☒ **Talk** ☐ **Poster**

Carbon Mineralization of Sulfate Wastes Containing Pb: Synchrotron Pb M3-Edge XANES Analysis of Simultaneous Heavy Metal and Carbon Sequestration

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Sulfate wastes are produced in large quantities and contain toxic heavy metals such as lead (Pb), posing environmental risks. Because of favorable solubility differences, these wastes can be repurposed for engineered carbon dioxide (CO_2) sequestration. Understanding the fate and mobility of heavy metals during this process is important. This study focuses on Pb and the effect of zinc (Zn) on Pb in carbon mineralization. Synthesized gypsum was treated with a carbonate-rich solution at pH 11.5 to convert the sulfates to carbonates. Aqueous solutions and mineral solids were analyzed. Synchrotron-based micro-X-ray fluorescence and a novel application of Pb M3-edge X-ray absorption near-edge structure provided detailed insights into Pb distribution and mineral forms. This work utilized the TES 8-BM beamline at the National Synchrotron Light Source II (NSLS-II), which enables simultaneous analysis of the Ca and S K-edges as well as the Pb M-edge. The Pb M5-edge (2.48 keV) has been used in previous studies for Pb analysis in the tender X-ray range.[1] However, a major limitation of the Pb M5-edge is fluorescence overlap with the S K-edge (2.47 keV). This spectral interference complicates measurements in sulfur-rich matrices, such as sulfates or sulfur-containing environmental samples. In this study, we employed a unique approach of Pb M3-edge XANES, enabling improved identification of Pb mineral phases in complex environmental systems. Results showed significant reductions in aqueous Pb and Zn concentrations, indicating effective metal sequestration. Carbon mineralization transformed Pb from soluble anglesite ($PbSO_4$) into insoluble cerussite ($PbCO_3$) and hydrocerussite ($Pb_3(CO_3)_2(OH)_2$). Pb primarily precipitated onto calcium carbonate surfaces through surface-mediated precipitation reactions. While the presence of Zn modified crystallization dynamics, it did not impede Pb sequestration and potentially enhanced surface reactivity, facilitating greater Pb immobilization. These findings highlight carbon mineralization as a sustainable approach to immobilize toxic metals in sulfate wastes while advancing CO_2 sequestration efforts.

References

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