ACID SULFATE SOIL PROBLEMS IN THE MID-ATLANTIC AND WORLD

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Ways that *sulfidic materials get exposed to oxidation to give rise to active acid sulfate soils*

- Artificial drainage of tidal wetlands that are potential acid sulfate soils, typically for agricultural purposes.
- Dredging with placement of the DM (dredged materials) in upland disposal areas.
- By surface or other mining activities.

More ways of exposure of *sulfidic materials*

- **By construction activities that cut through the oxidized zone, where soil materials are not *sulfidic,* into the unoxidized zone (of soil-geologic columns) that is *sulfidic*.**
- **Done in construction of highways, airports, housing developments, shopping centers and malls, athletic fields, and to artificially create wetlands etc.**
- **Sometimes happens naturally by stream bank or shore erosion.**

More ways

- By use of (usually clayey) *sulfidic materials* as low permeability cover materials for landfills – a common practice in New Jersey and in other states, including places in MD and DE.
- The *sulfidic materials* are usually covered with other non-sulfidic soil materials or geo-textiles. The extent to which oxidation is limited by such covering is not well known, but oxidation is known to happen beneath such covers.

Mangrove tidal swamp along river in Senegal, West Africa, oyster shells on brace roots of Rhizophera plants.

Active acid sulfate soil in drained (for rice farming) mangrove swamp in Guine‘ Bissau, West Africa. Jarosite along old mangrove root channels. White salts, after drying, near surface. Exclusion of sea water, to try to lessen salt problem, enhances sulfide oxidation that acidifies the soil and give rise to sulfate salts. Crops don’t grow.

Dredged materials (DM) deposition at Hart-Miller Island, note dark color of probable *sulfidic materials* and likely presence of MBO's

Hart-Miller Island is a constructed Island in Chesapeake Bay northeast of Baltimore. Dikes were built in 1980's to contain about 2 square miles of DM, subsequently raised twice to contain more DM.

Special problems of MBO's

- **Mono-sulfidic black oozes (MBO's) contain iron monosulfides, FeS, to which the black color is attributable. They evolve H_2S when exposed to 10% HCL. Pyrite, an iron disulfide, FeS_2, does not do this.**
- **When MBO's are stirred in water the sulfide oxidizes very rapidly and consumes the dissolved oxygen in the water. When this happens, by turbulence in water bodies, fish kills can happen when the oxygen is gone.**

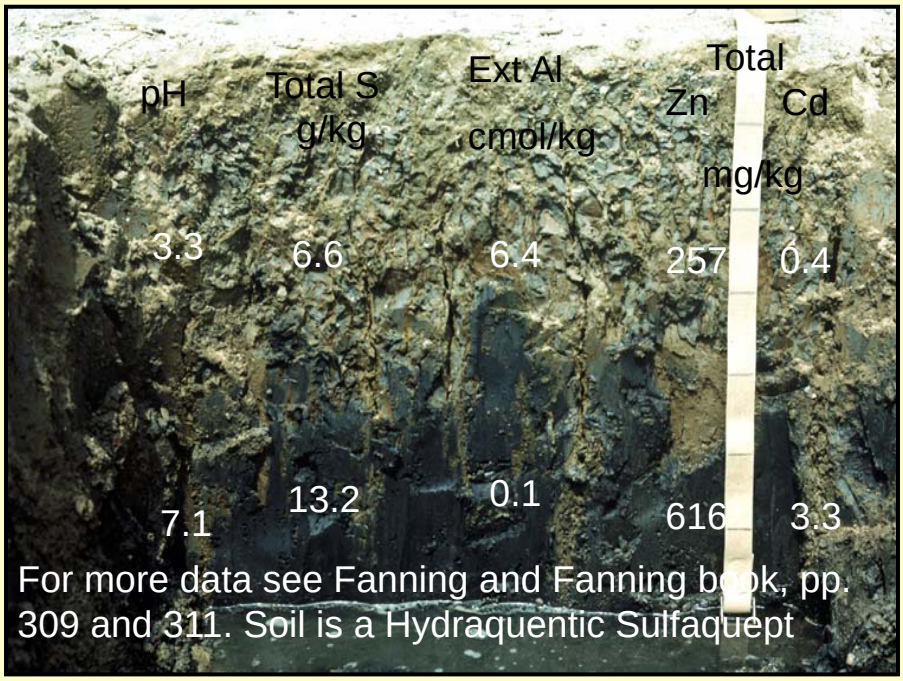
DM about 2 months after deposition at Hart-Miller Island in Chesapeake Bay. Cracking pattern develops by desiccation and salts (white) form by drying at soil surface. The DM are *sulfidic materials* that are likely to acidify to a pH of 3.5 or less in a few weeks or months as the DM dry and oxidation takes place. The original *Sulfaquent* soil will become a *Sulfaquept* after a *sulfuric horizon* forms.

Note soft, soupy nature (high n-value) of DM beneath surface crust of drying *sulfidic materials* before sufficient drying & oxidation to form a *sulfuric horizon.*

Phragmites reeds begin to invade acid sulfate soil in DM at Hart-Miller -- about one year after DM deposition

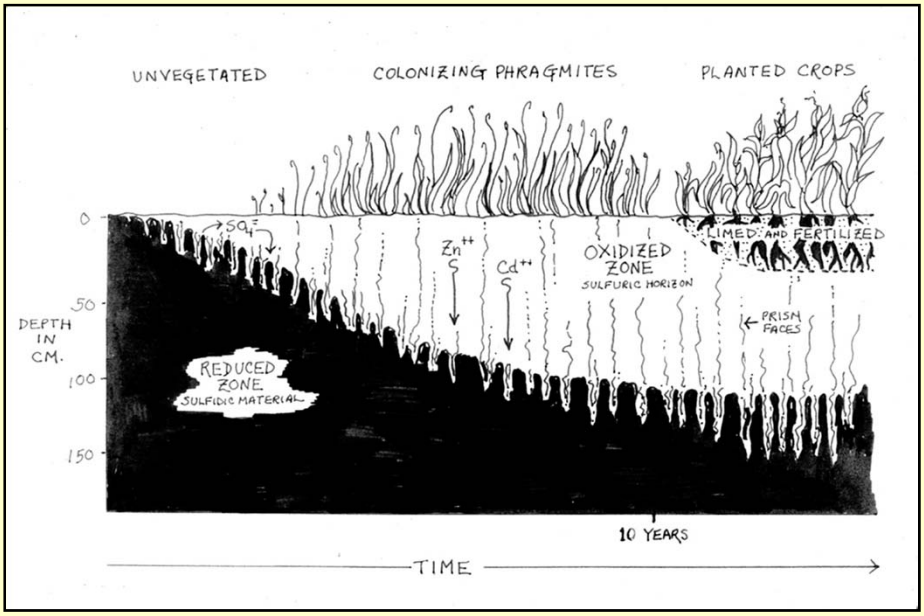
Deposition of DM by conveyor belt in diked area in Baltimore, MD in 1982.

Site of 4 year old soil in dredged materials from Baltimore Harbor seen in next slide



For more data see Fanning and Fanning book, pp. 309 and 311. Soil is a Hydraquentic Sulfaquept

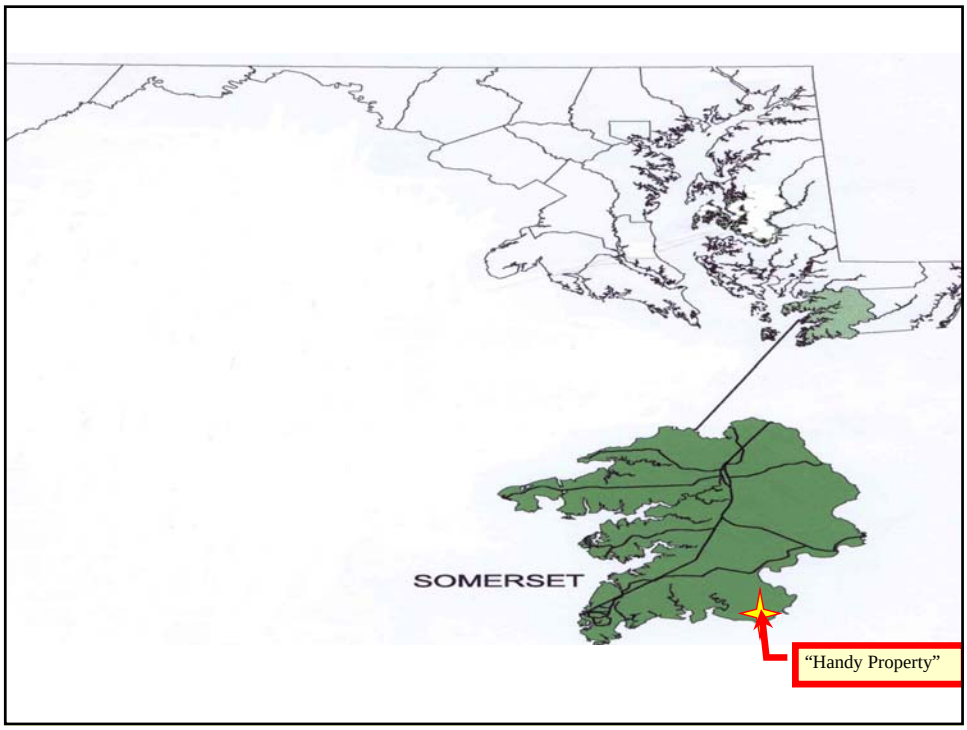
Dead duck at edge of pond in a.s.s. on DM in Baltimore. Cause of death? The pH of the pond water was probably below 3. Muskrats lived in the pond.

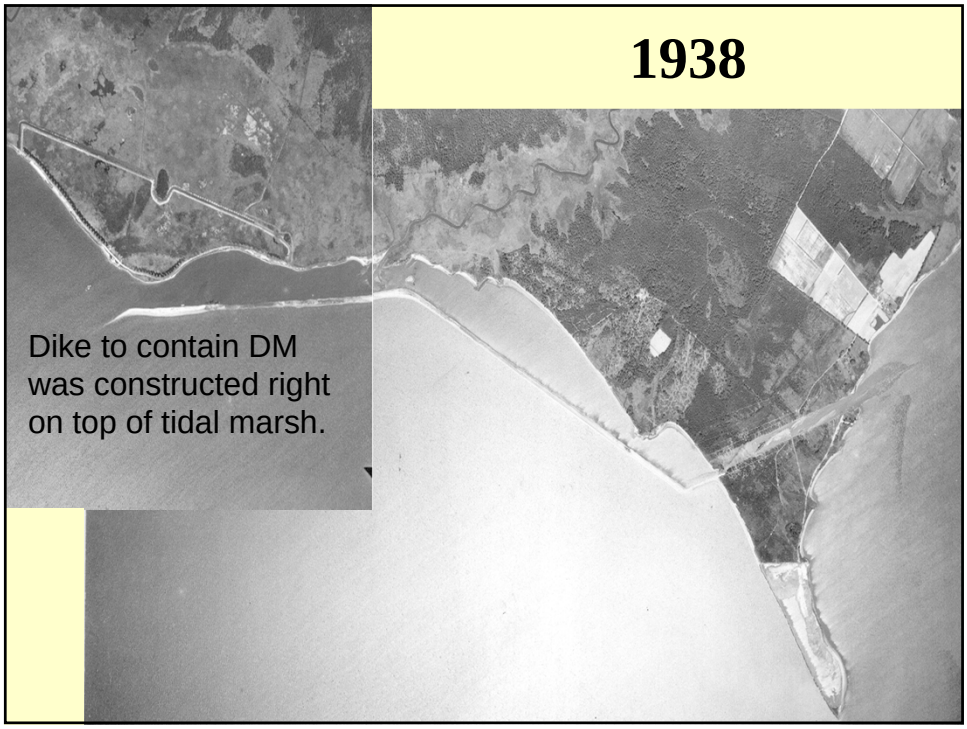


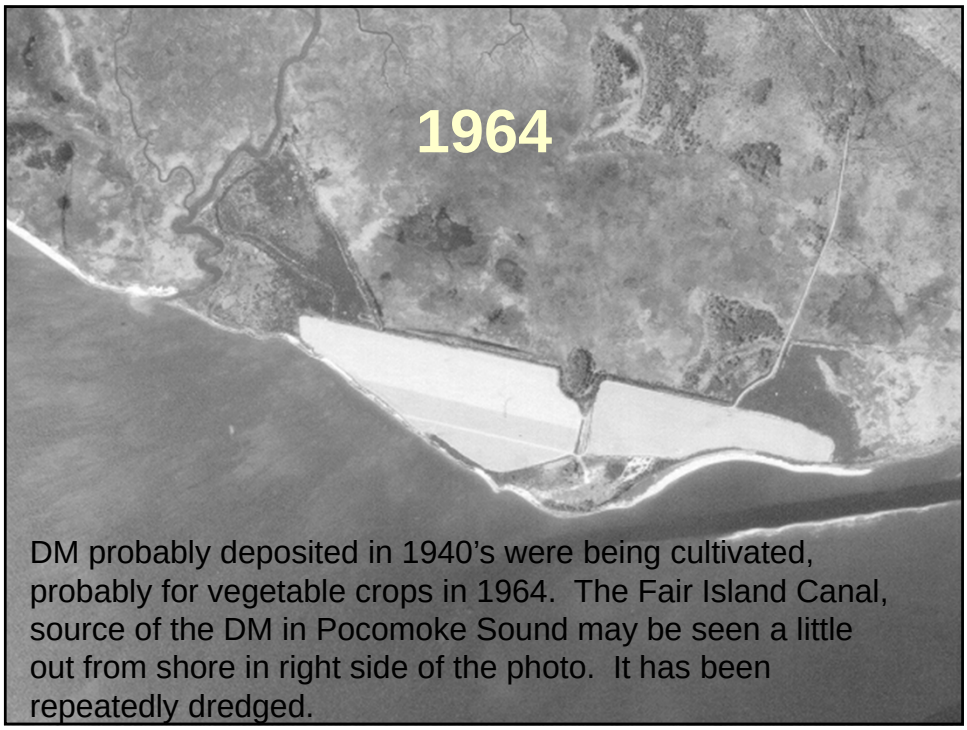
Idealized time development sequence of soils in sulfidic DM, from Fanning and Fanning (1989). How long do sulfides last?

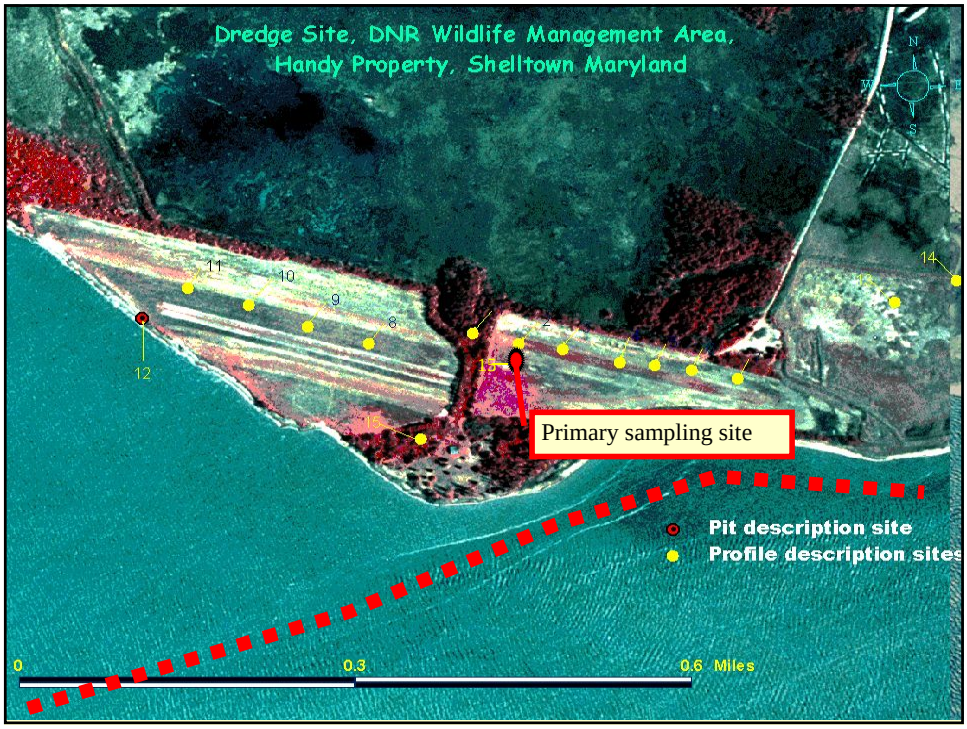
Acid Sulfate Soils in Dredged Materials From Tidal Pocomoke Sound in Somerset County, MD

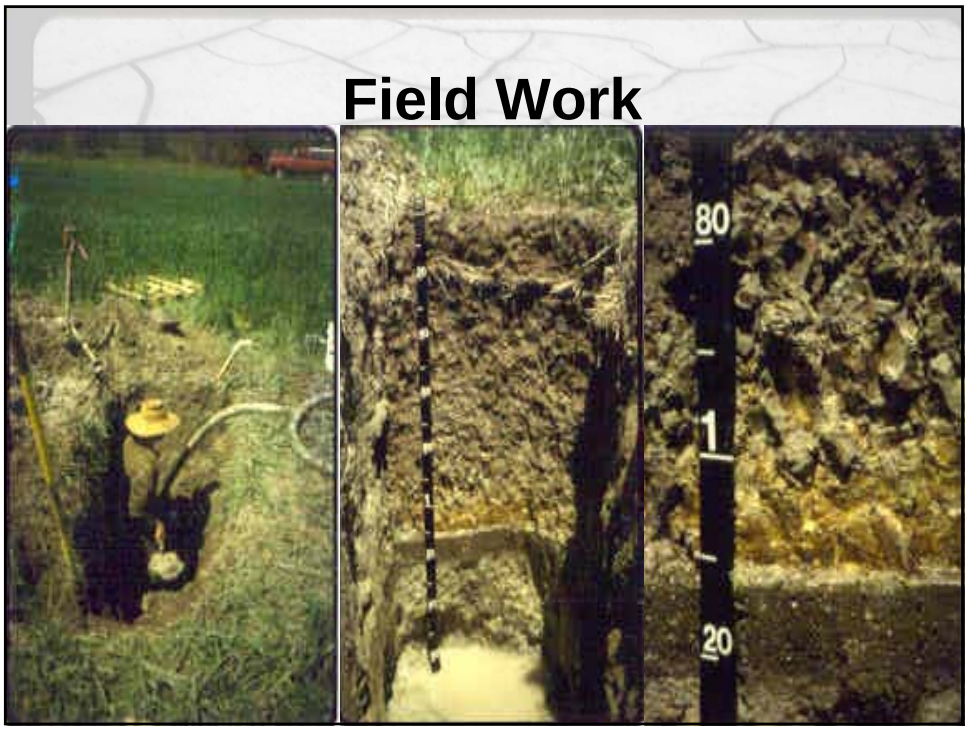
S.Y. Demas, A.M. Hall,
D.S. Fanning, M.C.
Rabenhorst, E. K. Dzantor




1938
Dike to contain DM was constructed right on top of tidal marsh.

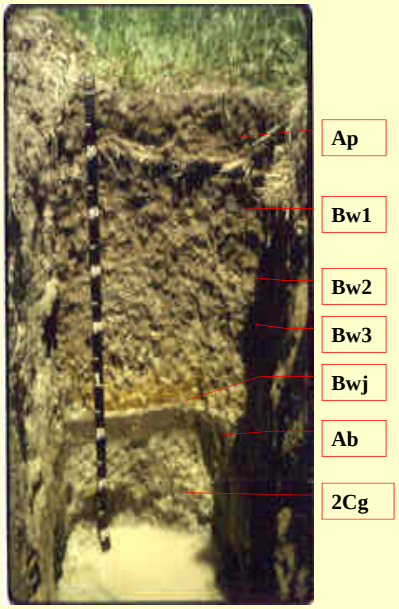

1964
DM probably deposited in 1940's were being cultivated, probably for vegetable crops in 1964. The Fair Island Canal, source of the DM in Pocomoke Sound may be seen a little out from shore in right side of the photo. It has been repeatedly dredged.


Dredge Site, DNR Wildlife Management Area,
Handy Property, Shelltown Maryland
N
W
E
S
11
10
9
8
12
14
Primary sampling site
Pit description site
Profile description sites
0
0.3
0.6 Miles


Field Work
80
1
20

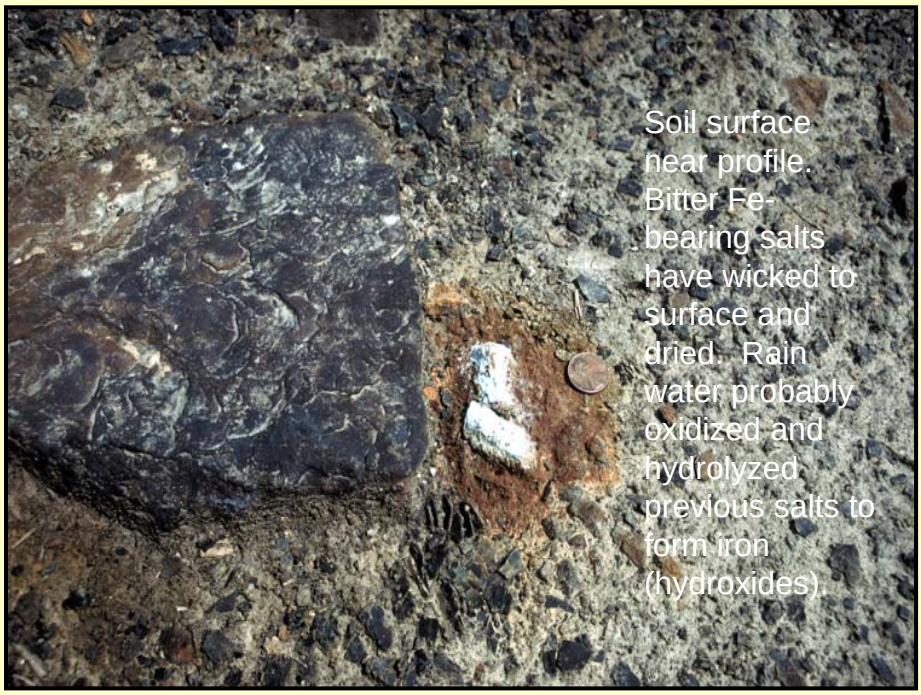
Sulfic Endoaquept

The soil, probably a Sulfaquent when the DM were first deposited in 1940's, probably became a Sulfaquept in a year or so, but now is an Endoaquept as it no longer has a sulfuric horizon with an upper boundary within 50 cm of the soil surface.

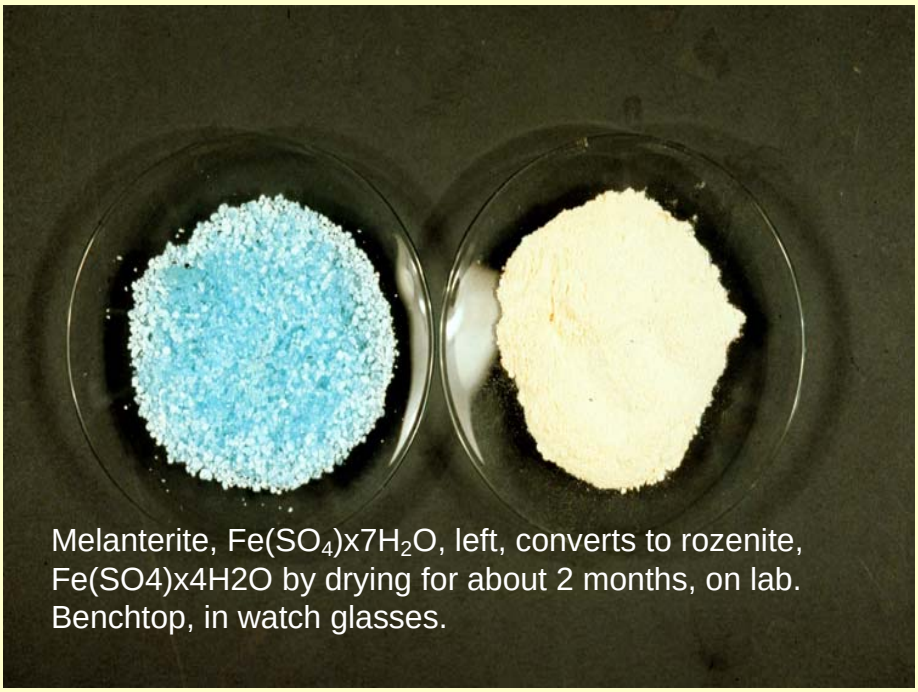


The sulfides are mostly gone from the bulk of the soil in DM in 60 years. Leaching under the dike at top of buried soil probably speeded the development

Active acid sulfate soil in mine spoil in Allegany Co., MD, photographed in 1977. Spoil was deposited in 1950's. Soil has a *sulfuric horizon* with pH about 2.3 and would now be classified as a *Sulfudept*. The soil was nearly barren of vegetation, but later became more vegetated. Marks on tape are at 10cm increments.

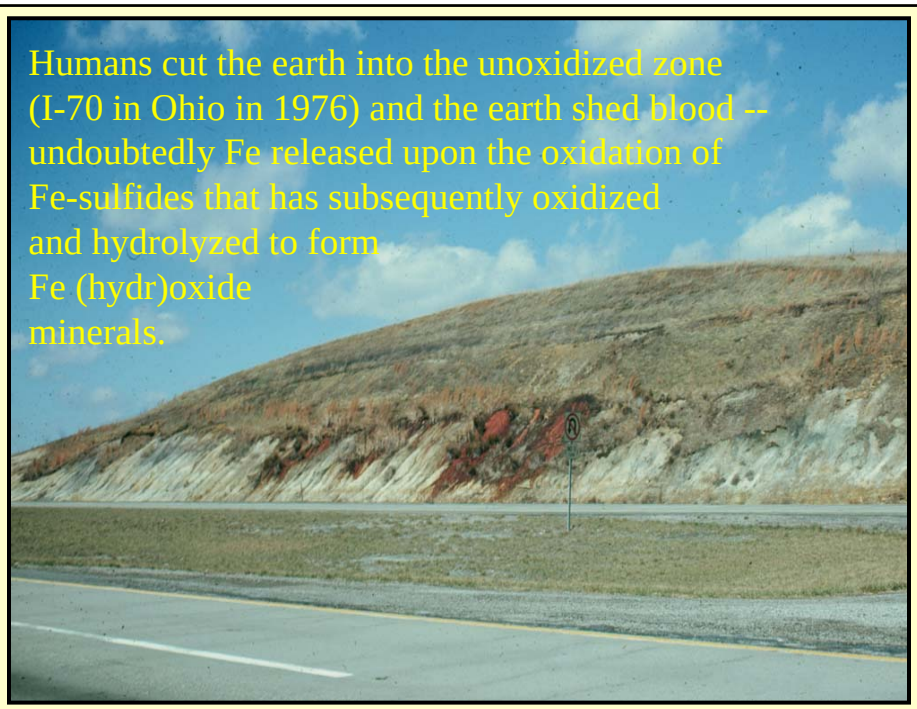

Soil surface near profile. Bitter Fe-bearing salts have wicked to surface and dried. Rain water probably oxidized and hydrolyzed previous salts to form iron (hydroxides).


Dr. Jerry Bigham of Ohio State U. examines ferrous sulfate minerals melanterite, blue, and rozenite, white, in a seepage area of surface mine in Ohio



Melanterite, $Fe(SO_4)x7H_2O$, left, converts to rozenite, Fe(SO4)x4H2O by drying for about 2 months, on lab. Benchtop, in watch glasses.

Acid Mine drainage in Ohio, slide from Dr. J. M. Bigham, Ohio State University. Iron sulfates, dissolved in water, oxidize and hydrolyze to produce the red/orange iron (hydr)oxide gunk in the stream. The hydrolysis produces sulfuric acid in the stream water.



Housing develop-ment on exposed *sulfidic materials* in Crofton, MD about 1980.

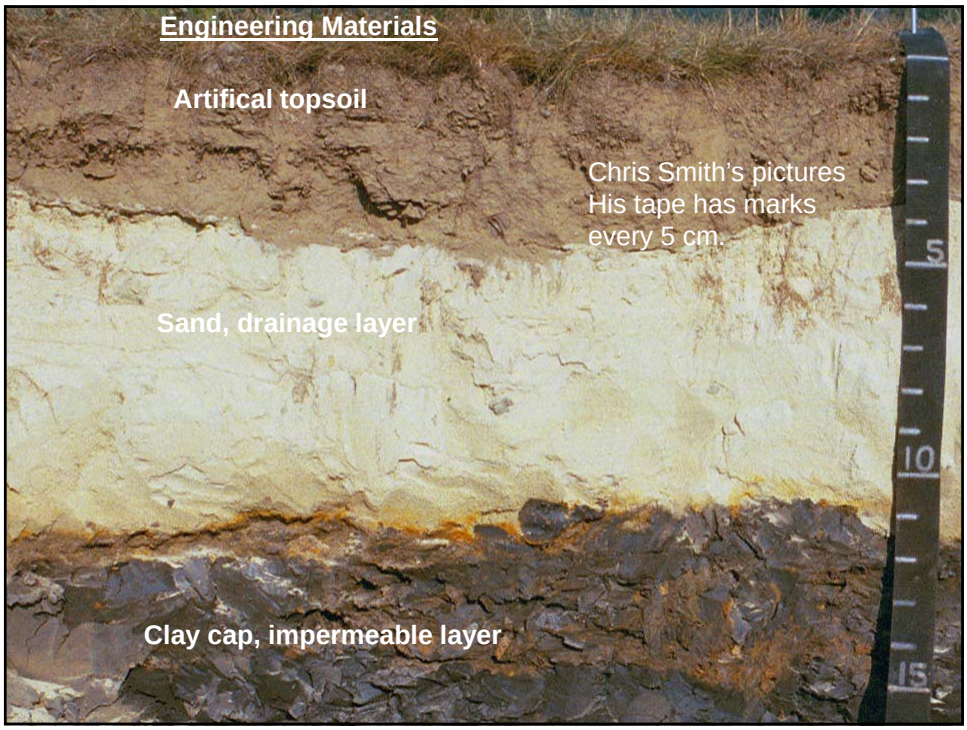
Use of Sulfidic "clay" to cover Edgeboro Landfill, New Brunswick, NJ. "Clay" Mine in fore-ground. Gray "clay" on landfill in background, covered with Triassic red beds soil material.

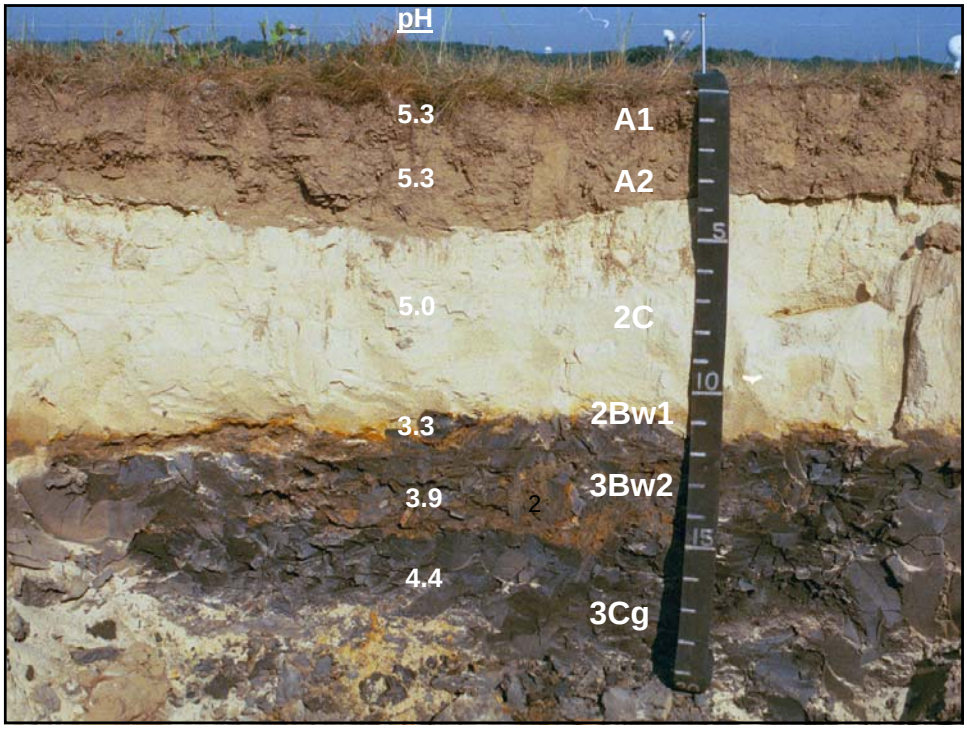
Pyrite nuggets in a pile of sulfidic clay ready for use as a cover material at Edgeboro landfill, New Brunswick, NJ

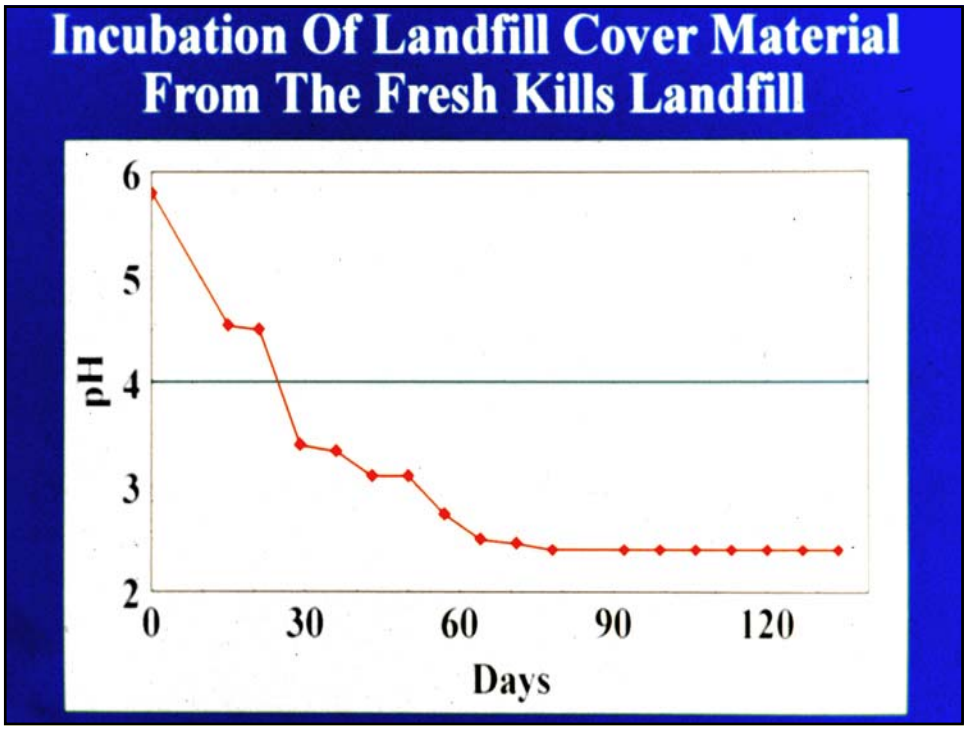
Active acid sulfate soil on Edgeboro Landfill in NJ.

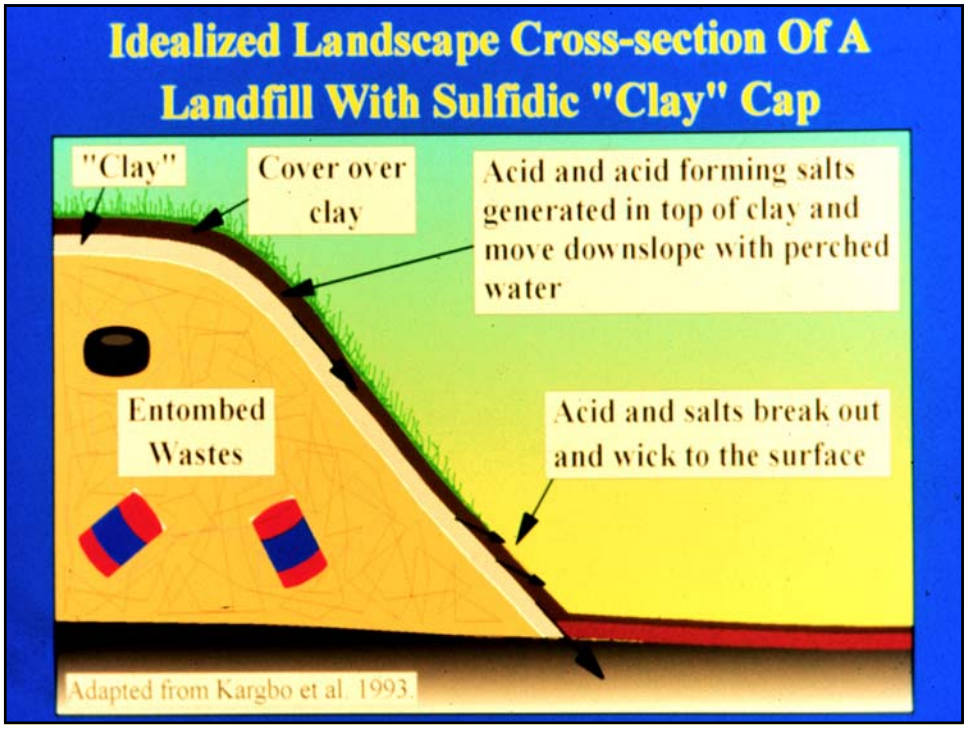
Acid drainage coming off *sulfuric horizon* on Edgeboro Landfill, New Brunswick, NJ.


View from top of Burlington Co. NJ landfill in 2004 toward where sulfidic clay, like that in lower part of soil profile on landfill is mined as landfill construction continues. Construction of the soil where profile occurs was completed in about 1998.


Engineering Materials
Artifical topsoil
Chris Smith's pictures
His tape has marks
every 5 cm.
Sand, drainage layer
Clay cap, impermeable layer
5
10
15


pH
5.3
A1
5.3
A2
5.0
2C
3.3
2Bw1
3.9
3Bw2
4.4
3Cg


Incubation Of Landfill Cover Material
From The Fresh Kills Landfill
pH
6
5
4
3
2
0
30
60
90
120
Days



Addressing the question of what eventually happens to active acid sulfate soils with time

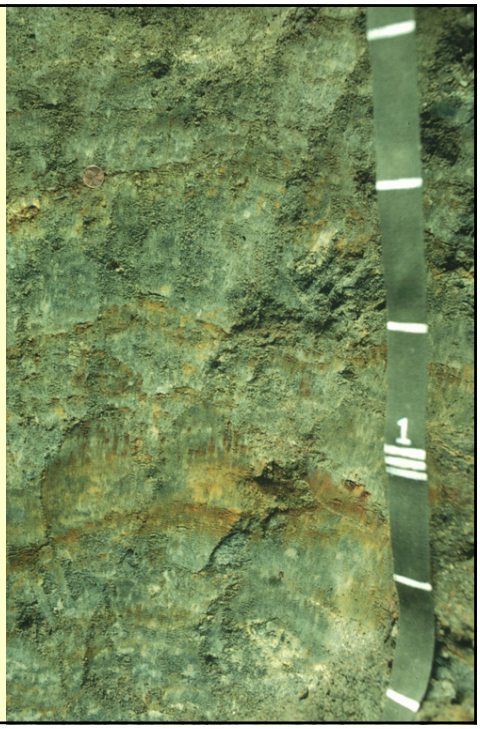
- **On stable upland surfaces they pass into the post-active stage in a few decades or centuries.**
- **In the Mid-Atlantic region they remain acid with pH of about 4-4.5 for many thousands of years unless treated repeatedly with high doses of liming agents over many years.**
- **Jarosite in some of these soils persists for thousands if not millions of years to document that they once experienced acid sulfate weathering -- sulfuricization**.

Acid Sulfate Soil Phenomena have taken place throughout much of geologic time

- The bacteria that form sulfides have apparently been around for a billion or more years.
- Many natural upland soils have experienced active acid sulfate weathering early in their genesis.
- The next two slides display such a soil.

Post-active acid sulfate soil (Udeptic Hapludult) on steep slope in glauconitic sediments in Anne Arundel County, MD, USA. Depth increments on tape are decimeters (10cm increments)

Lower portion of post-active acid sulfate soil in glauconitic sediments, Anne Arundel County, MD, USA, showing jarosite and iron (hydr)oxide concentrations (mottles), presumed formed by sulfuricization many millenia before present.



Acid Sulfate Soils remain a problem

- **The problems are particularly severe where humans set off (usually unknowingly?) a new cycle of active sulfuricization.**
- **The problems are mainly avoidable if engineers and others, who are involved in the disturbance of the surface of the earth, learn and wisely apply acid sulfate soil and weathering principles.**

Suggested things that TCCSWCD should do to positively contribute to the solution of acid sulfate soils problems in its geographic district and beyond.

1. Invite USDA NRCS or other appropriately trained soil scientists to map the soils of lands in the SWCD disturbed by construction activities, using appropriate *Soil Taxonomy* classes (e.g. great groups of *Sulfaquepts* or *Sulfudepts*) to identify acid sulfate soils and other soils that occur on these lands. Work with soil scientists to develop soil survey interpretations for the management and reclamation of these soils and make this information available to land owners and others (e.g. soil conservationists, cooperative extension service workers etc.), who advise others pertaining to these matters.

2. Insist on and help to develop county/city ordinances to prevent the disturbance of *sulfidic materials* that occur in the un-oxidized zone of the soil-geologic column of the lands of the district by public (e.g. highway and airport etc.) and private (e.g. housing developments and shopping centers etc.) construction activities and help to improve regulations/ordinances of the jurisdictions that already have such ordinances, City of Fredericksburg and Spotsylvania County from what I understand. Where *sulfidic materials* must be disturbed by construction activities, insist that they be identified and kept separate from non-acid-forming materials during the construction and that they be buried and packed and covered with an appropriate thickness of non-acid forming materials when they are put back into the land where (ideally) they will not oxidize more rapidly than they were where they existed in the natural unoxidized zone under natural conditions prior to the construction.

3. Organize and promote education programs for those who engage in and/or are affected by construction or other soil disturbance activities with the goal of preventing the formation of active acid sulfate soils and reclaiming and improving those soils and lands where active acid sulfate soils already exist. Concerned soil scientists of UM, VT, MAPSS, AND VAPSS want to help you do this.