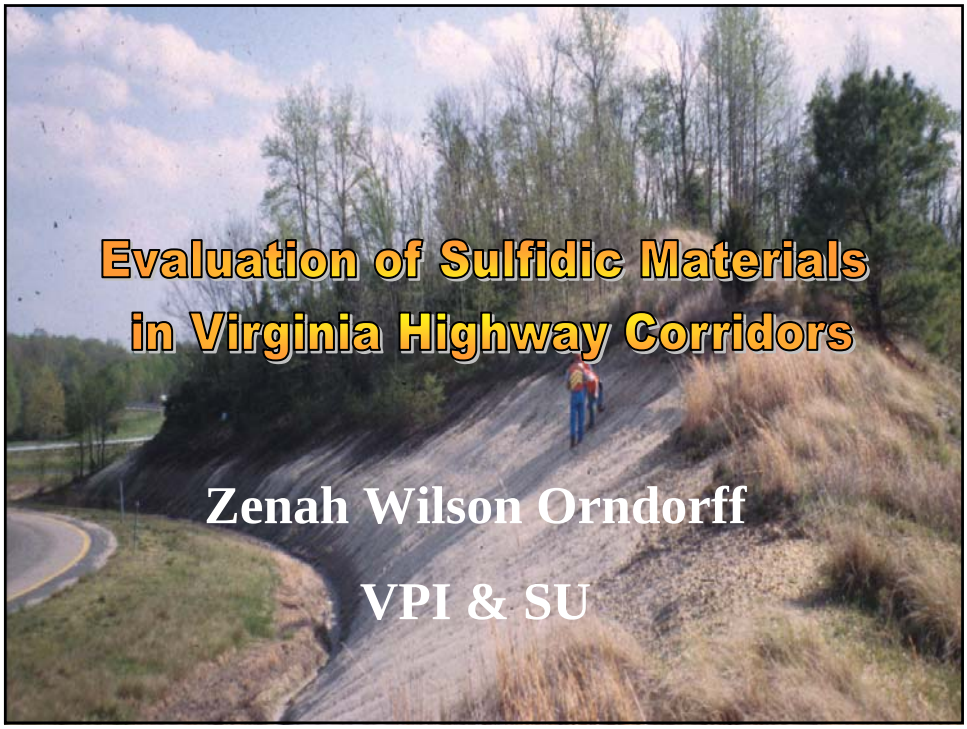


During the 1980's the Virginia Department of Transportation (VDOT) started noticing problems…...

Poorly established vegetation

Iron staining

Stafford County, northern Virginia

…at numerous sites...

Vegetation poorly established along channel for diverted creek.

Chesterfield County, southeast Virginia.

…..all around the state.

Iron staining and poorly established vegetation.

Wise County, southwest Virginia

The common factor among these roadcuts: exposure of sulfidic materials.

Sulfide oxidation along highway corridors in Virginia has resulted in:

- **barren road banks that are prone to erosion, and are aesthetically displeasing.**
- **degradation of road construction materials.**
- **decline in local surface water quality due to input of acidity and metals.**

In 1997 we began a four year study with the following objectives:

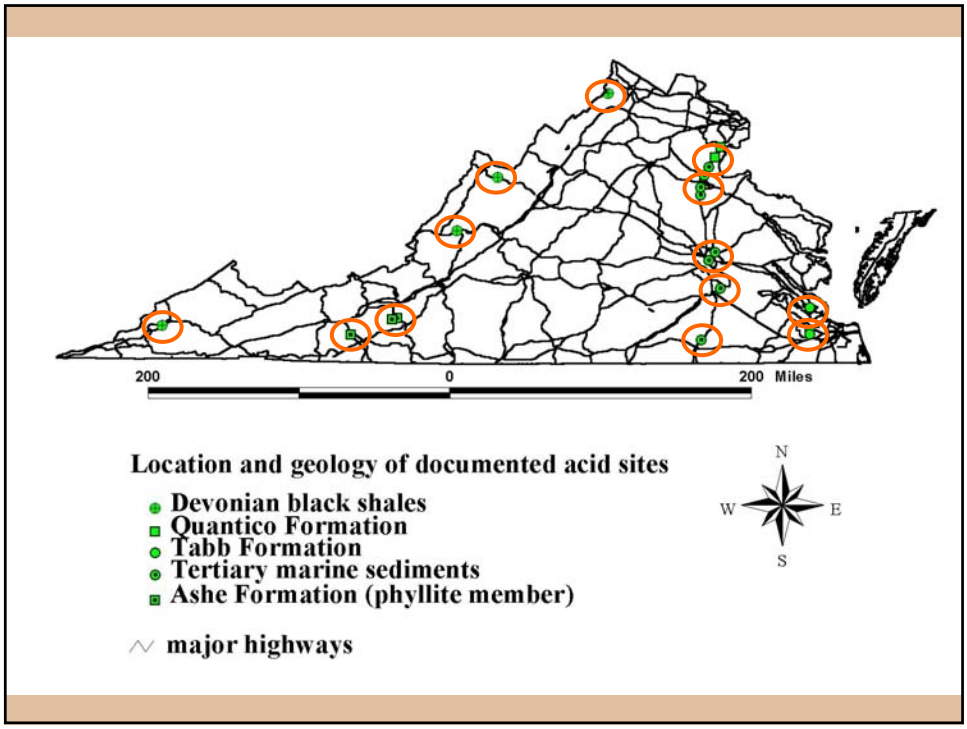
- Identify and characterize acid-producing sulfidic deposits around the state.
- Compile a state-wide sulfide-hazard risk map.
- Evaluate procedures for estimating potential acidity on a diverse set of geologic materials.
- Evaluate relationship between depth to sulfidic sediments and landscape in the coastal plain.

Compiling a state-wide sulfide hazard map for Virginia: materials and methods.

- In the fall of 1997, a questionnaire regarding occurrence of acid roadcuts was distributed to VDOT.
- Approximately twenty sites were identified from around the state.
- Additional sites were reported later or discovered independently.

Compiling a state-wide sulfide hazard map for Virginia: materials and methods.

- Geologic materials and road drainage grab samples, where available, were collected from all sites.
- Geologic samples were tested for:
  - potential peroxide acidity (PPA)
  - total-S
  - pH (unconsolidated samples)
- Water samples were tested for:
  - pH
  - S content
  - metal content (Fe, Al, Mn, Cu, Zn)



Potential peroxide acidity (PPA):

- 120 ml of hydrogen peroxide (H_2O_2) is added in numerous small increments to a 1 g sample.
- The H_2O_2 oxidizes sulfides and acidity is produced.
- The amount of acidity produced is determined by titration with NaOH.

Potential peroxide acidity:

- 269 carbonate-free samples from diverse sulfidic materials were evaluated by PPA and total-S.
- As expected, total-S was strongly related to PPA (R^2 = 0.81)
- PPA is a robust test which may be used to assess potential acidity of diverse sulfidic materials.
- S may serve as an adequate screening tool in the routine analysis of potentially acid materials.

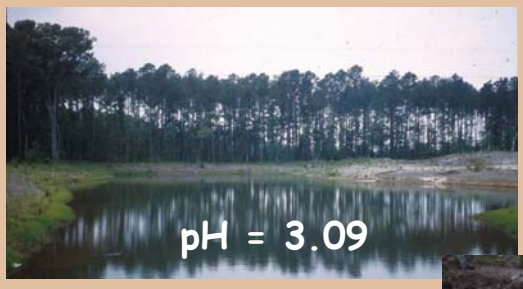
The good, the bad, and the ugly.

- PPA < 10 Mg $CaCO_3$/1000 Mg material (total-S < 0.2%): can readily be managed.
- PPA 10 - 60 Mg $CaCO_3$/1000 Mg material (total-S = 0.2 - 2%): can be remediated with intense management.
- PPA > 60 Mg $CaCO_3$/1000 Mg material (total-S > 2%): extremely difficult to remediate.

Compiling a state-wide sulfide hazard map for Virginia: the Tabb Formation.

Roadcut along 64E in Suffolk.

Compiling a state-wide sulfide hazard map for Virginia: the Tabb Formation.



← Pond at Hampton Roads Center

Runoff from stockpiled material at Hampton Roads Center. →

Compiling a state-wide sulfide hazard map for Virginia: the Tabb Formation.

Sample locations	Hampton and Suffolk
PPA	< 10 Mg $CaCO_3$/1000 Mg material
Total-S	< 0.2%
pH	3 - 4
water	pH = 3.1; Fe = 12 mg/L; Mn = 2 mg/

Compiling a state-wide sulfide hazard map for Virginia: the Tabb Formation.

The Tabb Formation (Sedgefield member) may be considered likely to produce moderately problematic roadside management conditions which could require special reclamation efforts.

Compiling a state-wide sulfide hazard map for Virginia: Tertiary marine sediments.

- The Chesapeake Group: Yorktown, Eastover, St. Mary's, Choptank, and Calvert Formations.
- Lower Tertiary Deposits: Brightseat, Aquia, Marlboro, Nanjemoy, Piney Point, and Chickahominy Formations.

Compiling a state-wide sulfide hazard map for Virginia: Tertiary marine sediments.

Chesterfield County: Proctor's Creek was redirected to this excavated channel during road construction.

Compiling a state-wide sulfide hazard map for Virginia: Tertiary marine sediments.

Interchange of I-295/Rt-360 in Mechanicsville.

Compiling a state-wide sulfide hazard map for Virginia: Tertiary marine sediments.

Within 5 years, erosion has removed over 30 cm of sediment...

...and the guardrail is severely corroded.

Compiling a state-wide sulfide hazard map for Virginia: Tertiary marine sediments.

I-95 in Spotsylvania County. The stability of this sign is compromised by concrete degradation and erosion. Acid conditions (soil pH ~ 2.5) limit vegetation.

Compiling a state-wide sulfide hazard map for Virginia: Tertiary marine sediments.

Sample locations	Greensville, Prince George, Chesterfield, Henrico, Hanover, and Spotsylvania Counties; City of Richmond.
PPA	10 – 20 (oxidized) 30 – 50 (reduced) Mg $CaCO_3$/1000 Mg material
Total-S	< 1.0% (oxidized) 1.0 – 2.5% (reduced)
pH	2.5 – 3.5 (oxidized) 5.5 – 8.0 (reduced)
water	pH = 3.2; Fe = 17.5 mg/L; Mn = 2.1 mg/L

Compiling a state-wide sulfide hazard map for Virginia: Tertiary marine sediments.

Tertiary marine sediments may be considered highly likely to produce problematic roadside management conditions which require intense reclamation efforts.

Compiling a state-wide sulfide hazard map for Virginia: the Quantico Formation.

Roadcut along Mine Road in Stafford County.

Compiling a state-wide sulfide hazard map for Virginia: the Quantico Formation.

Iron-staining along curbs and sidewalks through the Hampton Oaks subdivision. Homeowners in this neighborhood apply the equivalent of 2 Mg agricultural lime per hectare per month to maintain soil pH above 5.5.

Compiling a state-wide sulfide hazard map for Virginia: the Quantico Formation.

Concrete etching occurs when acid drainage "dissolves" out the cement, deteriorating the concrete.

Compiling a state-wide sulfide hazard map for Virginia: the Quantico Formation.

Sample Locations	Stafford and Prince William Counties
PPA	6 – 100 Mg $CaCO_3$/1000 Mg material
Total-S	0.2 – 4.0%
pH	2 - 4
water	pH = 2.5; Fe = 249 mg/L; Mn = 18 mg/L

Compiling a state-wide sulfide hazard map for Virginia: the Quantico Formation.

Exposures of the Quantico Formation may be considered highly likely to produce severely problematic roadside management conditions which require intense reclamation efforts.

Compiling a state-wide sulfide hazard map for Virginia: the Ashe Formation.

Rt-750, Floyd Co.

Drainage from this roadcut flows to the culvert on the right.

Compiling a state-wide sulfide hazard map for Virginia: the Ashe Formation.

Sample Locations	**Floyd and Carroll Counties**
PPA	**1 – 20 Mg $CaCO_3$/1000 Mg material**
Total-S	**0.0 – 2.0%**
pH	**3.5 – 4.5**
water	**pH = 3.2; Fe = 39.7 mg/L; Mn = 1.4 mg/L**

Compiling a state-wide sulfide hazard map for Virginia: the Ashe Formation.

Exposures of phyllitic material from the Ashe Formation may be considered somewhat likely to produce moderate to severe problematic roadside management conditions.

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

- Marcellus shale
- Millboro shale
- Needmore Formation
- Chattanooga shale

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

Exposure of the Millboro shale and Needmore Formation along Rt-250 in Highland County.

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

The Rt-250 roadcut drains to this sedimentation pond.

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

Culvert beneath I-64 in Clifton Forge

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

Inside the culvert at Clifton Forge.

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

Sulfate salts precipitated in rock fractures.

Copiapite precipitated along the roadcut.

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

Sample locations	Frederick, Highland, Alleghany, and Wise Counties
PPA	0 – 60* Mg $CaCO_3$/1000 Mg material
Total-S	0 – 3.3%
water	pH = 2.7; Fe = 59.0 mg/L; Mn = 38.5 mg/L

* numerous samples contained carbonates which neutralize acidity.

Compiling a state-wide sulfide hazard map for Virginia: Devonian black shales.

Exposure of the Marcellus, Millboro, and Chattanooga shales, and the Needmore formation, may be considered somewhat likely to produce severely problematic roadside management conditions.

Compiling a state-wide sulfide hazard map for Virginia: the coalfields.

- Not sampled due to existing research on potential acidity.
- PPA values are typically < 10 Mg $CaCO_3$/1000 Mg material.
- Carbonates help neutralize acidity.

Compiling a state-wide sulfide hazard map for Virginia: the final map.

All formations, based on draft version of digital geologic map of Virginia.

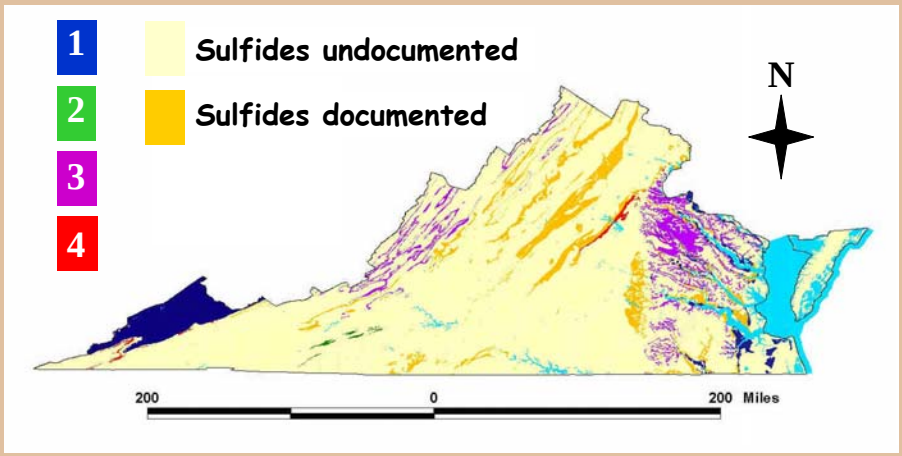
Not characterized

- Sulfides not documented.
- Sulfides documented. Acid potential unknown.

Characterized

- 1: PPA < 10; S < 0.5%.
- 2: PPA < 10; S > 0.5%.
- 3: PPA 10 - 60.
- 4: PPA - more than 10% of samples > 60.

Compiling a state-wide sulfide hazard map for Virginia: the final map.



Conclusions

- Sulfide hazard analysis should be considered an essential step in the pre-design phase of highway construction and other earth-disturbing activities.
- Development of a state-wide sulfide hazard rating map may help minimize problems associated with acid sulfate weathering during future road construction by delineating the extent, and characterizing the potential acid severity, of sulfide bearing formations.

Acknowledgements

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