Mineralogical Analysis of Iron Slag from Standish, NY

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Abstract

In the mid to late 1800's and into the early 1900's, Standish, NY was the site of the world's largest catalan forge which extracted iron from the local Adirondack ores. Over the course of almost 100 years of industrial activity, this forge left behind a large 60 ft tall pile of slag, a byproduct of the smelting processes. The pile covers ~13 acres of land in the Adirondacks. This research aimed to better understand the variety of phases present at the site as well as products associated with weathering. Though there are a variety of slag types found in the Standish slag pile, all are chemically dominated by CaO and SiO_2. Powder X-ray diffraction (XRD) of numerous samples from Standish indicate that there is phase homogeneity throughout the site and that materials like glass, gehlenite, pseudowollastonite, and quartz dominate the unweathered material. Pure iron prills are also present in many of the Standish slags. When the iron prills are exposed to air, they quickly oxidize. In some highly eroded and fissile slag samples, calcite is an additional phase. Many samples at the site are coated with a layer of white powder that is composed of a mixture of Ca-rich phases such as bassanite ($2CaSO_4 \cdot H_2O$) and kottenheimite ($Ca_3Si(SO_4)_2(OH)_6 \cdot 12H_2O$). XRD analyses of slag samples exposed to laboratory leaching experiments with nitric acid indicate that calcite is the dominant phase lost in multiple samples. Overall, the breakdown of the Ca-silicates as well as the oxidization of iron dominates the weathered products at the site.

Introduction

The Adirondack Mountains are located in the northern portion of New York (fig. 1). Within the Adirondacks, the Standish slag pile can be found (fig. 2). This pile sits at ~ 60 ft tall and covers ~13 acres of land (fig. 2,3). This research aims to conduct a mineralogical analysis of the slag at Standish to develop an understanding of the overall mineralogy of the rock at this site.

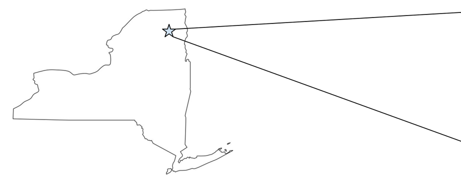

Figure 1: Map of New York State, star represents research location; Standish, NY.

Figure 2: Expanded map view of the research location, the area outlined in red represents the slag pile.

Figure 3: Photograph of the slag pile at Standish.

Historically, this region of the Adirondacks was mined for iron ore, which was discovered in 1749 by a Swedish naturalist, Peter Kalm (Dawson et. al. 1988). In 1883, an 8- fire bloomery was established by the Chateaugay Ore and Iron Company at Standish. Two years after the bloomery was constructed, a blast furnace was constructed allowing both bloom iron and pig iron to be produced (fig. 4,5) (Dawson et. al. 1988). The ore used at Standish was a magnetite-rich material from the nearby Lyon Mountain mine. This material was crushed at the mine and then transported to Standish for smelting (fig.6). During the smelting process, a flux was likely added to help with smelting efficiency. After smelting, the waste material, slag, was carted away by train and deposited.

Figure 4: Historical photo of blast furnace in Standish, N.Y. (Keller., 1932).

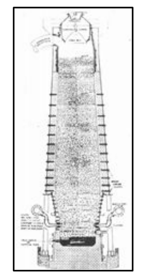

Figure 5: Diagram of blast furnace (Dawson et al., 1988).

Figure 6: Historical photo of railroad tracks leading to blast furnace in Standish, N.Y. most likely taken from the West facing East toward the pile. (Keller., 1932).

Methods

A total of 10 samples that reflected the variety of slag types at Standish were selected for analysis. 4 of these samples were involved in previous research that investigated the impact of weathering and laboratory leaching (Leonard and Farthing 2019) and both the pre and post acid test samples were used in this study.

All samples were crushed in a ball mill and then analyzed using a Malvern/PanAlytical X-Pert XRD. Each analysis ran at 45 Kv, 40 mA. Data was gathered between 5.0042 °2θ and 59.9882 °2θ with a step size of 0.0080 and a counting time of 10.1600 seconds/step.

Sample Pictures

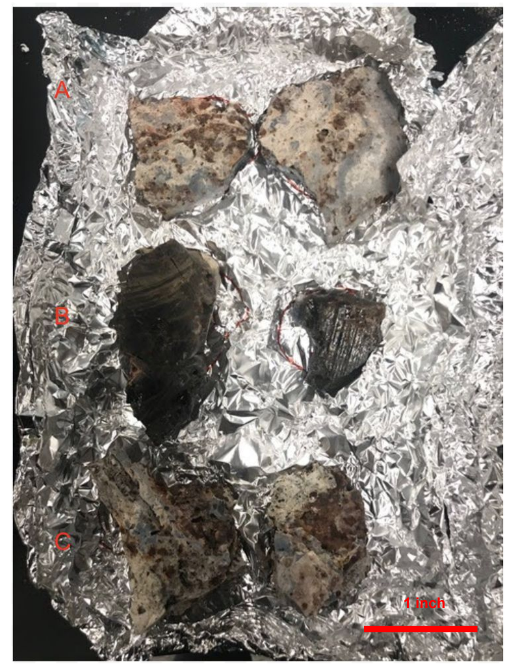

Figure 7: Photograph showing three of the several morphologies found at Standish. A) chalky morphology, B) more crystalline morphology slag characterized as glassy crusted slag, C) massive morphology, commonly found in the middle of slag samples (Leonard, Kelk and Farthing 2019).

Figure 8: Photograph of a bulk sample of slag in situ (Leonard, Kelk, and Farthing 2019).

Figure 9: Photograph of a sample of slag that XRD analysis.

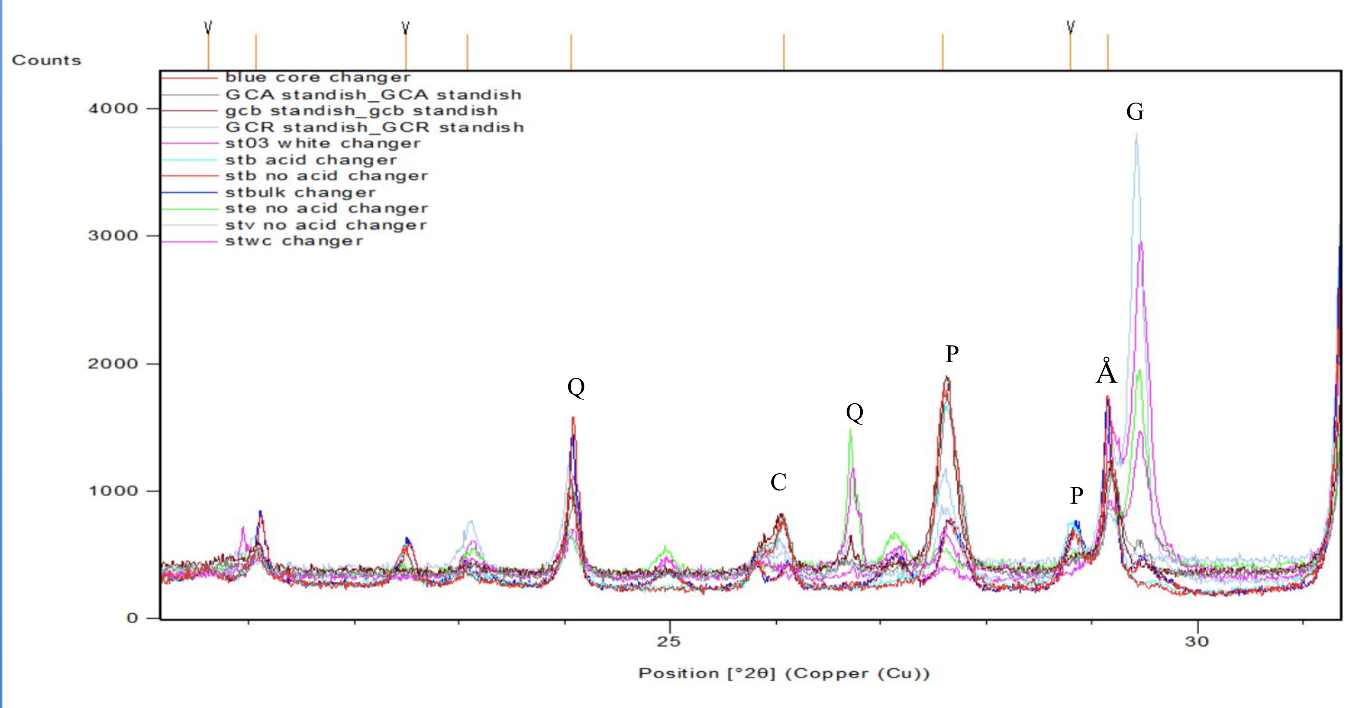

Figure 10: Graphical representation of the XRD scans for all samples analyzed. Overall most scans aligned with similar mineral peaks. Q is quartz, G is gehlenite, Å is Åkermanite, P is pseudowollastonite, and C is calcite.

Table 1: List of minerals found within the slag at Standish in order of abundance. Minerals identified with an asterisk (*) were identified through analysis run on a zero background holder.

Mineral	Formula
Gehlenite	$Ca_2Al(AlSiO_7)$
Åkermanite	$Ca_2Mg_2(Si_2O_7)$
Pseudowollastonite	$Ca_3Si_3O_9$
Calcite*	$CaCO_3$
Kottenheimite*	$Ca_3Si(SO_4)_2(OH)_6 \cdot 12H_2O$
Bassanite*	$2CaSO_4 \cdot H_2O$
Quartz	SiO_2

Discussion and Conclusions

Despite the differences in morphology and degree of weathering found throughout the Standish slag, the mineralogy is relatively predictable. The dominant mineral phases found include gehlenite-åkermanite, pseudowollastonite, and calcite. Some of the samples are also predominantly glass and contain very few crystalline components. Throughout all the samples analyzed, the majority of them contained gehlenite, however, a shift in the °2θ for the most intense peak (~31°) suggests that the chemistry fluctuates from sample to sample. XRD search- and- match results indicate that the gehlenite has varying amount of Mg and in some cases, åkermanite is the dominant phase (as is the case in sample …). The calcite within the body of the samples has been protected from weathering because much of the Standish slag lacks significant porosity and permeability. Calcite might have been lost near the surface of the slag, but was still observed when we made whole sample powders. Many of these samples also contained pure iron, though it never formed peaks in the XRD pattern. This is because the iron was not able to be powdered and was usually removed by hand from the materials used for XRD analysis because the particles were too big and the sample could not be prepared flat. All of the minerals found make sense for the slag at Standish. The lack of iron in the minerals suggests that the smelting process at Standish was relatively efficient. The slag at Standish was clearly a Ca- dominated system. The smelting process itself involved the use of limestone as a flux material (Dawson et al., 1988) which is the source for the calcium. The additional elements needed to create the dominant minerals may have been associated with impurities in the limestone, additional gangue minerals that were unsuccessfully separated from the ore, or perhaps even the fire brick that lined the furnace. The mineralogical differences seen between the unweathered bulk samples and the white weathered products is likely caused by the surficial alteration of the slag samples. Calcite can also be found within this white weathered product and is secondary within this phase.

References

Dawson, J.C., Moravek, J.R., Glenn, M.F., and Pollard, G.C., 1988, Iron Industry of The Eastern Adirondack Region,Field Trip Guidebook: Plattsburgh, New York, New York State Geological Association (NYSGA), p. 166–168.
Keller, A.T., 1932, Hagley Digital Archives: https://digital.hagley.org/islandora/search?type=dismax&f%5B0%5D=mods_relatedItem_host_location_shelfLocator_ms%3ASeries%5C%20II%2C%5C%20Box%5C%2019%2C%5C%20Folder%5C%20106A (accessed March 2019)
Leonard, M. L., Kelk, R. M., & Farthing, D. J. (2019). The Impact of Physical and Chemical Weathering on Iron Slag from Standish, NY. *Geological Society of America Abstracts with Programs, 51(5). Doi: 10.1130/abs/2019AM-339236*

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