ARCHAEOBOTANICAL IMPACT OF PRE-COLONIAL ANDEAN MINING

Investigating Crop Phytoaccumulation of Lead (Pb) and Mercury (Hg)

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Smithsonian

Purpose

Find a reliable methodology to determine the agricultural impact of anthropogenic metallurgical pollution in the Andes using archaeobotanical samples

Pre-Hispanic silver figure possibly from Chimú culture (Coastal Peru)
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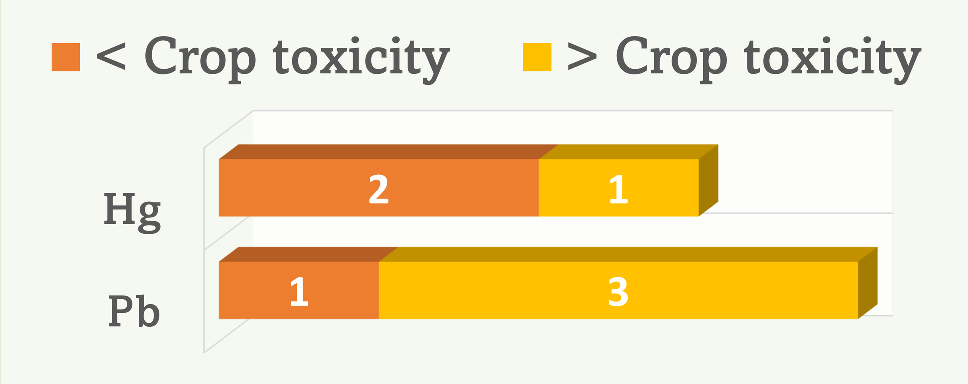
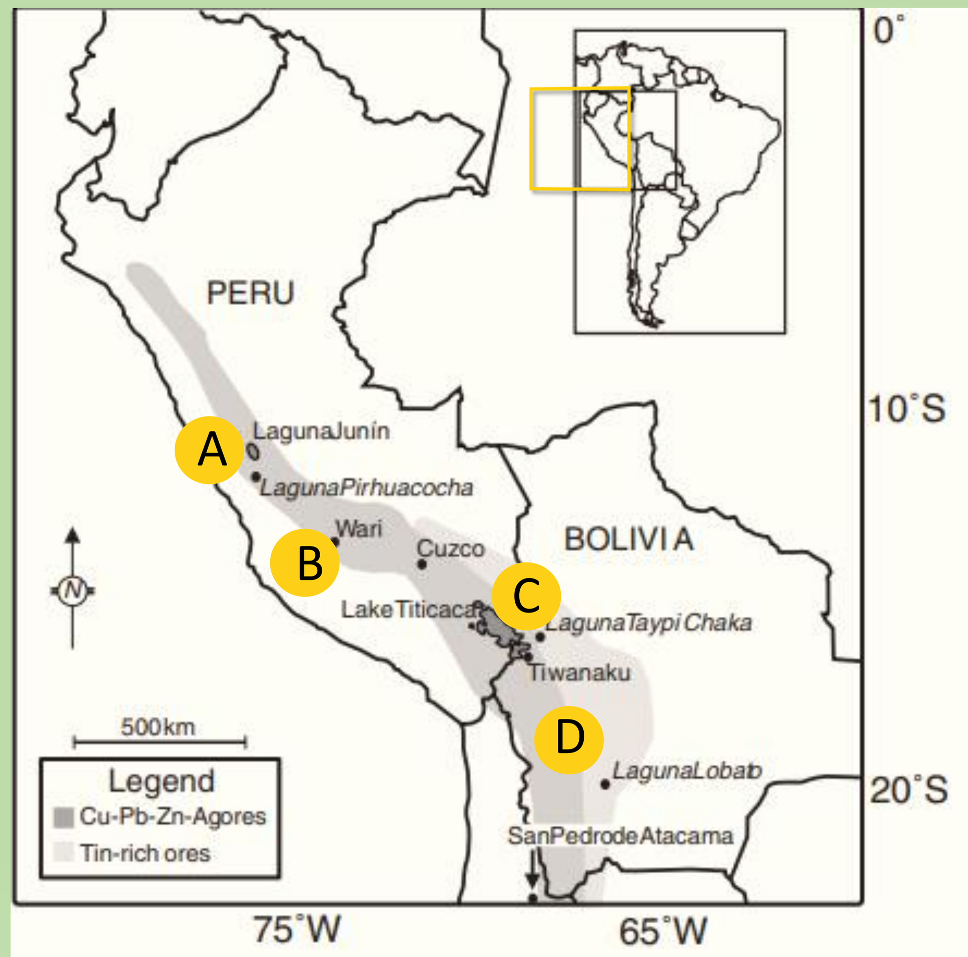


Lakebeds with sediment enrichment above Pb (Morococha, Potosí, and Titicaca) and Hg (Potosí and Huancavelica) threshold for plant toxicity by 1100 AD.



A: Morococha; B: Huancavelica; C: Titicaca; D: Potosí

Cooke et al (2008)

Timeline

1400 BC Cinnabar production begins in **Huancavelica** to create vermillion pigment.

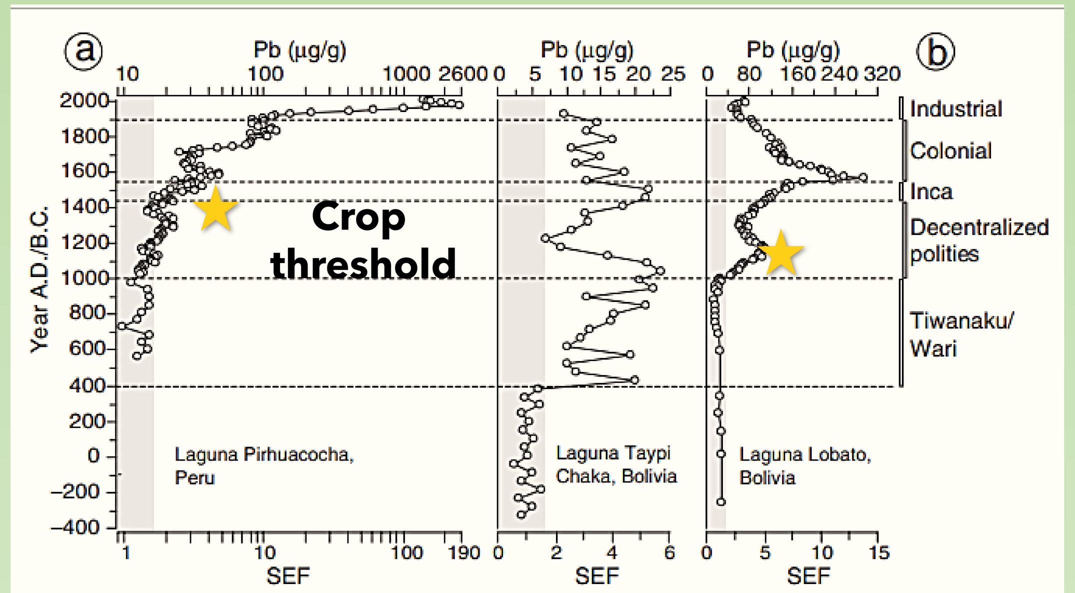
400 AD Copper mining begins in **Titicaca** with the use of wind-drafted furnaces called ***huayrachinas***.

1040 AD Titicaca political collapse leads to an exodus of people and their metallurgical knowledge to **Morococha** and **Potosí.**

1300 AD Rise of the Inca empire, who increase copper mining and introduce silver mining. Heavy metal sediment enrichment factors (SEF) reach **precolonial peaks in all regions.**

Pb conc. from lakes near mining centers with estimated crop toxicity thresholds.

Cooke et al (2007)



Non-traditional isotope analysis

Andean soil sediments as early as **1400 BC** have been found to contain anthropogenic metallurgical pollution using what is referred to as "**non-traditional isotope analysis**". This methodology allows for anthropogenic heavy metals to be recorded in environmental proxies including lakebeds, ice cores, and peatbogs. This has proven that mining occurred, and impacted environments, far longer than previously thought.

Non-traditional isotope analysis for anthropogenic mercury and lead has yet to be conducted on **archaeobotanical remains**. This can determine whether crops also accumulated toxic metals and expand our ecological understanding of precolonial mining. Andean mining areas like Potosí are still some of the **most contaminated in the world** with strong social tensions between miners and farmers over metallurgical pollution. It is pertinent to study this human-environment interaction from its insipience.

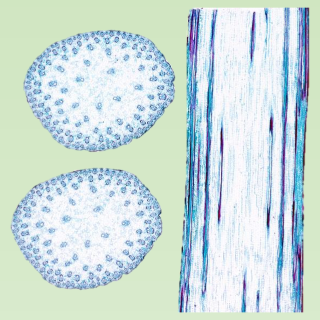
Heavy metal plant uptake

From the many heavy metals emitted by pre-colonial metallurgy, this project focuses on lead and mercury because of their **environmental permanency**, **botanical and human impact**, and **contemporary importance.**

Each plant has its own absorption mechanism for each heavy metal, which further depends on specific soil conditions like pH. Heavy metal toxicity generally endangers a plant's **cellular membrane, metabolic processes,** and **uptake of essential nutrients.**

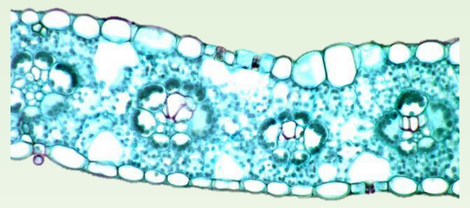
Mercury is potentially toxic to plants at **1 µg/g** and lead at **100 µg/g.** By the decentralized states period (1000-1400 AD), lakebed sediment near mining centers regionally experience **heavy metal concentrations higher than the thresholds**. I hypothesize that if agricultural soils correlate with lakebed concentrations, then plant remains will also **demonstrate toxic metal bioaccumulation through non-traditional isotope analysis**.

From Pb and Hg enriched soils, most bioaccumulated metals are absorbed by root hairs and kept in the **root system** to protect the rest of the plant.



From roots, relatively few toxic metals are transported to the aerial portion of a plant through the **stem**, specifically the water-carrying xylem.

The least amount of toxic metals is absorbed through the plant's **foliage** from the surrounding atmosphere.



Zea mays (corn) cross-section micrographs
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Future research

- Collect **agricultural soils** and **plant macroremains** from mining regions
- Conduct **mass spectrometry** to determine **Pb** and **Hg** concentrations
- **Compare** with Andean precolonial **pollution record**

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