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Sources and Spatial Distribution of Metal Pollutants in Soils near the El Paso Smelter: A Forensic Study with Pb and Pu Isotopes.

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Lead and copper smelting has been conducted at El Paso since the late 1800's, and as a result, environmental media near the smelter have become contaminated. A study has been conducted to investigate the sources and spatial distribution of metal pollutants (Pb, Cd, Zn, Hg, As, Cu) and concomitant tracers (Ag, In, Sb, Bi) in soils from the smelter vicinity. Sampled locations were residential and non-residential locations in El Paso (Texas, USA), Anapra (New Mexico, USA) and Ciudad Juarez (Chihuahua, Mexico).

Lead isotope studies indicate that the soil Pb is derived from smelting, and is consistent with two-component mixing between lead ores from Chihuahua (northern Mexico) having $^{206}Pb/^{204}Pb$ of 18.6 – 18.8 and ores from the Hanover, New Mexico (USA) mining district with $^{206}Pb/^{204}Pb$ of $\sim$ 17.6. The Pb isotope results also exclude other common anthropogenic Pb sources such as paint and gasoline emissions as being major contributors. Concentrations of Hg and Pb of up to 10 and 11,000 ppm were found in surface soils within 1 km of the smelter.

The metal concentration results clearly indicate that soils near the smelter ($<$ 5 km) exhibit much higher concentrations of smelter-related elements than do soils from control locations ($>$ 10 km distant). A general trend of decreasing concentrations vs. distance from the smelter was also observed. However, the results indicate that metal concentrations vary widely even at a fixed distance from the smelter point source. This phenomenon results from a combination of natural and anthropogenic processes that disturb and re-distribute soils in the surface environment. The site conditions consist of a very arid environment with little vegetation cover that is frequently disturbed by high winds and severe episodic rainfall. To study these effects, we have investigated stratospheric fallout plutonium ($^{239+240}Pu$) as a proxy measure of disturbed vs. undisturbed soil conditions. The premise is that "undisturbed" locations will have high $^{239+240}Pu$ activities, and hence contain most or all of the cumulative deposition inventory of smelter pollutants, while soils with low $^{239+240}Pu$ activities can be regarded as "disturbed", and cannot contain the entire deposition inventory. $^{240}Pu/^{239}Pu$ atom ratio measurements reveal that the Pu is from stratospheric fallout, precluding other local or regional sources. Our results indicate that $^{239+240}Pu$ activities are closely correlated with concentrations of smelter pollutants within a specific distance grouping; hence, the soil concentrations of contaminant metals are described by a "distance" factor and a "disturbance" factor, the latter being probed using $^{239+240}Pu$ as an effective proxy measure. Linear correlations ($r^2 > 0.95$) are observed for metal concentrations vs. $^{239+240}Pu$ activity for a given distance grouping; lines of varying slope are observed for different distance groupings. In desert soils remote from the smelter, the metal constituents are present from other anthropogenic and geogenic sources, and their concentrations are uncorrelated with $^{239+240}Pu$ activity.