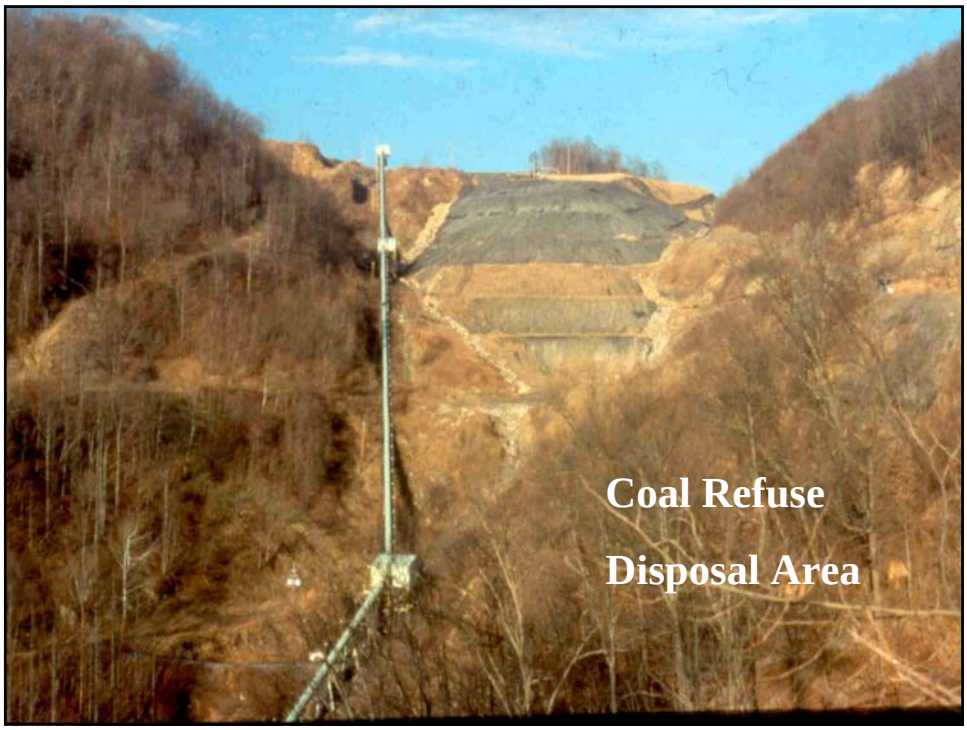
Properties and Reclamation of Coal Refuse Disposal Areas



What's this stuff called?

- Coal refuse – mine engineers
- Coal waste – regulators and scientists
- Gob pile – most common non-technical name
- Colliery spoil – if you're a Brit
- Culm – if you're from Pennsylvania Anthracite belt
- Slate dump – if you're a local miner
- Mine dump – also a local term for abandoned side hill piles
- Refuge – if you're from Grundy
- Red Dog – if the pile has burned

Coal Processing Wastes

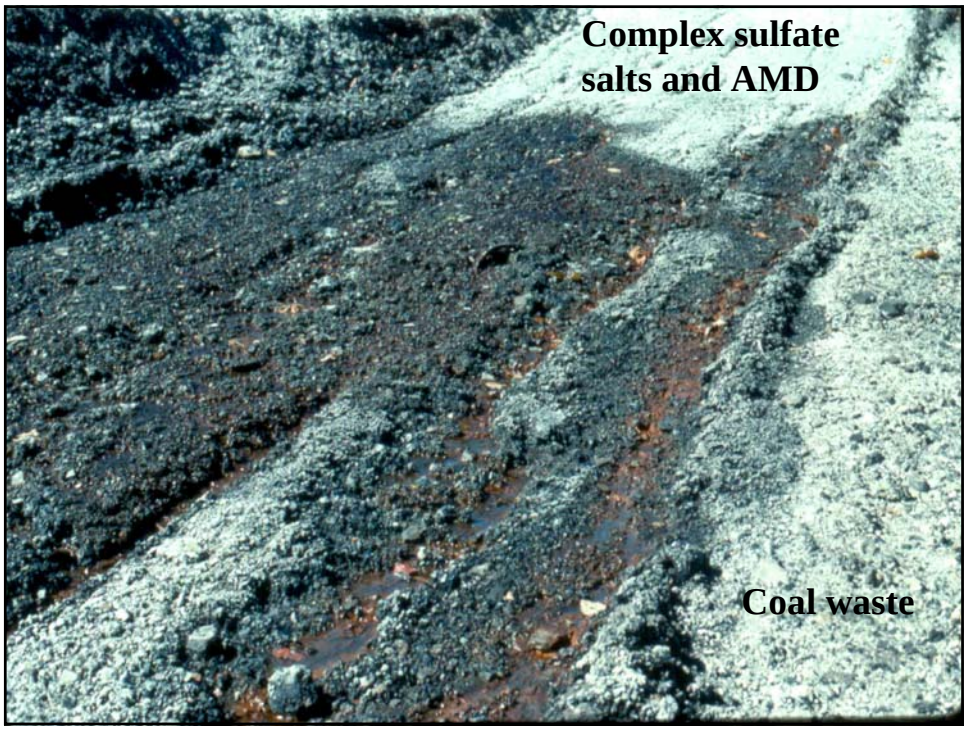
- Up to 50% of run-of-mine coal from Appalachian deep mines reports to coal waste disposal piles
- In Virginia alone, we have over 5000 ha of active and abandoned coal refuse piles.
- The vast majority of Appalachian coal refuse is potentially acidic with an average lime requirement of > 10 tons per 1000 (= tons of lime requirement per acre per 6").

200 ha coarse coal refuse disposal facility near Pound Virginia. No topsoil was set aside for reclamation of this facility.

Fine coal slurry (< 1 mm) from the fine coal cleaning circuit is typically impounded behind a dam of coarse refuse. These cells usually are found high and to the rear of the valley fills to minimize catastrophic effects of dam failures.

Table 17–2. Median values for some physical and chemical properties of coarse coal refuse from southwestern Virginia (Stewart, 1990). Median of samples taken from 5 active piles and 22 abandoned piles.

Parameter	Median value
Physical properties (whole refuse)	
% material >2-mm diam.	60%
Fine earth fraction: % material <2-mm diam.	40%
Physical properties (fine earth fraction)	
% sand sized (2–0.05 mm)	60%
% silt sized (0.05–0.002 mm)	25%
% clay sized (<0.002 mm)	15%
Soil textural class	Sandy loam
Chemical properties (whole refuse)	
Plant available water	38 g kg^{-1}
pH	4.16
EC	0.04 S m^{-1}
Cation exchange capacity	3.65 $cmol_c kg^{-1}$
Available P	7.6 mg kg^{-1}
Potential acidity (acid base accounting)	23 Mg ha^{-1}
Total S	0.8%
Potential acidity (H_2O_2)	63 Mg ha^{-1}



Challenging Properties

- **Inherent Variability. As Barry Stewart once said: *Lee, this stuff is just consistently variable*!**
- **Steep slopes and black color combine to generate severe heat loads, especially on S-facing slopes.**
- **Potential acidity and AMD generation.**

Challenging Properties

- Spontaneous combustion: pyrite oxidation is exothermic and the piles contain large amounts of combustible C!
- Sulfides begin to oxide in the presence of oxygen and water.
- High S coals have been known to combust in coal cars following heavy rains in hot weather.
- Most modern coal refuse fires are accidental or arson.
- Modern compacted piles do not combust due to limited oxygen flows.

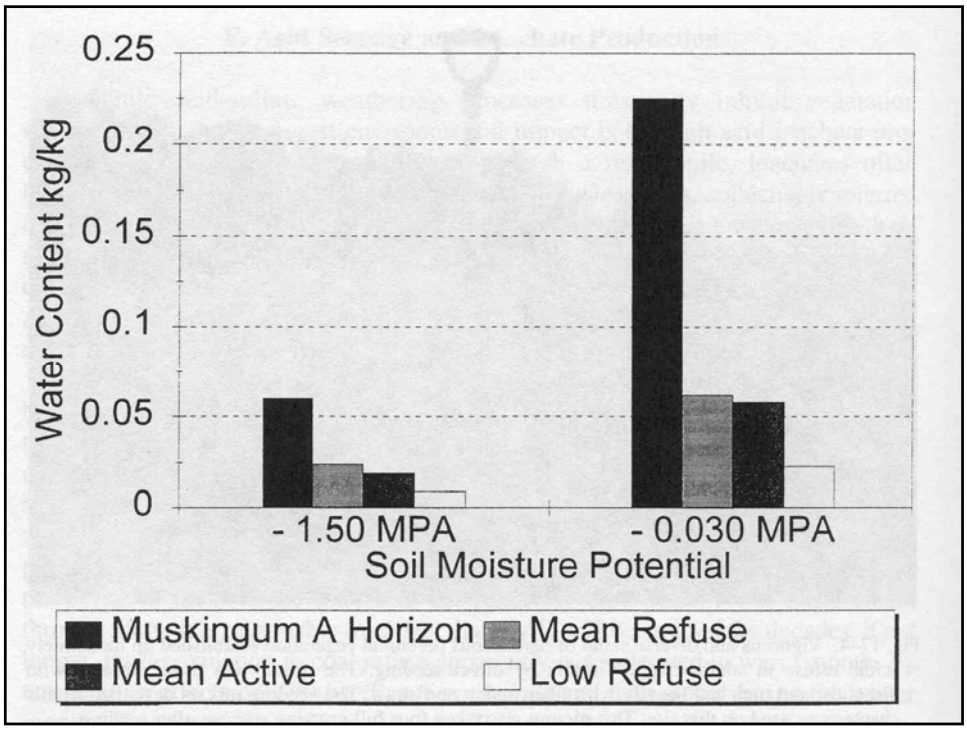
Burning pile in Pennsylvania with “red dog” exposed on low slopes.

Burning pile in Shanxi Province, China. These houses are occupied by miners and families.

Another local pile in Shanxi actively burning under houses. The local workers here were attempting to put the fire out by infiltrating water into these shallow pits. What's wrong with this approach?

Challenging Properties

- Low fertility and P-fixation potentials from rapidly forming Fe and Al oxides.
- Very low water holding and common compaction combine to limit rooting depth.
- Processing surfactants may actually make the surface hydrophobic, and fills are compacted for fill stability and to exclude oxygen to limit combustion.



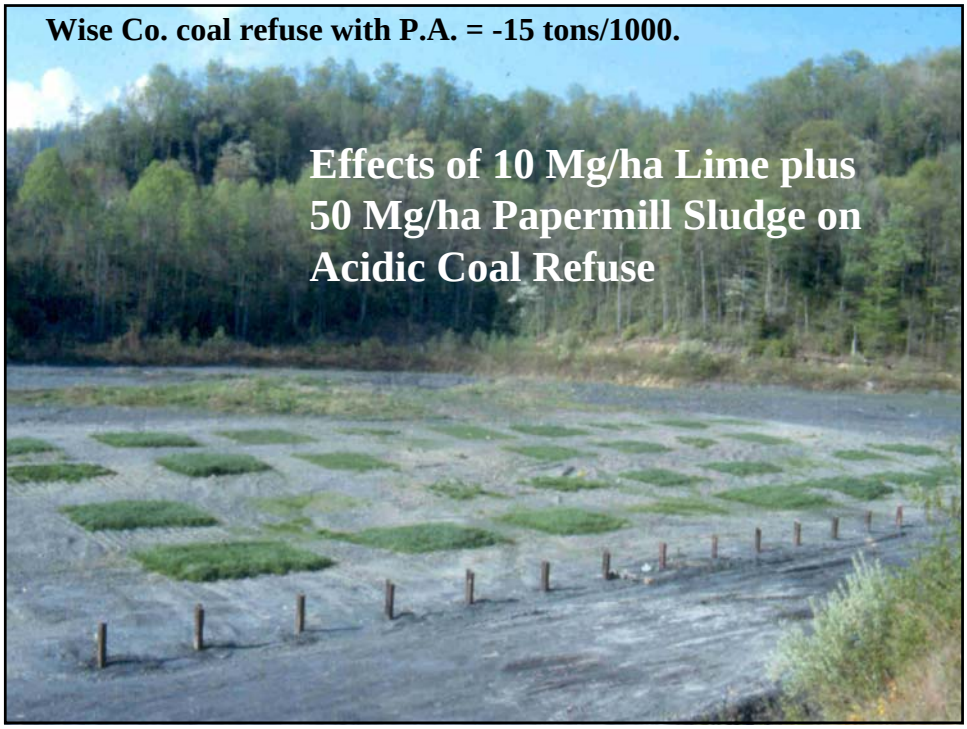
Three year-old seeding on acid forming refuse in West Virginia failing due to excess salts, low P and low water holding capacity and rooting depth.

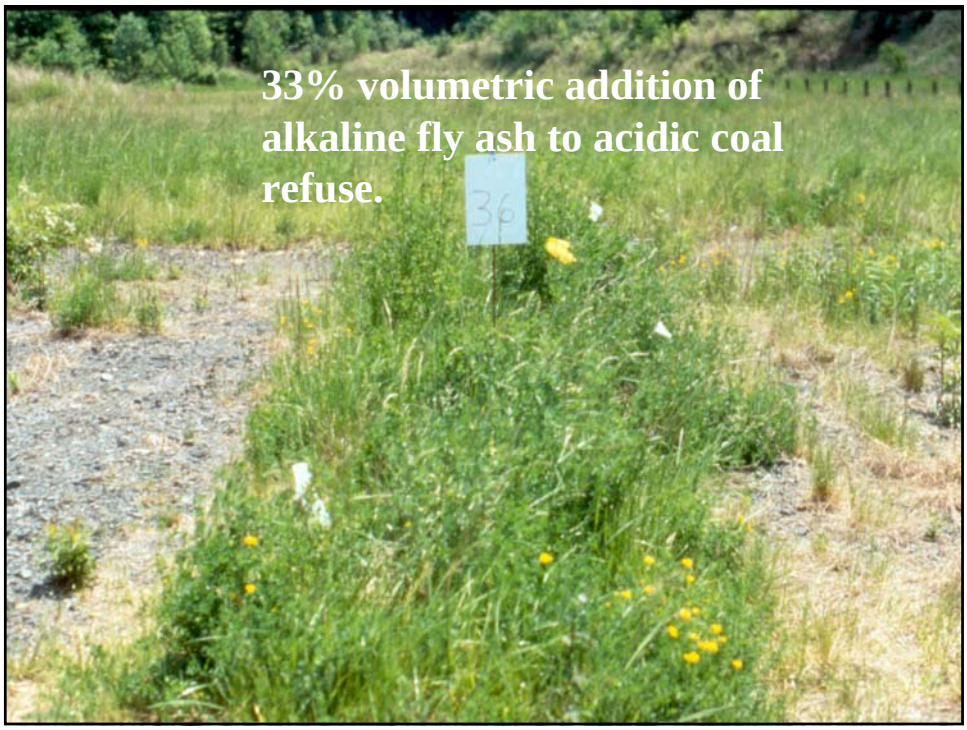
The soil pH here was 4.5, not directly limiting.

Revegetation Issues

- Very few coal refuse disposal facilities have stored sufficient topsoil or suitable spoil materials to cover these piles for revegetation.
- Current federal and state regulations allow direct seeding, but only with sufficient proof of concept and appropriate testing of the refuse materials.

In addition to adequate lime, direct seedings need heavy P to offset fixation losses. We also believe the P limits S oxidation and salt evolution in these moderately acid forming materials.


Wise Co. coal refuse with P.A. = -15 tons/1000.
Effects of 10 Mg/ha Lime plus
50 Mg/ha Papermill Sludge on
Acidic Coal Refuse


33% volumetric addition of
alkaline fly ash to acidic coal
refuse.

Topsoil thickness trials being installed in Wise Co. Soil cover was varied from 0 to 1 m with and without 25 Mg/ha lime at contact.

After two years, trenches were ripped up the limed and non-limed sides of each wedge to observe rooting vs. subsoil properties.

Note very limited growth on bare waste, but rapid increase in cover and vigor with very limited (15 cm) soil covers with lime at soil/refuse contact.

Table 17–3. Proposed refuse classification/revegetation criteria[‡].

Potential acidity by acid-base accounting (ABA)	Lime recommendation	Amendments and seeding strategies
<20 Mg ha^{-1} net acid	Lime to ABA need	Direct-seed with heavy P, straw mulch, and organic[§] amendments if possible. Use refuse seed mixture.
20–50 Mg ha^{-1} net acid	Lime to ABA, split if necessary	Direct-seed with heavy P, straw mulch, and organic§ amendment (required). Use refuse seed mixture.
50–100 Mg ha^{-1} net acid	Add lime (ABA need) at refuse-soil contact	Topsoil cover with 15–30 cm of final depth. Use conventional lime, fertilizer, and seed.
50–100 Mg ha^{-1} net acid[†]	Without lime	Topsoil cover with 50 cm or greater final depth. Use conventional lime, fertilizer, seed.
>100 Mg ha^{-1} net acid	Add lime (ABA need) at refuse-soil contact	30–50 cm of final topsoil depth. Use conventional lime, fertilizer, seed.

[†] On flat and gently sloping surfaces (<20%), lime and organic amendments may be applied in several treatments. Splitting lime applications, so as to allow it to react with the acidic refuse prior to seed application, may allow direct seeding on materials of up to 100 Mg ha^{-1} net ABA acidity. This will occur only on near-level to moderately sloped areas.

[‡] These recommendations do not take sideslope seeps and springs into account. Such seeps are usually acidic; affected areas will need to be spot treated.

[§] Organic amendment consisting of stabilized biosolids, papermill sludge, composted wood chips or similar material with C/N <30 at a rate of at least 50 Mg ha^{-1}, incorporated with a chisel plow.

Table 17–4. Seeding rates and species mixtures for establishment of permanent plant cover on coal refuse when applied in spring and fall.

Spring seeding		
Species	Latin name	Rate kg ha^{-1}
Redtop	*Agrostis alba*	3
Hard fescue	*Festuca ovina* (*var. Scaldis*)	20
Tall fescue	*Festuca arundinacea* Schreber	20
Annual ryegrass	*Lolium multiflorum* Lam.	15
German millet	*Setaria italica* L.	20
Weeping lovegrass	*Eragrostis curvula* Schrader	3
Birdsfoot trefoil	*Lotus corniculatus* L.	5
Yellow sweet clover	*Melilotus officinalis*	2
Ladino clover	*Trifolium repens* L.	2
Kobe lespedeza	*Lespedeza striata*	10

Fall seeding		
Species	Latin name	Rate kg ha^{-1}
Redtop	*Agrostis alba*	3
Hard fescue	*Festuca ovina* (*var. Scaldis*)	20
Tall fescue	*Festuca arundinacea*	20
Annual ryegrass	*Lolium multiflorum*	15
Cereal rye	*Secale cereale*	25
Weeping lovegrass	*Eragrostis curvula*	3
Birdsfoot trefoil	*Lotus corniculatus*	5
Yellow sweet clover	*Melilotus officinalis*	2
Ladino clover	*Trifolium repens*	2
Kobe lespedeza	*Lespedeza striata*	10

Direct seeding results after 3 years with lime, high P and 80 Mg/ha biosolids and acid/salt tolerant seed mix. The tall plants are native annual invading into the plots.

Table 17–5. General timetable for reclamation practices suitable for revegetation of coal refuse areas.

Activity	Date	Recommendations
Final grading	15 May–15 September	Final grading should be done in a manner to avoid severe compaction of the surface.
Liming	Year-round	Liming rate should be based on measured potential acidity. Single applications should not exceed 50 Mg ha^{-1}. Additional lime may be added at 24-wk. (6-mo) intervals.
Fertilization	15 March–15 November	If fertilizer is to be applied prior to seeding, nitrogen fertilizers should not be included.
Seeding	15 March–15 May	Apply complete spring seeding mixture with fertilizers.
	15 May–15 September	Apply only millet with reduced rates of N.
	15 September–15 November	Apply complete fall seeding mixture with fertilizers.
	15 November–15 March	Apply only cereal rye with reduced rates of N.

Coal Waste Revegetation Criteria

Daniels et al., 2000, Agronomy Mono # 41

- **Where liming is practical (PA ≤ 50 Mg/ha and slopes < 25%), direct seeding is feasible with heavy P (400 kg/ha) and mulch applications, and via the use of acid/salt tolerant species like Festuca rubra, etc.**

- **Additional organic amendment with biosolids or composts is highly recommended at ≥ 100 Mg/ha, incorporated.**

Coal Waste Revegetation Criteria

Daniels et al., 2000, Agronomy Mono # 41

- **Coal refuse materials with PA ≥ 50 tons per 1000 will require soil or spoil covers of up to 0.5 m depending on acidity. Adding a lime "blanket" at the refuse/soil contact significantly decreases the thickness requirements.**

Unfortunately, surface revegetation efforts per se seldom have any lasting effect on the discharge of acidic drainage from pyritic waste piles! Simply limiting O_2 to the bulk pile is not enough!