Case Studies in Differentiation of CCR from Native Soil or Fill with Similar Visual/Physical Characteristics to Successfully Facilitate CCR Removal

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ABSTRACT

Color differentiation between Coal Combustion Residuals (CCR) and native soil or fill material is often used for visual delineation during removal of CCR from lined or unlined impoundments, or even removal of buried CCR. However, when the adjoining native soil or fill material appears visually similar to the CCR, what technique(s) can be used to identify and differentiate CCR? In order to overcome this challenge at two confidential sites in Southeast coastal areas, Resolute evaluated several techniques in the field and laboratory. Techniques included Electron Microscopy (EM), Handheld X-Ray Fluorescence (XRF) Analyzer, and traditional visual and tactile geologic identification methodologies. Other important aspects of the identification of the CCR are an understanding of the regulatory program (i.e., within the Federal CCR rules, or in a state regulatory program), consideration of site-specific CCR regulatory concentrations, technique implementation time (i.e., instantaneous field decision vs. laboratory analysis with shipping and turnaround time), and technique accuracy and repeatability. Selected techniques were then utilized in real-world CCR excavation scenarios. This presentation will discuss those important considerations, observations, results, and lessons learned.

KEYWORDS: Coal Combustion Residuals, CCR, Coal Combustion Products, CCR Differentiation, CCR Identification, CCR Excavation Confirmation, CCR Scanning Electron Microscopy SEM, Polarized Light Microscopy PLM, X-Ray Fluorescence Analyzer XRF

INTRODUCTION

The differentiation between Coal Combustion Residuals (CCR) and soil can be extremely difficult for qualitative methods alone (e.g., physical characteristics such as color, texture, grain size, plasticity, etc.) when soil appears very similar to the CCR. This paper offers alternatives based on case study findings to assist in differentiating CCR from similar-appearing native or fill material adjacent to CCR material.

REVIEW OF TRADITIONAL SOIL CLASSIFICATION METHODOLOGIES

Traditional soil classification methods typically focus on grain size and texture properties. CCR materials have, in general, properties and characteristics that are well known. For example, CCR fly ash size range (0.5 um to 300 um; or 0.0005 mm to 0.3 mm) is the size of clay (<0.002 mm), silt (0.002 - 0.075 mm), and fine sand (0.075 – 0.425 mm) particles, making it difficult to differentiate based on particle size alone. CCR fly ash is typically spherical, but difficult to differentiate in field because of grain size. CCR bottom ash may be larger, coarser-grained material within the fine sand range, which sometimes occurs with slag. Where this association with slag is present, CCR bottom ash is more readily identifiable in delineation situations.

Color may also be a useful indicator for CCR material if a substantial contrast exists when compared to adjacent native or fill soil material. However, both CCR material and adjacent native or fill soil material may vary in color, depending on mineral composition, weathering, moisture content and other factors. This can create situations where CCR can be visually similar to many native or fill soils. For example, light to dark gray ash is similar in color to soils and sediments found in coastal areas and marshes, as well as redox soils below groundwater.

Observation of a material’s plasticity is useful in characterization. CCR (fly and bottom ash) is generally not plastic, while clays and silts vary in plasticity.

Noting smear properties of a material help to distinguish materials. CCR fly ash may produce a smear from silt sized particles. However, organic silts may also produce a smear, so additional properties must also be compared prior to making a final determination.

POTENTIAL ADDITIONAL METHODOLOGIES FOR CCR CONFIRMATION

When ash and soil are visually distinct, additional methods beyond traditional soil classification methods may not be needed. However, additional methodologies for CCR confirmation may need to be employed in instances where the adjacent native or fill material closely resembles the CCR material. Potential examples of these alternatives include, but are not limited to the following:

- Polarized Light Microscopy (PLM)
- Electron Microscopy (EM)
- Handheld X-Ray Fluorescence (XRF) Analyzer
- Laboratory Analytical Results (especially in state-specific regulatory situations)

CASE STUDIES

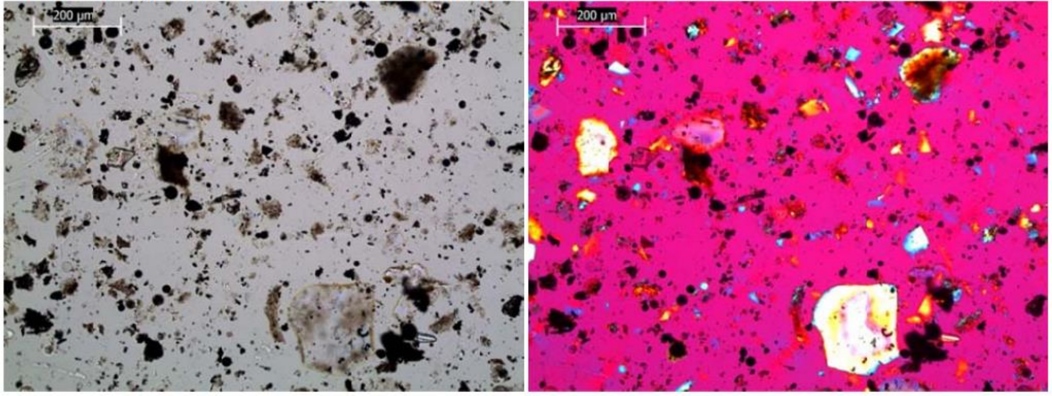
Case Study #1
Evaluation of PLM as CCR Excavation Confirmation Method

In the following case study, a CCR ash pond closure by removal was being planned. CCR material and native soil were observed to be similar in color and grain size. A certification of CCR removal (and decontamination) was required by the regulatory agency. CCR material on site contained concentrations of one or more Appendix IV constituents above local background and/or calculated risk exposure concentration based on guidance from state/federal regulatory requirements. In certain cases, such as this one, background determination can be extremely complex depending on the native naturally-occurring mineralogy, and further complicated by the presence of constituents commonly associated with CCR. Some background situations, such as small coastal or riverfront sites with limited land area, may require significant evaluation to demonstrate to regulators that background constituents are truly representative of background, and not a result of CCR material based on proximity to CCR.

At this site, Polarized Light Microscopy (PLM) was initially evaluated to assess the viability of determining CCR content in soil for use in obtaining a clean closure certificate. One question to be addressed was, “Can the percentage of ash in PLM slides be correlated to concentration of App. IV constituent?”. At this site, a volume of soil with less than 8% ash (vol.) was calculated to be equivalent to background App. IV concentrations, and a volume of soil with greater than 32% ash could exceed state’s risk-based cleanup concentrations

A PLM bench-scale laboratory evaluation was implemented to better understand a possible correlation between analytical and volumetric CCR concentrations. Known percentages of pure ash were mixed by a laboratory, by volume, with background native soil for PLM evaluation utilizing a 400-point count method (multiple slides were evaluated per sample). Mixtures from 0% to 100% ash (vol.), with blind duplicate mixtures, (i.e., two sets of 10% samples, etc.) were prepared and submitted for PLM and laboratory analysis. **Figure 1** shows photomicrographs of the 10% ash sample and the blind duplicate 10% ash sample. **Figure 2** illustrates the 20% ash sample, and **Figure 3** illustrates the 100% ash sample.

Photomicrographs of overview from sample 8A262/10340717 in plane and crossed polarized light.



Photomicrographs of overview from sample 3B372/10340718 in plane and crossed polarized light.

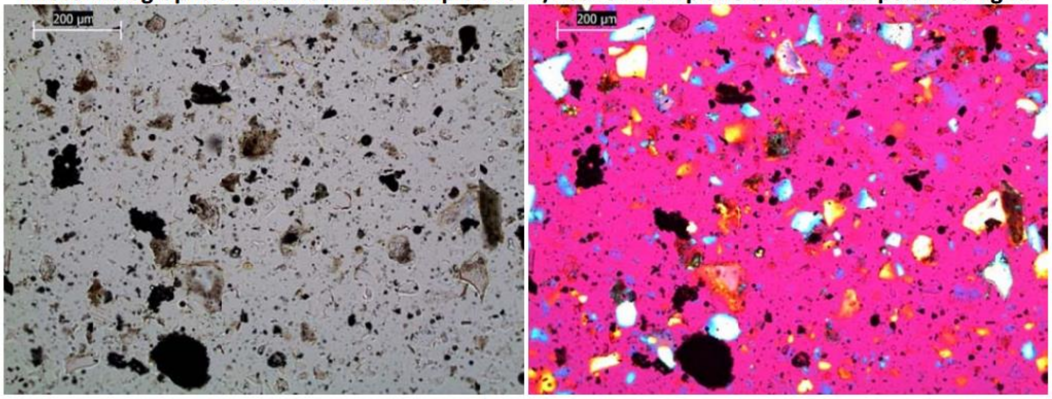


Figure 1, Two 10% Ash Samples

Photomicrographs of overview from sample 5B254/10340720 in plane and crossed polarized light.

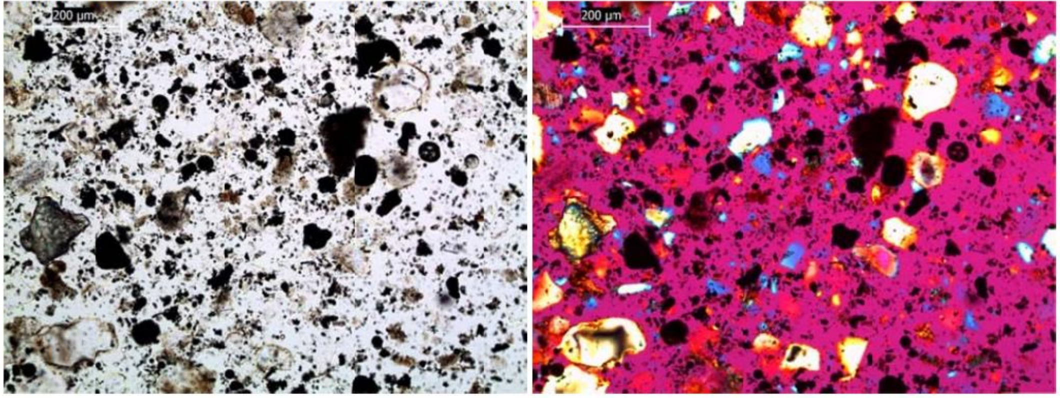


Figure 2, 20% Ash Sample

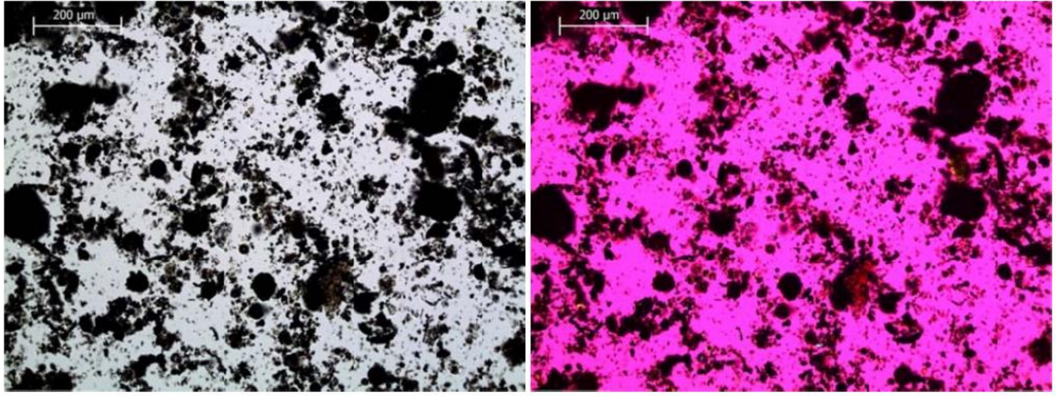

Photomicrographs of overview from sample 3A645/10340724 in plane and crossed polarized light.

Figure 3, 100% Ash Sample

The results of the comparison (**Table 1**) indicated that, with the exception of 0% and 100% CCR samples, the PLM method consistently overestimated ash percentages compared to the known percentage by volume mixture for each sample. PLM results were 42% to 187% higher than the actual known mixture percentage by volume. PLM results were not repeatable, as shown in the two 10% ash samples resulting in 28.75% and 18.00% ash reported by PLM. The results were then adjusted for density differences, but these corrections for density did not correct the PLM overestimates. The PLM method also detected "bottom ash" in the 0% ash on-site "background sediment" samples, indicating likely misidentification.

% Ash	**% Sediment**	**Lab ID**	**PLM % Ash (Fly Ash & Bottom Ash)**	**PLM % Sediment**	**Error PLM % Ash**	**Error PLM % Sediment**
0%	100%	6A132	0.75%	99.25%	--	-0.75%
5%	95%	9B569	10.75%	89.25%	115.00%	-6.05%
10%	90%	8A262	28.75%	71.25%	187.50%	-20.83%
10%	90%	3B372	18.00%	82.00%	80.00%	-8.89%
15%	85%	4B824	27.25%	72.75%	81.67%	-14.41%
15%	85%	2A336	29.50%	70.50%	96.67%	-17.06%
20%	80%	5B254	41.25%	58.75%	106.25%	-26.56%

% Ash	% Sediment	Lab ID	PLM % Ash (Fly Ash & Bottom Ash)	PLM % Sediment	Error PLM % Ash	Error PLM % Sediment
50%	50%	6A982	71.25%	28.75%	42.50%	-42.50%
100%	0%	3A645	94.25%	5.75%	-5.75%	--

Table 1, Procedure Validation-PLM Analysis vs Known CCR Percentage Sample

Conclusions from the PLM bench-scale laboratory evaluation indicated that quantitatively, the accuracy and repeatability of PLM samples from this site were unsuitable for establishing ash percentages or correlating Appendix IV concentrations to ash percentages. It is likely that the sample volumes on the PLM slides are too small to be representative, although multiple slides per sample were counted, or there may be difficulty in fully homogenizing samples. Qualitatively, ash was always identified, potentially mis-identified, and biased high.

A subsequent Field Pilot Test was performed where the client further evaluated field use of PLM with “Heavy/Moderate/Light/Trace” rather than hard percentages. Additional changes included the use of a different PLM laboratory and supplementing PLM with scanning electron microscopy (SEM) for further confirmation of ash types (CCR ash or wood ash).

“Trace” concentrations were reported in vertical extent and excavation confirmation samples (similar to detection in 0% sample above). “Trace” concentrations were also identified in shallow soil outside of the ash pond at a “background” location.

Case study #1 - Conclusions

The lessons learned from the study indicate that CCR fly ash (and wood ash from other sources) are likely present throughout and around CCR sites. PLM detected ash (wood and CCR) at very low levels in every sample in the bench scale test and almost every sample in the pilot scale test. This may be attributed to wind carried flue material and wildfire events.

PLM appears quantitative, but it appears to not have the field-to-lab repeatability for true quantitative results. PLM results utilized as qualitative: “ND”, “<2%”, or “Trace” may be acceptable.

A potential downside of the PLM method is that it may lead to excavation outside of a defined unit, and low-level detections or misidentifications in shallow layers that could lead to large or “unending” excavations.

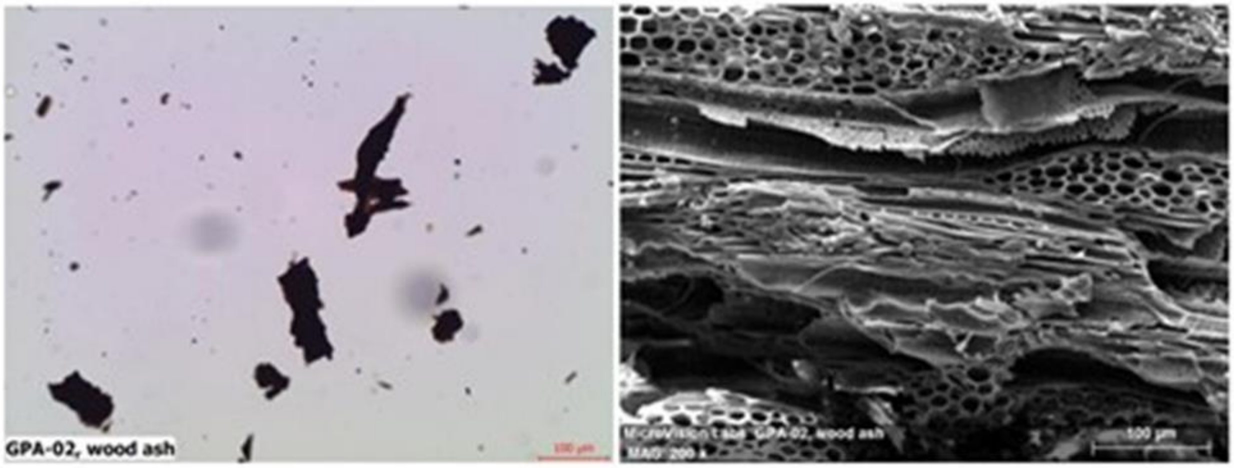
Case study #2 - CCR Excavation Delineation/Confirmation Method

This case study involves a site where the ash pond was closed prior to the implementation of the federal CCR rules. CCR material that was used historically for structural fill was observed to extend off-site. A CCR excavation was implemented under a state regulatory program, not the CCR rules since the closure pre-dated the regulation. Constituent concentrations in the CCR were driving excavation extent and not solely the presence of CCR material alone. Multiple lithologies and fill layers were present on site. CCR material and some native and fill soils were similar in color & grain size to each other.

During off-site excavation of light grey ash, a slight color change was observed. The photo**, Figure 4**, illustrates a light grey fill layer over a yellowish tan sand. Traditional soil classification evaluation indicated this material was likely CCR ash.

Laboratory analysis for COCs in multiple samples indicated that “driver” COCs were not present. Samples were sent to the laboratory for PLM and SEM evaluation to confirm that it was not CCR. The laboratory report stated that the majority of sample was “mineral grains.” The lab reported “Trace” detections of coal, coal ash, and tar, with “Light” amounts of wood ash.

Figure 4, Excavation Exposure



PLM Image

SEM Image

Figure 5, Case Study #2 PLM vs SEM

Case study #2 - Conclusions

During excavation or delineation outside of ash pond impoundments, slight changes in observed CCR ash characteristics may be important. Similar to Case Study #1, samples consistently detected “Trace” levels of CCR, which may pose a perception risk in certain cleanup situations. The regulatory driver in this case was COC concentrations rather than presence of CCR. The PLM/SEM analyses provided useful supplemental data that this off-site material was not CCR. Proper identification saved the client from several hundred cubic yards of additional excavation.