2011/2012 Powell River Project Annual Report

Predicting TDS Release from SW Virginia Soil-Overburden Sequences

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Executive Summary

Release of total dissolved solids (TDS) from Appalachian coal mine spoils to headwater streams has emerged as a significant concern for the coal mining industry, its regulatory agencies, and non-governmental organizations. The overall objective of this project is to develop a new set of techniques to reliably predict the amount, ionic composition, and temporal pattern of TDS release from a range of spoil and overlying soil materials from regional coal surface mines. This project was initiated in 2010 with sole support from Powell River Project. In 2011/2012 we received significant parallel funding for this program from the Appalachian Research Initiative for Environmental Science (ARIES) to support our collaboration with the University of Kentucky and West Virginia University to broaden the scope to the central Appalachian region while continuing to focus on SW Virginia in more detail. Therefore, we are utilizing Powell River Project (PRP) funds to focus specifically on the determination of TDS release potentials of soil-saprolite-hard rock sequences in SW Virginia. This information will better allow operators to determine the thickness and availability of low TDS forming strata for use in new and innovative mining and reclamation plans designed to limit TDS release to local streams.

For the PRP portion of this study, we are sampling up to 10 different locations in representative SW Virginia strata where we can clearly sample a relatively intact section of weathered surficial soils, underlying oxidized and partially weathered (brown) rock strata, continuing down into

unweathered gray strata with depth. Samples are being analyzed for size consist, approximate mineralogy, acid-base accounting parameters, abrasion pH/hydrolysis and total elemental analysis. Next, we will investigate net TDS release from ground/crushed spoil fractions (e.g. 2.5 cm to 2 mm; < 2mm sieved; ground to < 0.05 mm) that will be equilibrated with varying soil:

H_2O_2 ratios to develop TDS release indices. The amount and temporal pattern of TDS release for each material will then be related to the chemical and mineralogical analyses described above to determine which field vs. laboratory determined spoil properties are the best predictor(s) of TDS release potentials. To date we have sampled three locations (11 complete weathering sequences) from surface soils down to underlying spoils and preliminary results presented here. In the field, the interface between weathered and oxidized surficial materials and deeper unweathered strata has been clearly delineated by changes in pH and electrical conductance (EC), but not by color.

Background Research

We have submitted significant and detailed results from our ongoing studies of TDS release potentials from SW Virginia overburden for the past several years in our annual reports (2009-2011). For the sake of brevity, we will not repeat those materials here, but we will gladly provide them again upon request. In short, all academic, industry and agency collaborators in the Powell River Project are well aware of the daunting challenges faced by the coal industry related to potential TDS emissions from coal mining activities and our related work efforts on that topic over the past decade.

Overall Research Objectives

I. To obtain a representative regional sample set of mine spoils and associated weathered overburden and soils from the central Appalachian region with varying potentials for TDS release.

II. To fully characterize these spoil materials via a wide range of laboratory analytical procedures for their potential to release important TDS components upon leaching and weathering.

III. To characterize the TDS elution behavior of selected mine spoil materials via column leaching analyses for TDS and component ions of interest.

IV. To determine whether predictive relationships exist between the various lab procedures employed to estimate TDS release potential and the actual TDS flux behavior observed from the leaching columns.

Collaboration with the Appalachian Research Initiative for Environmental Science (ARIES) Project.

Over the past two years we have collaborated with the Virginia Center for Coal and Energy Research and major regional coal producers (Alpha, Arch, Patriot, TECO and others) in the development of a large multi-state research consortium, as the Appalachian Research Initiative for Environmental Science (ARIES; http://www.energy.vt.edu/ARIES). The overall program and detailed scope of work continue to evolve, but our TDS prediction research program was expanded greatly (with ARIES funding) to include significant cooperation with the University of Kentucky (UK - Richard Warner and Chris Barton) and West Virginia University (WVU - Jeff Skousen and Louis McDonald). The expanded program involves a much larger sample set and more detailed analyses than were capable of addressing with PRP funding. However, the ARIES monies allocated to Virginia Tech are budgeted to support column leaching and humidity cell testing on a much larger (e.g. 40 to 50 spoils) regional sample set, to develop scaling factors for field application of the column data, and to develop a regional GIS + spoil testing data base for future statistical analyses and modeling efforts.

For the past year, we have utilized the funds provided by PRP to continue our focused and detailed efforts on sampling combined weathered:unweathered soil:spoil sequences in SW Virginia along with analytical testing of those materials and improved TDS prediction methods specific to our strata. That being said, the ARIES funded collaborations with UK and WVU will enable us to “farm out” our Virginia spoil samples for much more comprehensive lab testing procedures than would be possible under our original PRP proposal and will also allow us to correlate results with a much wider range of strata from the adjoining region. Thus, the methods and results detailed below remain specific to the work that we are conducting with PRP funds and do not reflect the larger ARIES project per se.

2011 to 2013 Specific Objectives

1. Measure the net TDS elution potential of a range of materials originating from the Pottsville Group in SW Virginia and analyze the difference between (a) fresh relatively unweathered materials at depth; and (B) well-weathered surficial materials.

2. Determine which indicator has a stronger correlation with TDS elution potential in select mine spoils: (a) Previous long-term exposure to the earth's surface, leading to reduction in soluble salts from the long-term leaching effects of percolating water; or (b) variations in the elemental composition of varying geologic strata.

3. Investigate the nature of the boundary between high and low TDS strata in order to determine if:(a) An abrupt boundary exists at some confining layer, such as a shale; or (b) the boundary is more diffuse, being more related to distance from the earth's surface; or (c) no discernible boundary exists; variations occur with variations in parent material.

4. Determine if a relationship exists between TDS elution potentials and field description traits such as: HCl "fizz" reaction, hydrogen peroxide reaction and/or Munsell color (e.g. gray vs. brown colors).

Methods and Procedures

A range of weathering x depth samples is being collected from the dominant coal bearing formations of the Pottsville Group throughout SW Virginia. Sampling locations are chosen where a clear association between the surface weathered soil horizons and underlying partially weathered rock horizons can be confirmed and the materials are accessible. It is assumed that many of the surficial soils sampled are comprised of colluvium (gravity slope deposits), but that it is locally derived. Ideally, we will sample 3 to 4 replicate sequences from each of the 10 primary locations to offer some level of replication and to allow for study of variance within local strata. For the purpose of this study, a "location" is comprised of similar soil to overburden weathering sequences within several hundred meters of one another.

First of all, detailed soil and saprolite to rock morphological descriptions are made including textures, structure/rock fabric, weathering features, nature of layer contacts, etc. Samples are being collected from each distinct soil horizon or rock layer/zone (see Fig. 1) beginning from the soil surface and extending to some depth (15 to 100 m) below the surface where visual evidence of weathering and oxidation are not present. Samples are handled as either "soil" horizons or "rock" horizons, each being treated differently. Soil samples are passed through a 2mm sieve for subsequent physical and chemical analysis. Rock samples are crushed and sieved until all material also passes through a 2mm sieve. Samples will be further ground as called for by specific tests. After preparation, samples are being analyzed for a range of physical and chemical parameters that we assume may assist in prediction of TDS loadings.

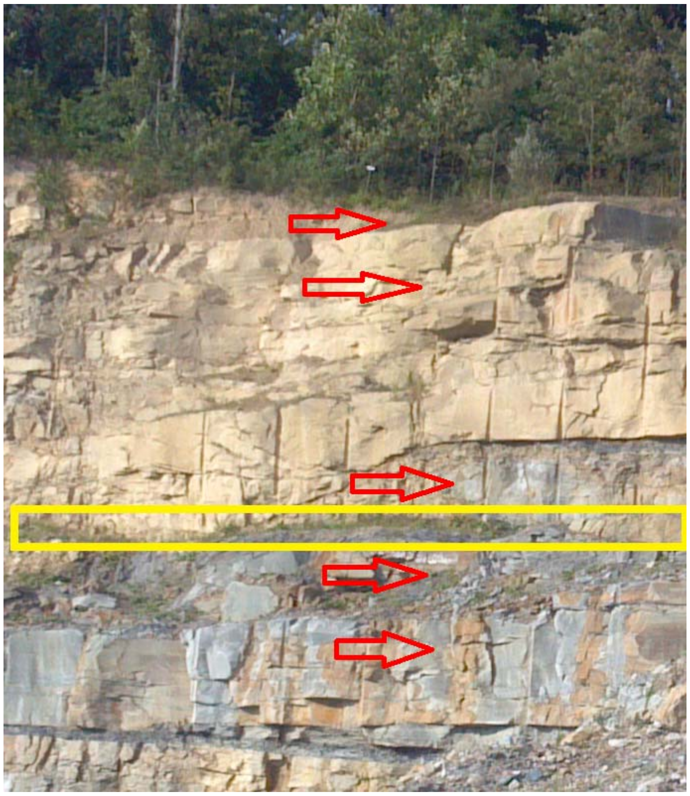

Figure 1 – An example profile illustrating the sampling scheme. Each distinct layer (red arrows) is collected and described. Special notice of the boundary between brown and gray materials (yellow box) is also taken, in an effort to better characterize the transition between these materials. Of the 11 samples to date, this boundary is often a tight shale layer.

Our overall results will be used to help determine which spoil materials will be relatively low with respect to TDS production for use in final reclamation of backfills and valley fill areas where significant contact with groundwater is anticipated. We also will generate field guidance for depth of cut or removal of these materials vs. easily measureable or observable field criteria.

All samples are being be analyzed for the following parameters:

Saturated paste electrical conductance (EC) and pH

Saturated paste EC and pH following hydrogen peroxide oxidation

Exchangeable cations

Dilute acid extractable nutrients and metals

Extractable Fe and Mn oxides

Total-S and S-forms if S $\geq$ 0.2%

Calcium carbonate equivalence

% Rock fragments

Particle size analysis

These parameters will be compared to field description traits such as color, depth, cementation, etc., to determine if any relationship exists between quickly identifiable field characteristics and long term TDS elution potential.

Results to Date

Eleven sequences from three locations have been sampled to date. Field descriptions and preliminary lab results (pH/EC) are listed for one typical sequence in Table 1 below. Transitions between brown surficial materials and underlying gray materials have generally occurred in the range of 10-20 meters. Often, the boundary between these materials has been found to be associated with a thin tight shale or siltstone layer, presumably preventing water and oxygen from penetrating deeper. In the field, the interface between weathered and oxidized surficial materials and deeper unweathered strata has been clearly delineated by sudden increases in pH and electrical conductance (EC) of the ground rock materials, but not by strata color per se. This is surprising, but may simply indicate that the strata we have sampled from highwalls are exposed primarily on along relict fracture traces during blasting which are oxidized by percolating groundwater, but not highly weathered and leached. Further sampling will confirm whether these are predictable trends or isolated occurrences.

Future Plans

Over the next year, the remaining 5 to 10 sequences will be collected. Samples will be prepared as they are collected and lab analyses will follow soon thereafter. After collecting the full

sample set and lab analyses are complete, data will be compiled to allow statistical analysis to allow us to address all of our objectives as described earlier.

Table 1. Morphological and field test indicators for a typical soil to spoil weathering sequence. Depths indicate lower boundaries of layers. "A", "Bt", "C", and "Cr" indicate soft material, while "R" designates bedrock layers. Field moist Munsell colors are indicated by hue, value, and chroma. Colors transition from brown to gray at 15.85 meters, this is generalized below. Transition from soft materials to hard bedrock occurs at 4.87 meters. EC and pH values are recorded from a saturated paste extract. Note sudden increase in pH at bedrock contact. Electrical conductance (EC; mmhos/cm) values increase slightly at bedrock contact, but increase dramatically below the first intact shale layer.

Depth (m)	*Name*	*Rock Type*	*Color*	*Hue*	*Value*	*Chroma*	*pH*	*EC*
.25	*A*	*None*	*Drk.Brown*	*7.5YR*	*2.5*	*1*	*4.10*	*0.279*
1.00	*Bt*	*Sandstone*	*Lt. Brown*	*7.5YR*	*5*	*6*	*4.70*	*0.062*
1.45	*Bt*	*Siltstone*	*Lt. Brown*	*5YR*	*5*	*6*	*4.88*	*0 .051*
2.36	*Bt*	*None*	*Lt. Brown*	*5YR*	*5*	*8*	*4.91*	*0 .040*
2.92	*Bt*	*None*	*Lt. Brown*	*7.5YR*	*7*	*1*	*4.97*	*0 .045*
3.10	*C*	*Soft Coal*	*Drk.Brown*	*7.5YR*	*2*	*1*	*4.73*	*0 .063*
3.35	*C*	*Soft Coal*	*Drk.Brown*	*10YR*	*2*	*1*	*4.63*	*0 .068*
3.66	*Cr*	*Siltstone*	*Lt. Brown*	*10YR*	*5*	*4*	*4.93*	*0.053*
4.87	*Cr*	*Siltstone*	*Lt. Brown*	*10YR*	*5*	*6*	*4.82*	*0.104*
6.09	*R*	*Sandstone*	*Lt. Brown*	*10YR*	*4*	*6*	*8.45*	*0.192*
10.06	*R*	*Sandstone*	*Lt. Brown*	*10YR*	*4*	*3*	*8.26*	*0.144*
11.89	*R*	*Sandstone*	*Lt. Brown*	*10YR*	*5*	*1*	*8.21*	*0.183*
13.72	*R*	*Sandstone*	*Lt. Brown*	*10YR*	*5*	*6*	*8.31*	*0.124*
15.85	*R*	*Sandstone*	*Lt. Brown*	*10YR*	*4*	*2*	*7.56*	*0.204*
16.76	*R*	*Shale*	*Gray*	*10YR*	*3*	*1*	*8.08*	*0.796*
21.64	*R*	*Sandstone*	*Gray*	*10YR*	*4*	*1*	*8.07*	*0.445*
30.78	*R*	*Sandstone*	*Gray*	*10YR*	*3*	*1*	*8.94*	*0.643*
39.93	*R*	*SS w*	*Gray*	*10YR*	*4*	*1*	*8.40*	*0.483*
69.19	*R*	*Shale*	*Gray*	*10YR*	*3*	*1*	*8.28*	*0.640*