Tracking Heavy Metal Contamination Using Magnetism and Mineralogy in Tacoma
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Introduction
The ASARCO smelter in Tacoma has been related with arsenic (As) contamination throughout the South Puget Sound. Arsenic soil contamination is a heavy metal that is a constant concern. Exposure to high levels of arsenic and have serious health effects. In order to trace this contamination through Tacoma soils magnetic properties of soils are being examined. With magnetism we can separate characteristics of smelter contamination from other contaminating sources such as pesticides. This identification can inform/guide to proper remediation of soil including replacement.

Sampling
Sites were chosen from locations studied by WA Department of Ecology (Department of Ecology 2004, 2011). Locations all contained significant arsenic levels which varied from site to site.

<table>
<thead>
<tr>
<th>Site</th>
<th>Maximum As Concentration (ppm)</th>
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<tbody>
<tr>
<td>Masko Park (MAS)</td>
<td>78</td>
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<tr>
<td>Curran Orchard (COR)</td>
<td>148</td>
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<tr>
<td>Colegate Park (COL)</td>
<td>93.5</td>
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<tr>
<td>Vassault Overlook (VOL)</td>
<td>1050</td>
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<tr>
<td>Smelter Slag (TSS)</td>
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Methods
- Samples collected and dried.
  - Served at 2 mm and packed into #6 gelatin capsules (0.21 ml).
- Measured hysteresis and magnetic remanence acquisition using a MicroMag 3900 Vibrating Sample Magnetometer (WWU).
- Hysteresis loops cycle 0 T → +0.5 T → 0.5 T → 0 T
- Hysteresis Loop processing, corrected loops for high field slope assuming saturation @ 70% of max field

Predictions:
1) Magnetic properties should be similar in slag and soils containing smelter ash.
2) Saturation magnetization (Ms) and paramagnetic susceptibility (Xhf) should both vary with smelter ash contamination.

Results
- Xhf and Ms are approximately linearly related when all contaminated topsoils and slag samples are considered.
- Xhf and Ms measurements were higher for samples with higher arsenic levels.

Discussion
- Hysteresis loops of slag and soil samples are consistent with non-single-domain (SD) ferromagnetic particles of magnetite (Fe₃O₄) or maghemite (α-Fe₂O₃). These same minerals were observed in smelter slag material.
- There is a consistent ratio of ferromagnetic to paramagnetic material in all samples. Both paramagnetic and ferromagnetic content are highest in the slag and lowest in the least contaminated soils. This suggests mixing between a slag-like component and a low-Fe component.

Conclusions
- Sites that contained lower levels of arsenic did plot together as predicted on a plot of high field susceptibility and Ms.
- Magnetic properties of hysteresis loops can be used to fingerprint ASARCO smelter contamination.
- Future work will be done on less contaminated soils.

References

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