Tacoma Smelter Slag - Composition and Major Constituents

Michael P. Cole
Environmental Studies Program, University of Washington Tacoma

Introduction

Waste material resulting from copper smelting operations at the ASARCO Smelter is found in various locations around Commencement Bay. This material known includes tapping slag, a crystalline material formed from molten waste from the smelting process. The slag mineralogy will provide a basis for comparison with airborne dust. To date, the only study of slag mineralogy has been qualitative (Lasmanis *et al*. 1997). This study is an attempt to quantify the mineralogy of smelter waste products. Quantifying the mineralogy of smelter waste will allow future studies to link mineralogy and magnetic properties, providing a unique fingerprint of smelter contamination.

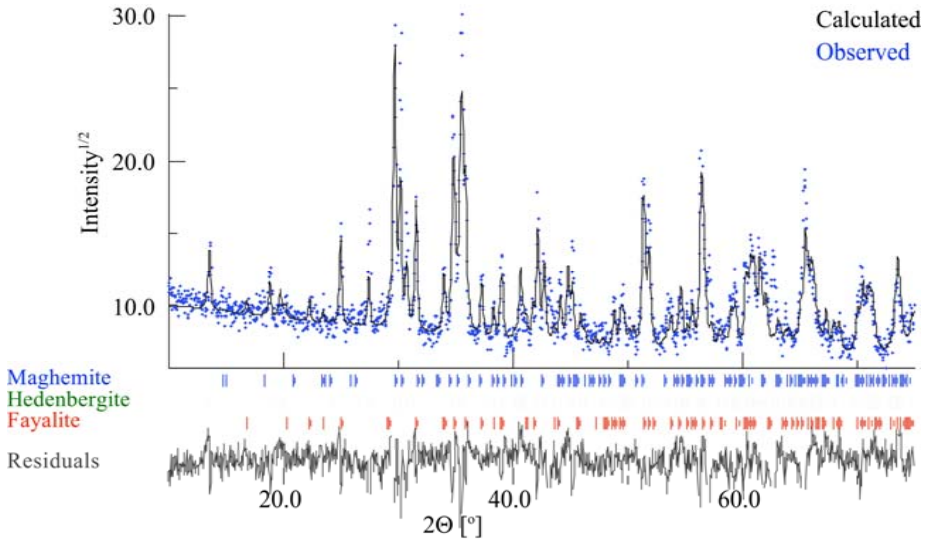
Sampling & Methods

- Hand and core samples were retrieved from the slag peninsula near Point Defiance Park.

Figure 1: Left: Map showing sampling location. Right: Photo of drill sampling site on slag peninsula.

- ~1g each of four samples were powdered for X-ray diffraction on the Phillips PW1842 X-ray diffractometer at the University of Puget Sound (CuKα; 40kV, 30A; 10° to 75° 2θ, .04° step).
- Quantitative phase analysis was carried out using MAUD software v. 2.31 (Lutterotti 2011). A version of the Rietveld method is used to calculate diffractograms based on known minerals, with weight percentages of minerals as unknowns.
- Backscattered electron images and approximate mineral compositions were collected using the scanning electron microscope in the UW Electron Microscopy Center (JEOL JSM 7000F with EDAX EDS; Schottky FEG source; 30 kV, 10A; working distance/ focus 10mm)

Results



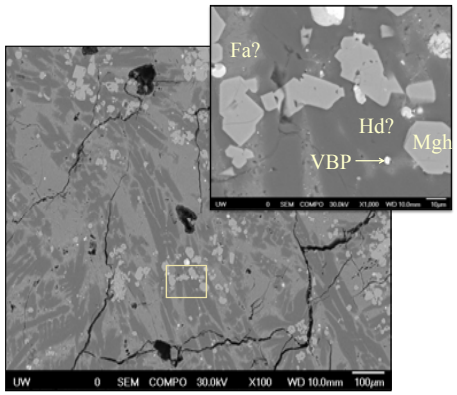


Figure 2 (Above): X-ray diffraction data (blue) and MAUD computed diffractogram (black) from sample TSS-03. Fit suggests that the ASARCO tapping slag contains the Ca-Fe silicate hedenbergite, Fe silicate fayalite, and Fe oxide maghemite (see Fig. 4 for quantities; σ=2.26, R_w=21.8%). Peaks of individual phases indicated as tick marks.

Figure 3 (Left): Backscattered electron images illustrating phases in TSS-03. Abbreviations: Fa = Fayalite, Hd = Hedenbergite, MGH = Maghemite, VBP = unknown very bright phase). Inset shows area in yellow square at higher magnification.

Figure 4 (below): Structures, compositions, and weight percentages of the three phases used in quantitative analysis of TSS-03.

Hedenbergite

Formula: $CaFe^{2+}Si_2O_6$
Weight %: 71.446686 +- 2.273733

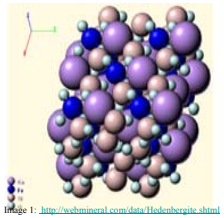


Image 1: http://webmineral.com/data/Hedenbergite.shtml

Fayalite

Formula: $Fe^{2+}_2(SiO_4)$
Weight %: 25.897352 +- 1.2829272

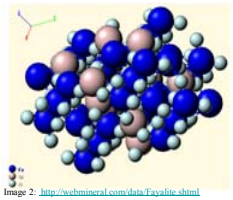


Image 2: http://webmineral.com/data/Fayalite.shtml

Maghemite

Formula: $Fe^{3+}_2O_3$
Weight %: 2.6559613 +- 0.54656243

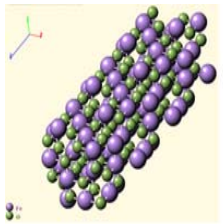


Image 3: http://webmineral.com/data/Fayalite.shtml

Discussion & Conclusions

- Silicate materials observed in the optical microscope, information obtained from XRD, SEM, and EDS confirm the presence of hedenbergite, fayalite, and maghemite, consistent with previous qualitative studies (Lasmanis *et al*. 1997) .
- Quantitative XRD analysis suggests that the minerals above do not account for all data (critical values for calculated diffractogram: σ<2, R_w<15%), indicating at least one additional mineral, possibly the "Very Bright Phase."
- Copper, lead, and arsenic are known components of the ASARCO slag but are absent in the minerals identified here. Future work will focus on identifying and characterizing Cu-Pb-As phases.
- The abundance of maghemite suggests that magnetic measurements should focus on techniques sensitive to maghemite.

References

Lasmanis, R., Norman, D.K., Cannon, B. 1997. Preliminary Study of Minerals in Tacoma Smelter Slags. Washington Geology 25(3) 19-25

Lutterotti, L. 2011. MAUD – Materials Analysis Using Diffraction [Internet]. Trento (Italy): Faculty of Engineering; [cited 2011 June 6]. Available from http://www.ing.unitn.it/~maud/

Acknowledgements

•**Hanson Fong**- Assistant Director, Institute for Advanced Materials & Technology- University of Washington-Seattle.

•**Peter Selkin, Ph.D.**- Assistant Professor- Environmental Science Program- University of Washington- Tacoma.

•**Jeff Tepper Ph.D.**- University of Puget Sound- Geology Department