, while Cu and Zn are stable isotope systems.

These isotopic tracers can then be used to determine the extent, pattern, and mechanism of heavy metal contamination in the Puget Sound region.



Washington State Department of Ecology, 2004

Figure 1. Lead concentrations in the southern Puget Sound region indicate significant contamination surrounding the Tacoma Smelter. However, isotope ratios are more robust than metal concentrations for tracing contaminants because, once in the environment, isotope ratios are not altered by chemical reaction and transport.



Tara Smiley, UW Isotope Geochemistry Laboratory, 2008

Figure 2. Our preliminary lead isotope analysis shows a dramatic shift in the $^{206}Pb/^{204}Pb$ ratio at a depth of approximately 30 cm. There are equally dramatic shifts in the $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios, identifying a clear isotopic fingerprint of Tacoma Smelter Pb. The analytical error is smaller than the data points in this figure.

Analytical Methods

➢ Ion Exchange Chromatography

The core sediments were initially leached to separate the contaminants (leaches) from the natural sediments (residues), so that we can analyze both.

Lead, copper, and zinc were separated from the leaches and the residues by ion exchange chromatography.

Lead was separated first by loading both the leaches and the dissolved residues onto a 100 μL teflon column, containing a strongly basic anion exchange resin, and eluting the lead with hydrochloric acid.

Copper and zinc were separated next by loading the samples onto 1.6 mL of a strongly basic anion exchange resin in a 4 cm long glass column. Copper and zinc were eluted separately in hydrochloric acid.

➢ MC-ICP-MS

Lead isotopes were analyzed by multi-collector inductively-coupled-plasma mass-spectrometry.

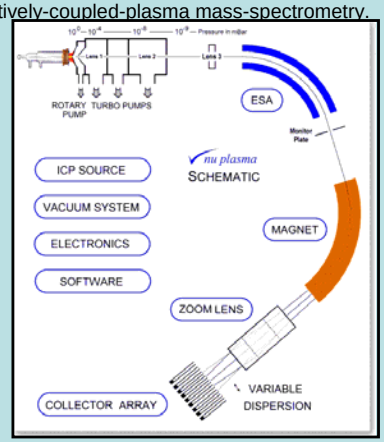


Figure 3. NuPlasma MC-ICP-MS Schematic Diagram.

Results

MC-ICP-MS technology allows, for the first time, precise analyses of variations in isotope ratios of Cu and Zn. We have obtained pure separates of the Zn and Cu from the samples previously analyzed for Pb isotopes. The final step will be Cu and Zn isotopic analyses.