

Mineralogical Functionality of Coal Fly Ash in Mortars After Rare Earth Element Recovery

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INTRODUCTION

Rare earth elements (REEs) are a set of 17 elements (lanthanides plus scandium and yttrium) that are not found concentrated in large ore deposits in nature. There has been huge growth in the amount of technology that uses REEs due to their diverse properties, but REEs are difficult to mine and expensive to separate. The global supply of REEs is largely controlled by a single country (China; >95%), and the lack of a domestic supply has been identified as a vulnerability to U.S. economic security. To alleviate this vulnerability, economical extraction methods from traditionally overlooked domestic feedstocks, such coal fly ash, are being explored. Coal fly ash is a waste product produced after coal is burned for power generation. A traditional use of fly ash is as an additive to concrete aggregate. However, it is unknown whether acidified fly ash, after the recovery of REEs, may be suitable for use in concrete. This study focuses on characterizing acidified fly ash after REE extraction, with the goal of determining how much ash may be added to mortar without eliminating the functionality of the fly ash. The particle size and roughness of fly ash particles will be studied using scanning electron microscopy imaging before and after exposing the ash to an acid leaching process for the recovery of REEs. The waste ash from the leaching process will then be added to mortars in various fractions. The mortar functionality will be tested by measuring the strength of the samples. A future study will include mechanical testing of concrete cores made using the mortars with the acidified fly ash.

METHODS

Raw fly ash was sieved by grain sizes of less than 20 μm , 20 – 35 μm , 35 – 53 μm , 53 – 75 μm , 75 – 125 μm and 125 – 250 μm . These grain sizes were then put into epoxy using a silicone mount and polished using a metallographic manual polisher. A concrete cylinder with 20% classic fly ash and a concrete cylinder with 10% beneficiated fly ash and 10% classic fly ash were each cut into billets using a rock saw. The billets were smoothed on a metallographic manual polisher. Then the billets were attached to glass using epoxy and trimmed down into thin sections using a saw. Next the concrete thin sections were ground down to a thickness of approximately 30 μm . Using the high energy x-ray beamline at GSECARS 13-ID-E Argonne National Lab, x-ray microprobe maps were created for mounted samples of epoxy grain mounts of less than 20 μm , 53 – 75 μm , and 125 – 250 μm , as well as a concrete thin section of 20% classic fly ash and concrete thin section of 10% classic fly ash and 10% beneficiated fly ash. The raw data collected was analyzed using software GSECARS Mapviewer to read X-ray fluorescence maps from synchrotron X-ray microprobes.



Fig 1: Raw fly ash in epoxy A) > 20 μm B) 53-75 μm C) 125-250 μm



Fig 2: Concrete thin section A) 20% raw fly ash B)10% raw fly ash 10% beneficiated fly ash

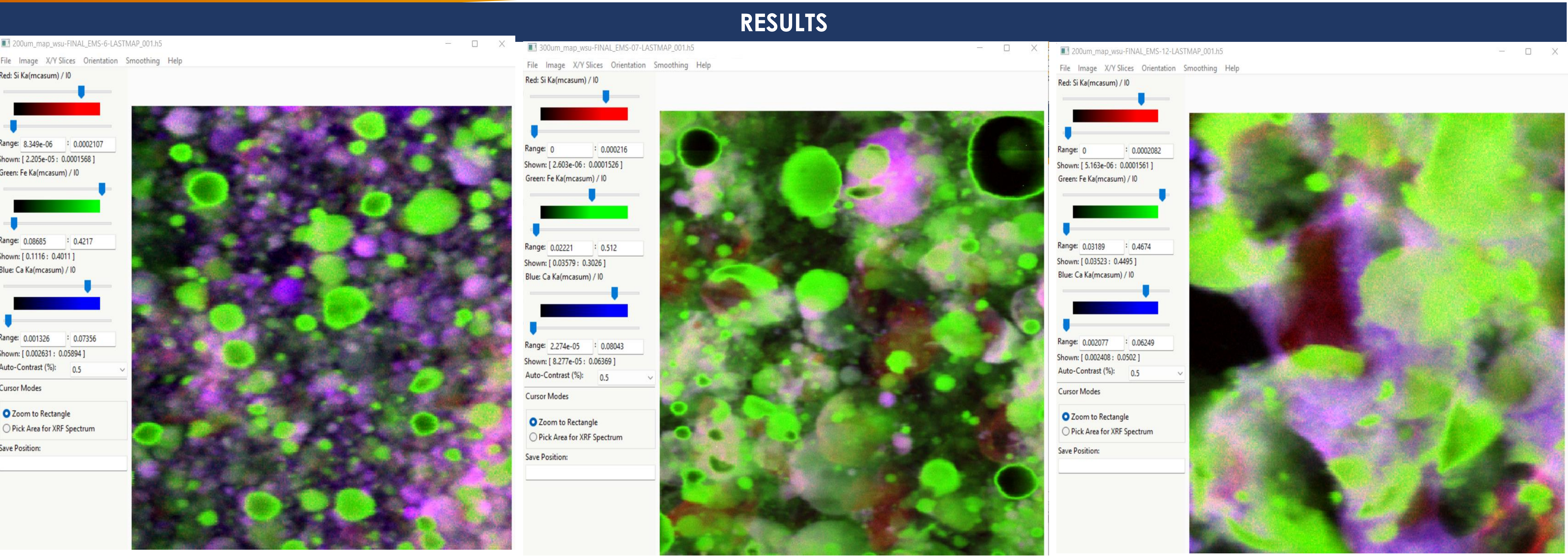
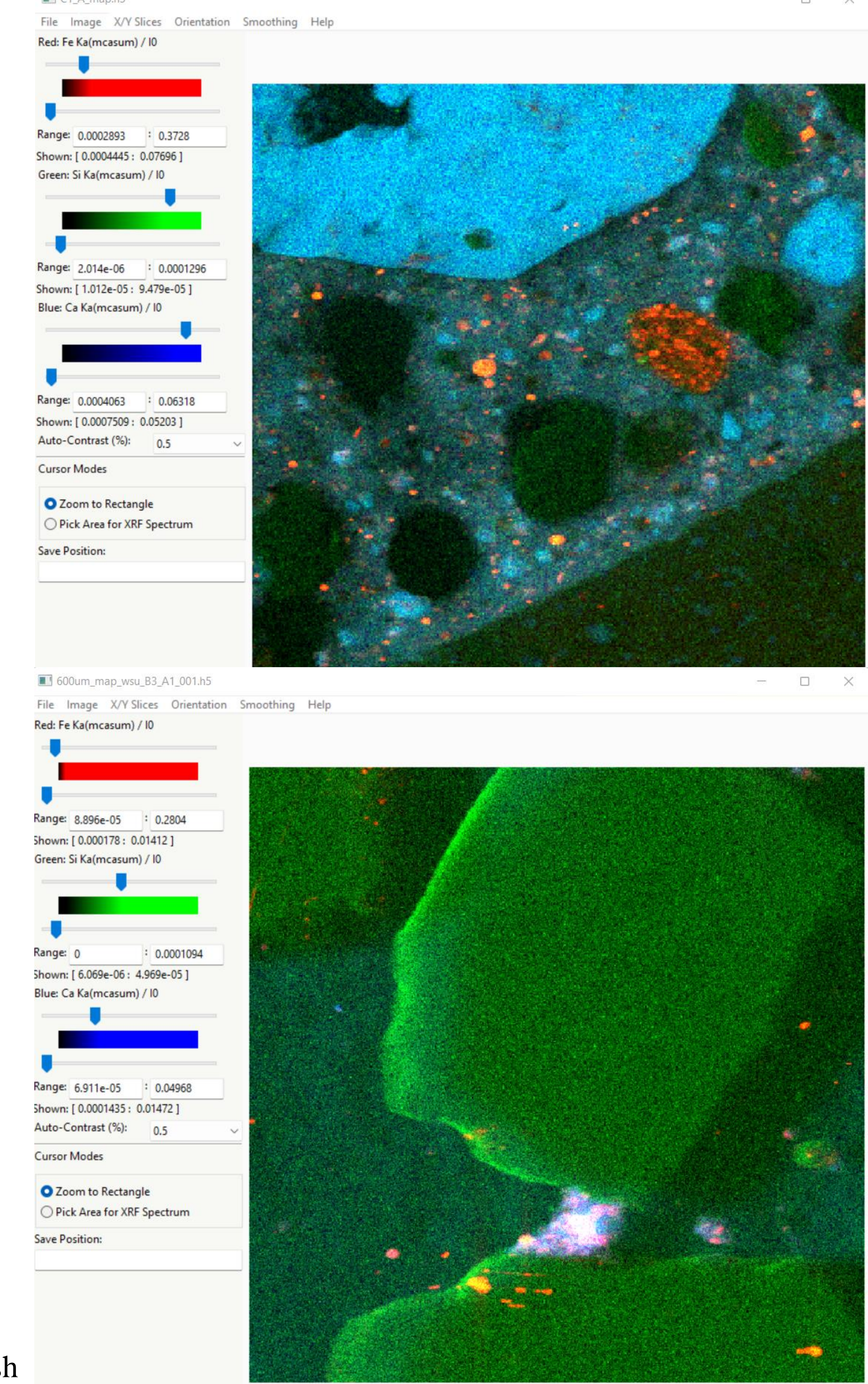


Fig 3: Elemental maps of raw fly ash grains in epoxy A) > 20 μm , B) 53-75 μm , C) 125-250 μm

Fig 4: Elemental maps of concrete thin section with A) 20% raw fly ash B)10% raw fly ash 10% beneficiated fly ash



CONCLUSIONS

The intensity maps show a Red-Green-Blue image for 3 different regions of interest. The fly ash grains that are less than 20 μm are more spherical and are high in iron. The purple shows there are a lot of calcium and silica. However, when the grains get bigger, there is more red meaning more silica, and there is less silica and calcium overlap. The iron particles have become less spherical. In the largest grains sizes of 125-250 μm , the iron is more angular. The calcium in ash with silica more in the largest grain sizes compared to the middle range. In the concrete thin sections, the cement with only raw fly ash has more calcium and iron compared to the cement made with 10% raw fly ash and 10% beneficiated fly ash. The concrete with beneficiated fly ash is richer in silica. The next step would be to use these maps to create X-ray fluorescence spectrum that will tell X-ray fluorescence because the use of X-rays of certain characteristic energies can be used to identify the presence of elements, and it is possible that accurate elemental abundances can be extracted from XRF data.

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