Non-Forensic Databases for Interpretation of Forensic Soils

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Some of these databases listed in this presentation have be used by the FBI Laboratory in aid of investigations, but most have not. Reference to databases here does not represent endorsement by the FBI or DOJ.

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July 20, 2016

Outline

- Background
  - Purposes of forensic soil examinations
  - Methods used in soil examinations
- Databases of mineral occurrence and soil properties
  - Surficial and bedrock geology
  - USGS Geochemical and Mineralogical Maps for Soils of the Conterminous United States
  - USDA soil databases
- Examples of databases applied to recent cases

Goals of forensic soil/geology exams

- Is this debris soil?
- Is the soil at this (crime scene/alibi) location a possible source of soil on the item (shoe, vehicle, garment shovel….)?
- Can specific locations be eliminated or identified as possible sources of the soil?
- What are the characteristics of the source location based on characteristics of soil components

Methods for forensic soil characterization

Types of Methods

- Vary depending on sample size, condition and the case circumstance
- Non- or minimally-destructive
- Particle-based observations usually more informative

Typical Methods

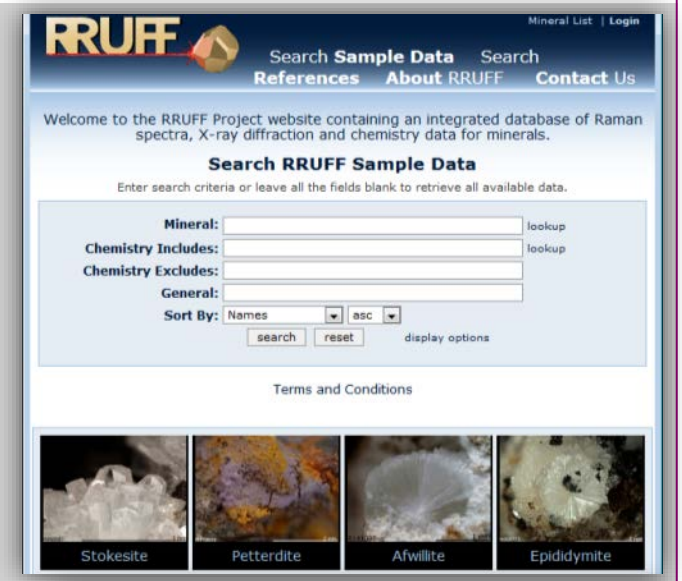
- Reflected light microscopy
  - # of soil sources in sample
  - Aggregate size shape
  - Grain coatings
- Polarized light microscopy
  - Mineral / Lithic fragment ID
  - Grain size/shape/inclusions/surface texture
- Color
- Powder XRD
  - Mineral ID (particularly for clay-sized particles)
- SEM
  - Surface texture, mineral ID

Specialized Methods

- Mineral Chemical characterization
- Raman Spectroscopy
- pH
- Microfossil ID
- Geochronology

Excellent availability databases for mineral ID

- PLM properties in books/web/apps
  http://www.mindat.org/
- MSA
  http://www.handbookofmineralogy.org/Index.html
- RRUFF - Mineral Raman Spectra + XRD patterns
  http://rruff.info/
- Mineral Optical/IR spectral
  http://minerals.gps.caltech.edu/FILES/Index.html
- Power XRD patterns from ICDD (not free)
  http://www.icdd.com/
- Clay characterization
  http://clays.org/SOURCE%20CLAYS/SCreferences.html



Need for databases of occurrence and soil properties

- Minerals
  - Details of Crystal Chemistry (will always be incomplete)

    http://georoc.mpch-mainz.gwdg.de/georoc/
  - Rarity of Minerals / Known localities (will always be incomplete)
  - Occurrence of surface features ✓
  - Known environmental associations ✓
- Soil properties
  - Texture ✓
  - Color ✓ (with some work)
  - Grain shape and surface texture ✓
  - pH ✓
  - Grain coatings

Glaucophane $Na_2[(Mg, Fe^{2+})_3Al_2]Si_8O_{22}(OH)_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As prismatic crystals; columnar, fibrous, or granular aggregates; massive. *Twinning*: Simple or multiple twinning ‖ {100}.

Physical Properties: *Cleavage*: Perfect on {110}, intersecting at ~56° and ~124°; partings on {010}, {001}. *Fracture*: Conchoidal to uneven. *Tenacity*: Brittle. Hardness = 6 D(meas.) = 3.08–3.22 D(calc.) = 3.132

Optical Properties: Translucent. *Color*: Gray, lavender-blue, commonly zoned; lavender-blue to colorless in thin section. *Streak*: Blue-gray. *Luster*: Vitreous to pearly. *Optical Class*: Biaxial (–). *Pleochroism*: Vivid; *X* = yellow to colorless; *Y* = violet to lavender; *Z* = blue. *Orientation*: *Y* = *b*; *Z* ∧ *c* = −7° to −6°, *X* ∧ a ≃ 8°. *Dispersion*: *r* < *v*, weak. $\alpha = 1.594–1.630$ $\beta = 1.612–1.648$ $\gamma = 1.619–1.652$ 2V(meas.) = 0°–50°

Cell Data: *Space Group*: *C*2/*m*. $a = 9.595$ $b = 17.798$ $c = 5.307$ $\beta = 103.66°$ $Z = 2$

X-ray Powder Pattern: Sebastopol quadrangle, California, USA. (ICDD 20–453). 8.26 (100), 3.06 (65), 2.693 (60), 4.45 (25), 3.38 (25), 2.937 (25), 2.523 (25)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	58.04	56.28	FeO	6.12	10.34	K_2O	0.02	0.11
TiO_2	0.66	0.17	MnO	0.07	0.25	F	0.02	
Al_2O_3	10.31	12.16	MgO	11.71	8.41	Cl	0.01	
Fe_2O_3	2.89	1.72	CaO	1.37	0.62	H_2O^+	1.98	
Cr_2O_3		0.11	Na_2O	6.97	7.04	H_2O^-	0.00	
						Total	100.17	97.21

(1) Tiburon Peninsula, California, USA; corresponds to $(Na_{1.96}Ca_{0.04})_{\Sigma=2.00}(Mg_{2.39}Al_{1.82}Fe^{2+}_{0.61}Fe^{3+}_{0.18})_{\Sigma=5.00}Si_8O_{22}(OH)_2$. (2) Kodiak Islands, Alaska, USA; by electron microprobe, Fe^{2+}:Fe^{3+} calculated; corresponds to $(Na_{1.90}Ca_{0.09}K_{0.02})_{\Sigma=2.01}(Al_{1.82}Mg_{1.74}Fe^{2+}_{1.20}Fe^{3+}_{0.18}Mn_{0.03}Ti_{0.02}Cr_{0.01})_{\Sigma=5.00}(Si_{7.83}Al_{0.17})_{\Sigma=8.00}O_{22}(OH)_2$.

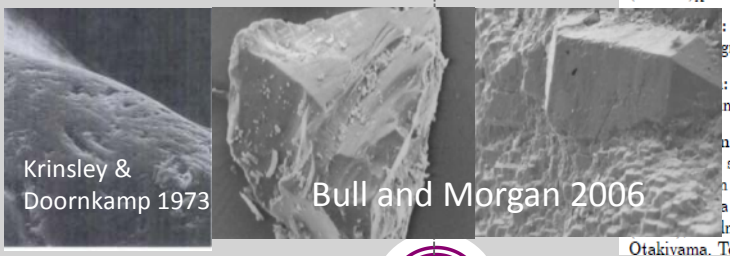
Polymorphism & Series: Forms a series with ferroglaucophane.

Mineral Group: Amphibole (alkali) group: $Fe^{2+}/(Fe^{2+} + Mg) < 0.5$; $Fe^{3+}/(Fe^{3+} + Al^{vi}) < 0.3$; $(Na + K)_A < 0.5$; $Na_B \geq 1.34$.

: Characteristic of the blueschist facies, in former subduction zones in mountain greenschist facies and in eclogites that have undergone retrograde metamorphism.

: Crossite, chlorite, epidote, pumpellyite, lawsonite, omphacite, jadeite, actinolite, mmingtonite, aragonite.

n: Widespread in some mountain belts. On Syra Island, Cyclades Islands, Greece. sites in the California Coast Ranges, as on the Tiburon Peninsula and at Vonsen n Co., at Glaucophane Ridge, Panoche Valley, San Benito Co., and near Valley a Co.; in the Kodiak Islands, Alaska, USA. At St. Marcel, Val d'Aosta, and Piollore lmont, Italy. On Anglesey, Wales. In Japan, at Ubuzan, Aichi Prefecture, and Otakiyama, Tokushima Prefecture.



Re-appropriating existing databases: Geology

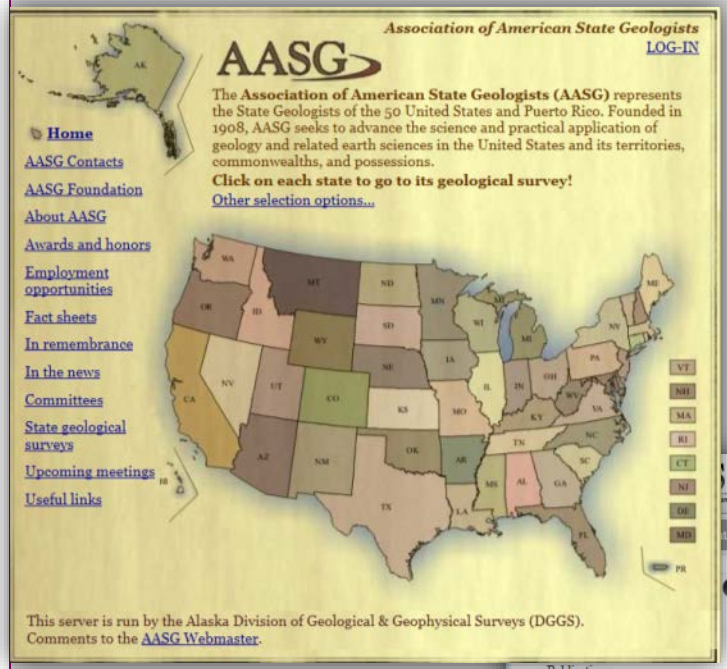
USGS Geologic Map Database

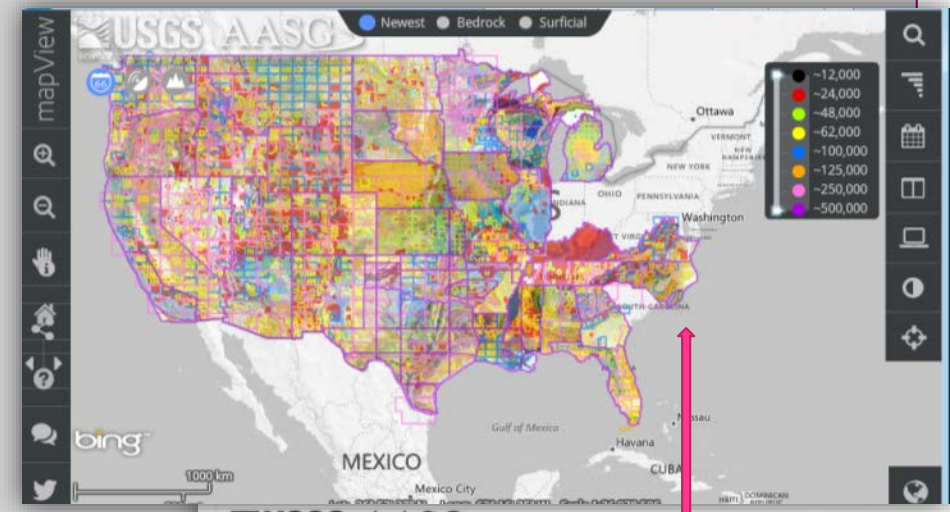
http://ngmdb.usgs.gov/ngmdb/ngmdb_home.html

Association of American State Geologists (AASG)

http://www.stategeologists.org/

Some states do not include maps in the USGS database.

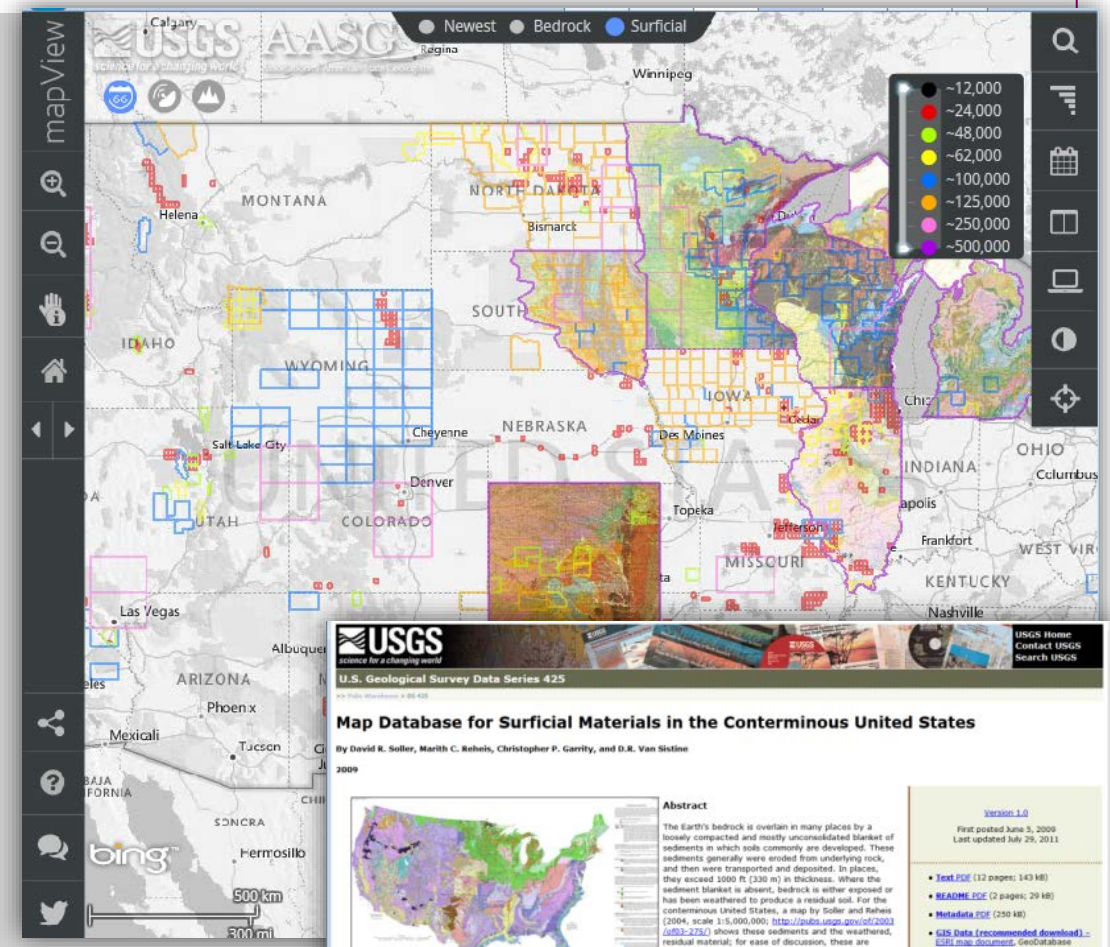




Surficial Geology / Quaternary Geology

- Surficial Materials of Conterminous U.S.
  (USGS DS-425) 1:5,000,000
- Maps from 1:12,000 to 1:500,000 from AASG and NGMDB

- Useful for:
  - Grain size distribution
  - Particle shape
  - Grain surface texture
  - (Mineral assemblage)



Bedrock Geology

- Useful where bedrock is exposed / weathered in place / minimally transported.
  - Useful for mineral content of soil
- Availability / quality of maps for forensic use is heterogeneous
  - maps are both scanned images and GIS data

EXAMPLE

Title: Geology of the Billows quadrangle, Kentucky [A digital rendition of this product is available]

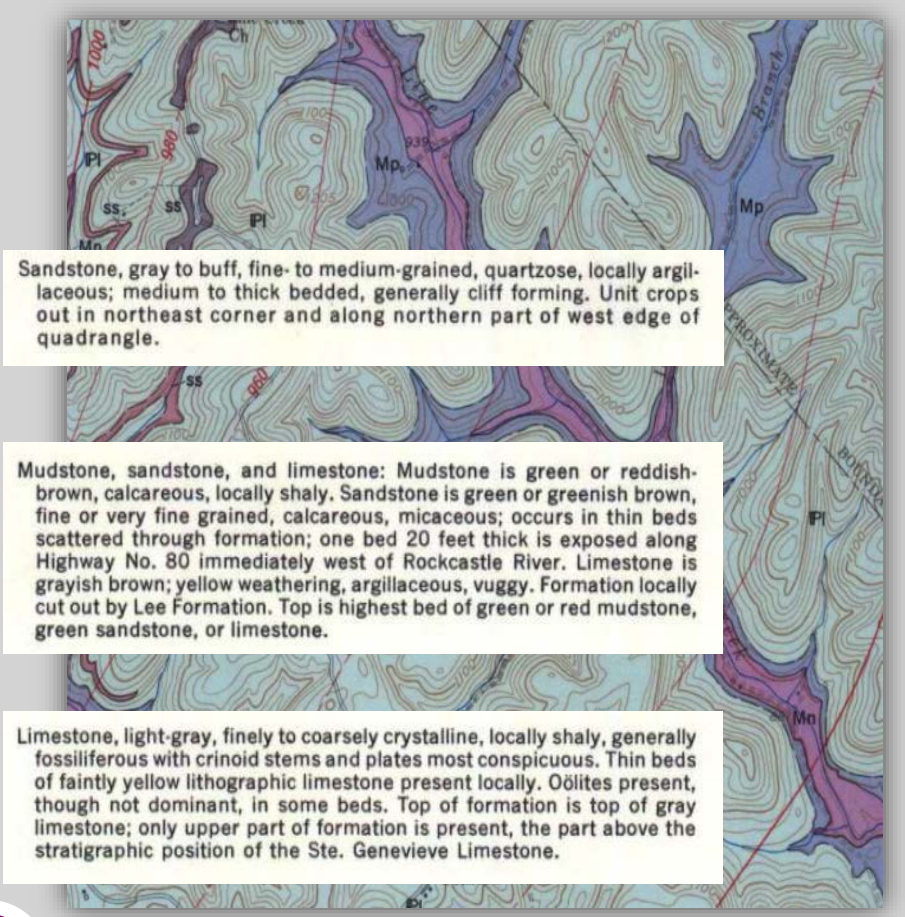
Author(s): Hatch, N.L.

Publishing Organization: U.S. Geological Survey

Series and Number: Geologic Quadrangle Map GQ-228

Publication Date: 1963

1:24,000 Bedrock Geology with detailed lithology description.



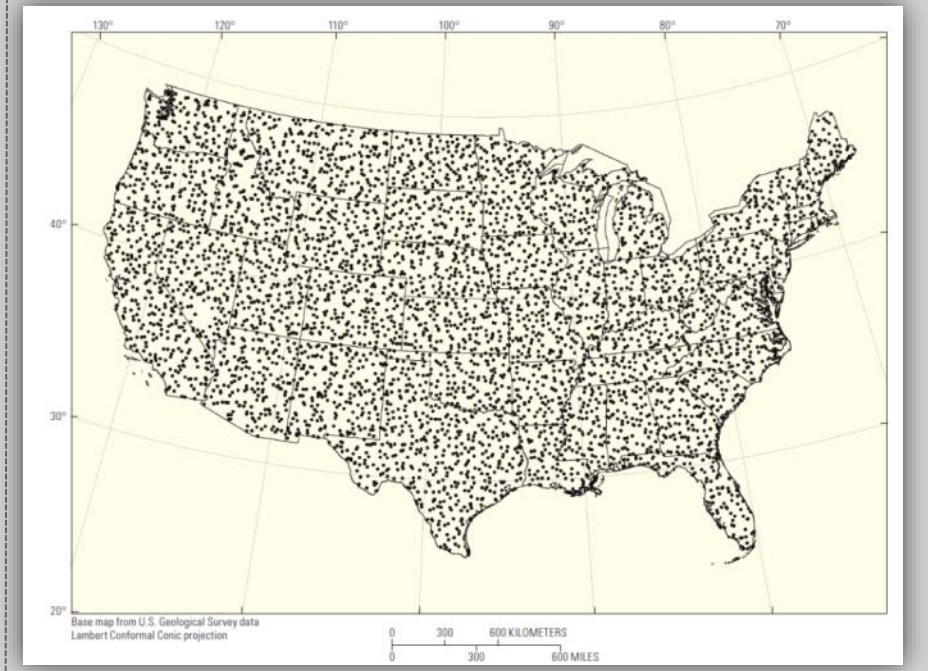
USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

- Soil Data Series 801/Open-File Report 2014–1082

http://pubs.usgs.gov/ds/801/

http://pubs.usgs.gov/of/2014/1082/

- 4,857 sites – Sieved to <2 mm
  - Surface (0-5 cm)
  - A-Horizon (composite)
  - C-Horizon (or >80 cm
- Quantitative powder XRD for mineral characterization (A,C)
- Elemental analysis 45 elements (+orgC/inorgC) (surface, A, C)
- Interpolation maps by Inverse Distance Weighting (IDW)
- 1 site per 1,600 km^2



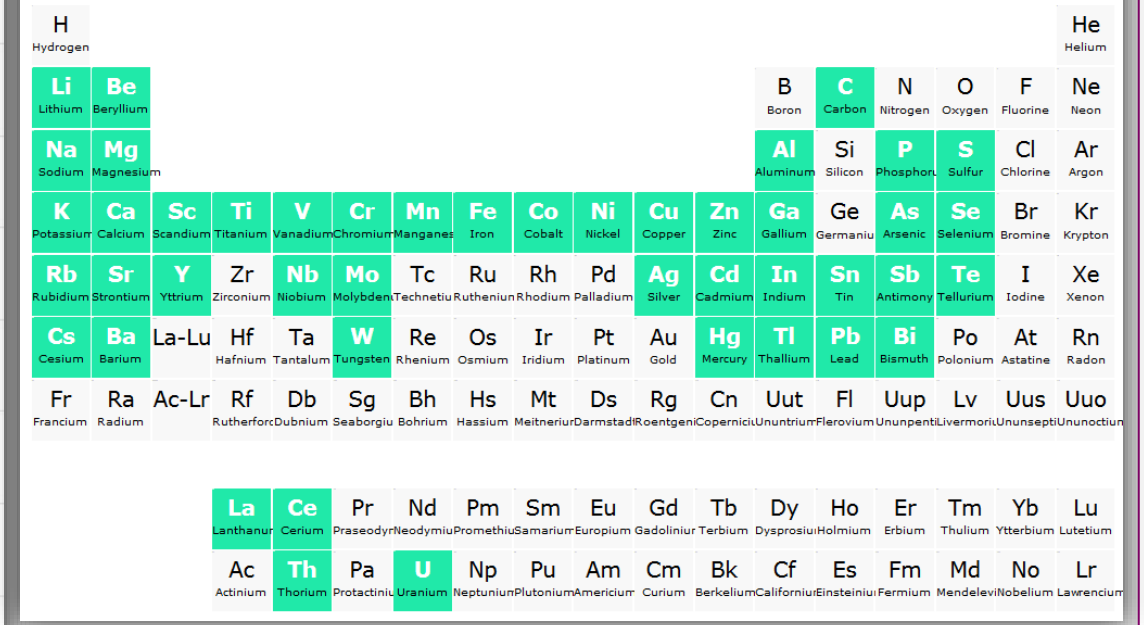
Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L., 2013, Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801, 19 p., http://pubs.usgs.gov/ds/801/.

USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

MINERALOGY

- Quartz
- Total Feldspars
  - Potassium feldspar
  - Plagioclase
- Total Clays
  - Total 10Å clays
  - Total 14Å clays
  - Kaolinite
- Total Carbonates
  - Calcite
  - Dolomite
  - Aragonite
- Total Zeolites
  - Heulandite
  - Analcime
- Hornblende
- Pyroxene
- Gibbsite
- Goethite
- Gypsum
- Hematite
- Pyrite
- Talc
- Serpentine
- Amorphous

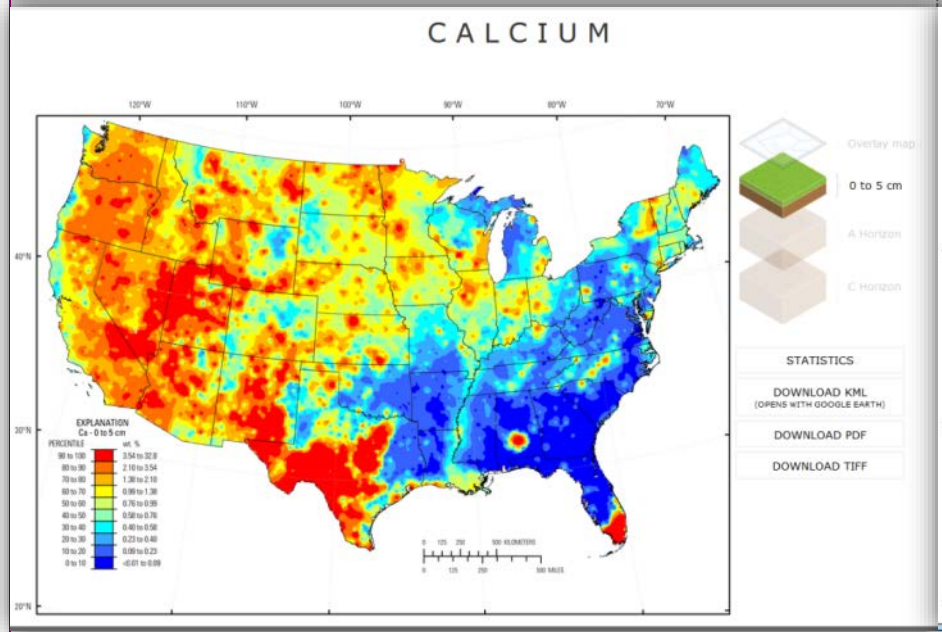
GEOCHEMISTRY

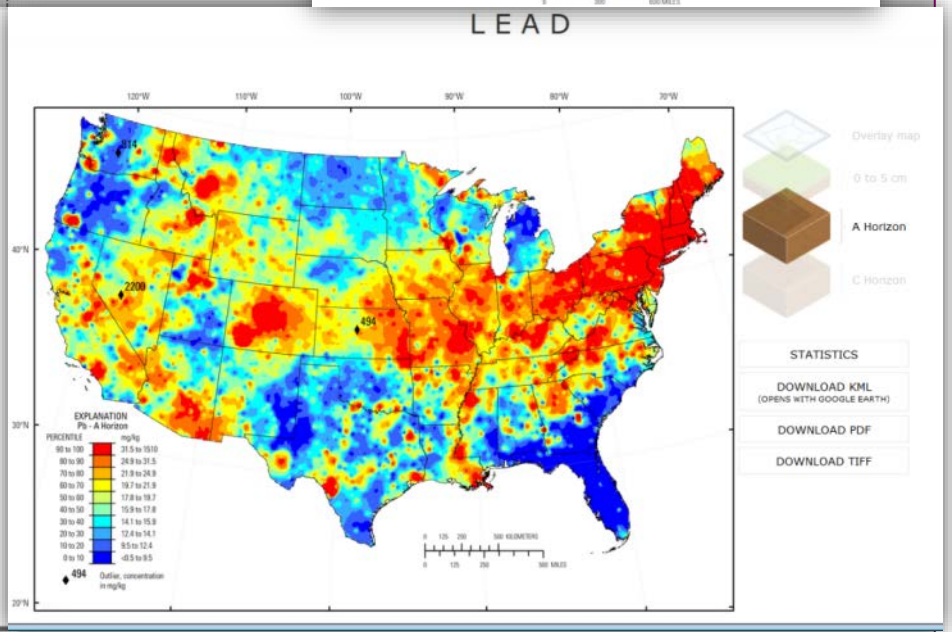


From USGS Open-File Report 2014–1082

USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

- Available both as tabular/point data and interpolated maps

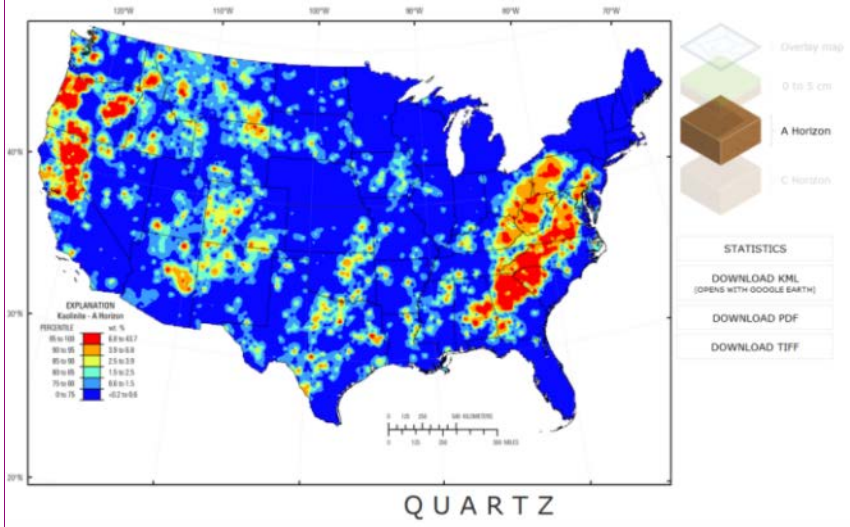




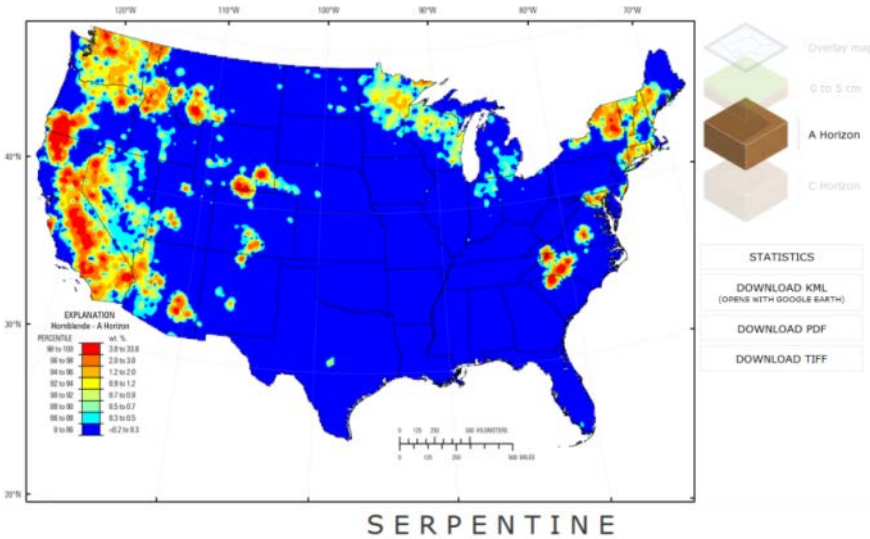
From USGS Open-File Report 2014–1082

USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

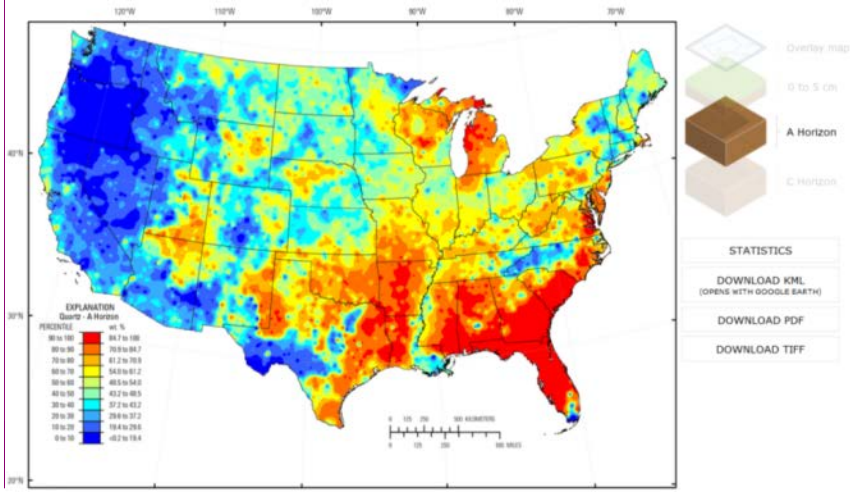
KAOLINITE



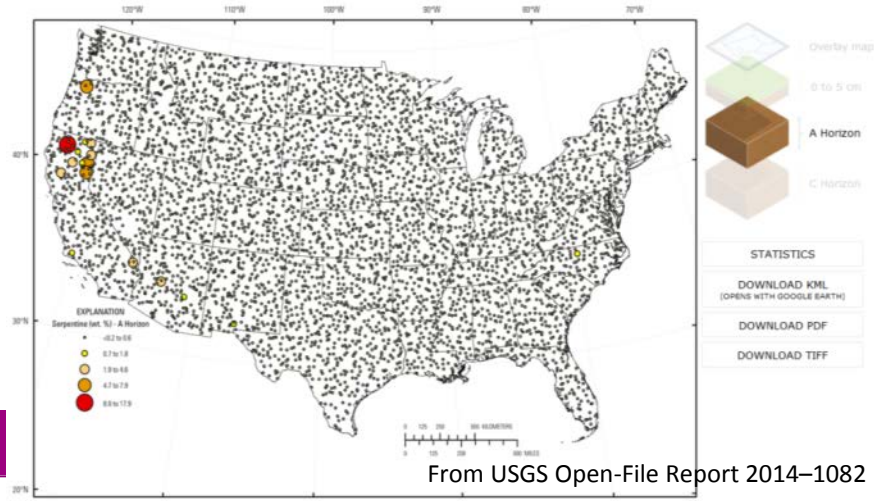
HORNBLENDE



QUARTZ



SERPENTINE

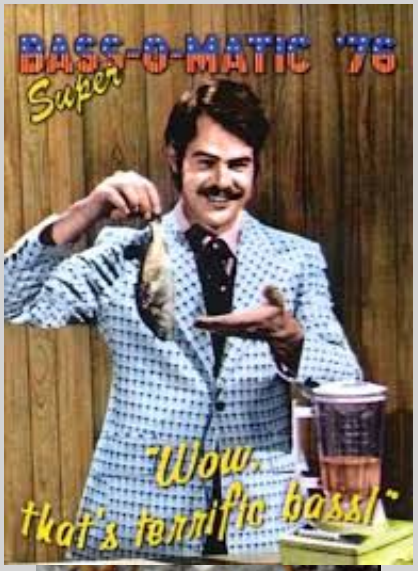


From USGS Open-File Report 2014–1082

USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

- Geochemical data are BULK measurements
- Soil are heterogeneous at many scales
- Forensic soils are from unknown horizons

From NBC/SNL



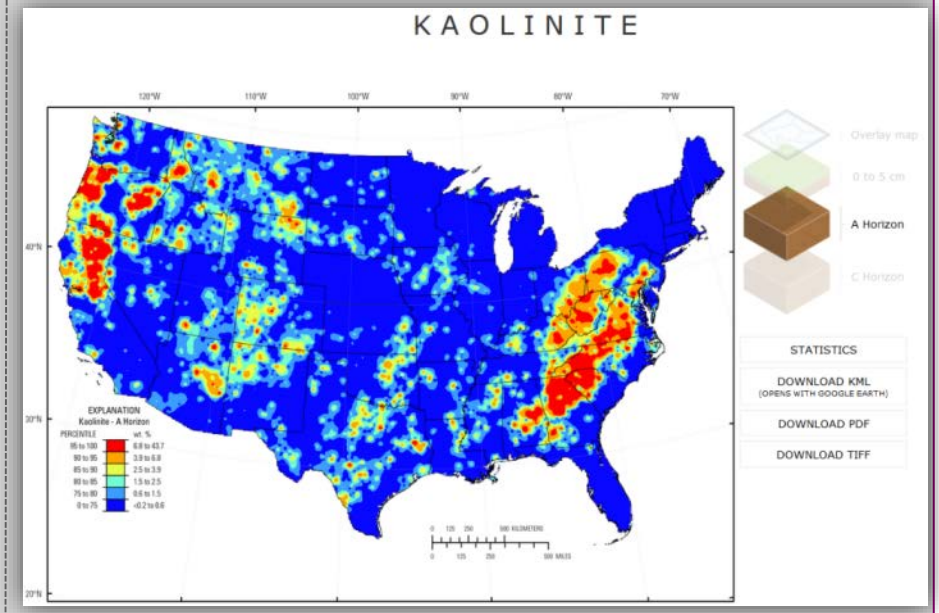
http://blogs.agu.org/terracentral/2015/05/31/uncovering-a-soil-mystery-using-micromorphology-and-petrography/

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=stelprdb1236841

Kalkaska Soil Profile
Surface layer: black sand
Subsurface layer: brown sand
Subsoil - upper: dark reddish brown sand
Subsoil - lower: strong brown and yellowish brown sand with columns of weakly cemented, dark reddish brown ortstein
Substratum: light yellowish brown sand

USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

- Clays are largely controlled by climate and landscape age which tend to be spatial continuous. (also parent material)



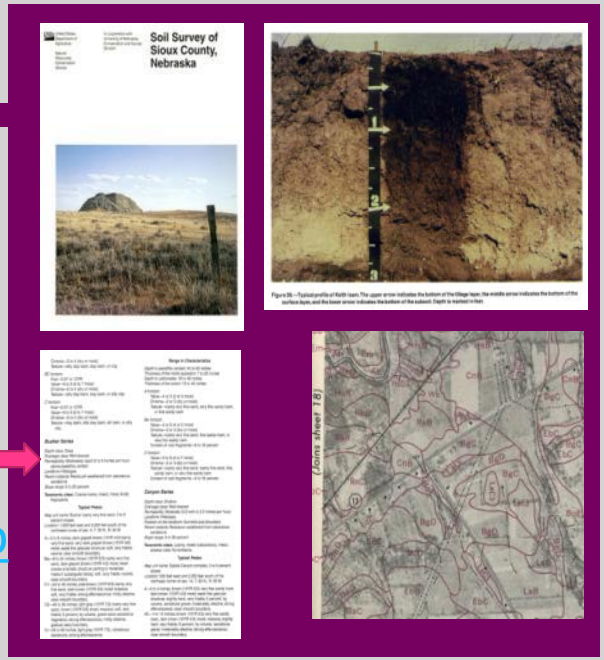
From USGS Open-File Report 2014–1082

USDA NRCS Soil Data (for forensic applications)

- Soil Surveys
  - Historical printed county soil surveys
  - Soil spatial databases
    - STATSGO coarsely mapped at 1:250,000
    - **gSSURGO** mapped at a scale of 1:12,000 to 1:63,360
- Official Soil Series Descriptions

  https://soilseries.sc.egov.usda.gov/osdnamequery.asp
- National Cooperative Soil Survey (NCSS) Soil Characterization Database:

  http://ncsslabdatamart.sc.egov.usda.gov/querypage.aspx



NCSS Soil Characterization Database
(Pedon/Field Descriptions with Laboratory Data)

Lab Report

pH & Carbonates

Layer	Depth (cm)	Horz	Prep	-1- pH KCl	-2- pH $CaCl_2$ 0.01M 1:2 4C1a2a	-3- pH H_2O 1:1 4C1a2a	-4- pH Sat Paste	-5- pH Oxid	-6- pH NaF	-7- Carbonate As $CaCO_3$ <2mm (%)	-8- Carbonate As $CaCO_3$ <20mm (%)	-9- Gypsum As $CaSO_4 \cdot 2H_2O$ <2mm (%)	-10- Gypsum As $CaSO_4 \cdot 2H_2O$ <20mm (%)	-11- Resist ohms cm^{-1} 8E1
78P00214	0-10	Ap	S		5.1	5.6								
78P00215	10-20	B	S		4.8	5.3								
78P00216	20-46	Bt1	S		4.6	5.2								
78P00217	46-72	Bt2	S		4.3	5.1								71000
78P00218	72-97	Bt3	S		4.2	5.0								
78P00219	97-132	Bt4	S		4.2	5.0								
78P00220	132-157	C	S		4.3	5.1								71000

*** Primary Characterization Data ***

Pedon ID: 77VA031001 (Campbell, Virginia) Print Date: Jun 24 2016 3:09PM

Sampled As : Cullen Clayey, kaolinitic Typic Hapludults

USDA-NRCS-NSSC-Soil Survey Laboratory ; Pedon No. 78P0028

Clay Mineralogy (<.002 mm)

Layer	Depth (cm)	Horz	Fraction	-1- X-Ray 7A2i (peak size)	-2-	-3-	-4-	-5-	-6- 7A3b (%)	-7-	-8-	-9-	-10- SiO_2 7C3 (%)	-11- Al_2O_3	-12- Fe_2O_3	-13- MgO	-14- CaO	-15- K_2O	-16- Na_2O	-17- Reth (mg g^{-1})	-18- Interpretation
78P00216	20.0-46.0	Bt1	tcly	KK 3	VR 1				KK 42	GI 1											
78P00217	46.0-72.0	Bt2	tcly	KK 4	VR 1	GE 1			KK 36	GI 1					18.6			--			
78P00219	97.0-132.0	Bt4	tcly	KK 3	VR 1				KK 40												
78P00220	132.0-157.0	C	tcly	KK 3	VR 1				KK 42												

FRACTION INTERPRETATION:
tcly - Total Clay <0.002 mm

MINERAL INTERPRETATION:
GE Goethite GI Gibbsite KK Kaolinite VR Vermiculite

RELATIVE PEAK SIZE: 5 Very Large 4 Large 3 Medium 2 Small 1 Very Small 6 No Peaks

- Forensically relevant characters:
  - pH, grain size distribution, carbonates, gypsum, salts…
  - Minerals

Locations of Sampled Pedons

Locations of Sampled Pedons with Geochemical Data

Cont. Site ID: S1977VA031001 Field Report **Pedon ID:** 77VA031001

Slope (%)	Elevation (meters)	Aspect (deg)	MAAT (C)	MSAT (C)	MWAT (C)	MAP (mm)	Frost-Free Days	Drainage Class	Slope Length (meters)	Upslope Length (meters)
3.0								well		

1Ap--0 to 10 centimeters (0.0 to 3.9 inches); reddish brown (5YR 4/4) interior loam; moderate fine and medium platy, and structureless granular structure; friable, slightly sticky, slightly plastic; 10 percent 250 to 600-millimeter Mixed rock fragments; strongly acid, pH 5.3, pH meter; clear smooth boundary. Lab sample # 78P00214

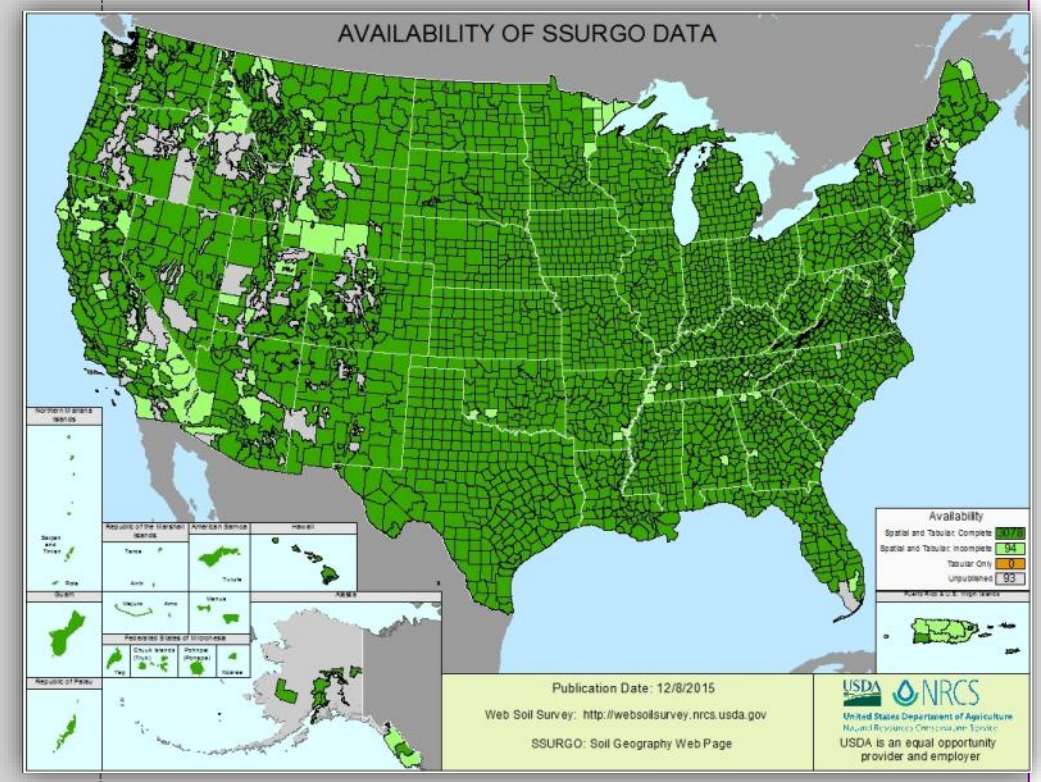
1B1t--10 to 20 centimeters (3.9 to 7.9 inches); reddish brown (2.5YR 4/4) interior clay loam; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; strongly acid, pH 5.3, pH meter; clear smooth boundary. Lab sample # 78P00215. Somewhat porus matrix dominated by min grains rep. all sand sizes. Some light brown rims on ped faces. Sm quan. of oriented clay mostly authigenic. A few black fine sand size aggregates

1B21t--20 to 46 centimeters (7.9 to 18.1 inches); dark red (2.5YR 3/6) interior clay loam; moderate fine and medium subangular blocky structure; friable, slightly sticky, moderately plastic; strongly acid, pH 5.3, pH meter; clear wavy boundary. Lab sample # 78P00216. Dense clay matrix flecked with imbedded sand grains. Oriented clay mainly authigenic some pressure oriented

Parameters characterized vary from site-to-site

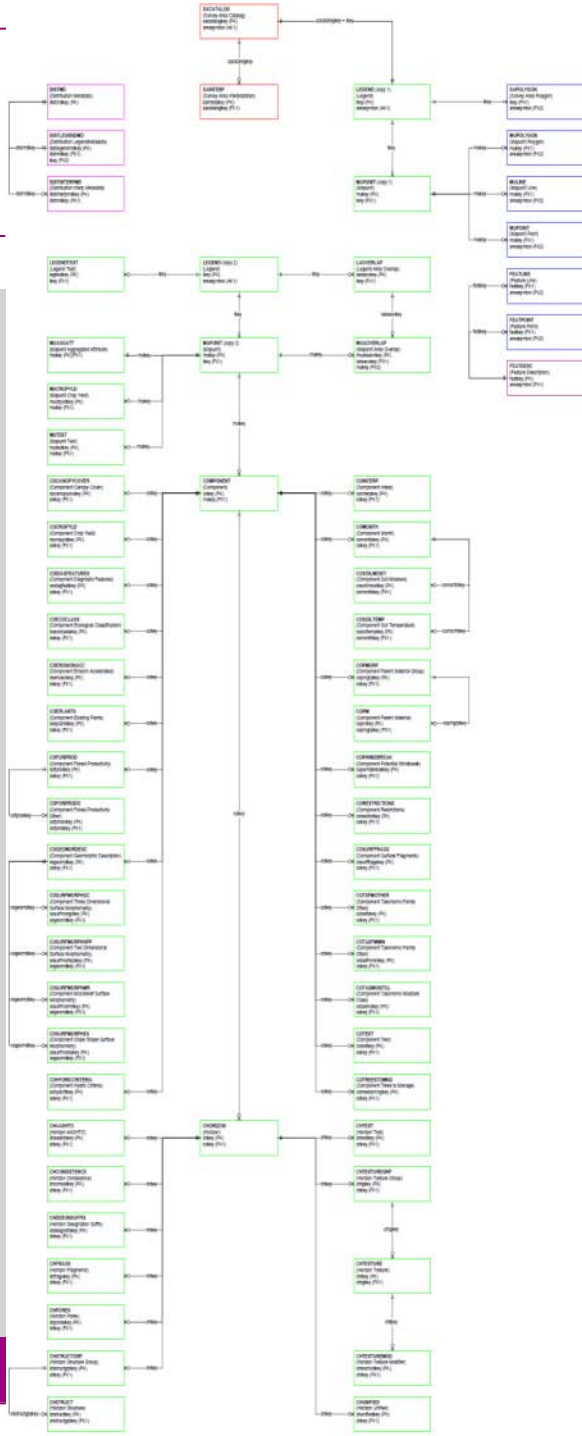
USDA NRCS Soil Databases

- Soil Survey Databases
  - STATSGO 1:250,000
  - SSURGO 1:12,000 to 1:63,360
  - gSSURGO (SSURGO as 10 m grid)
- Similar Data Structure

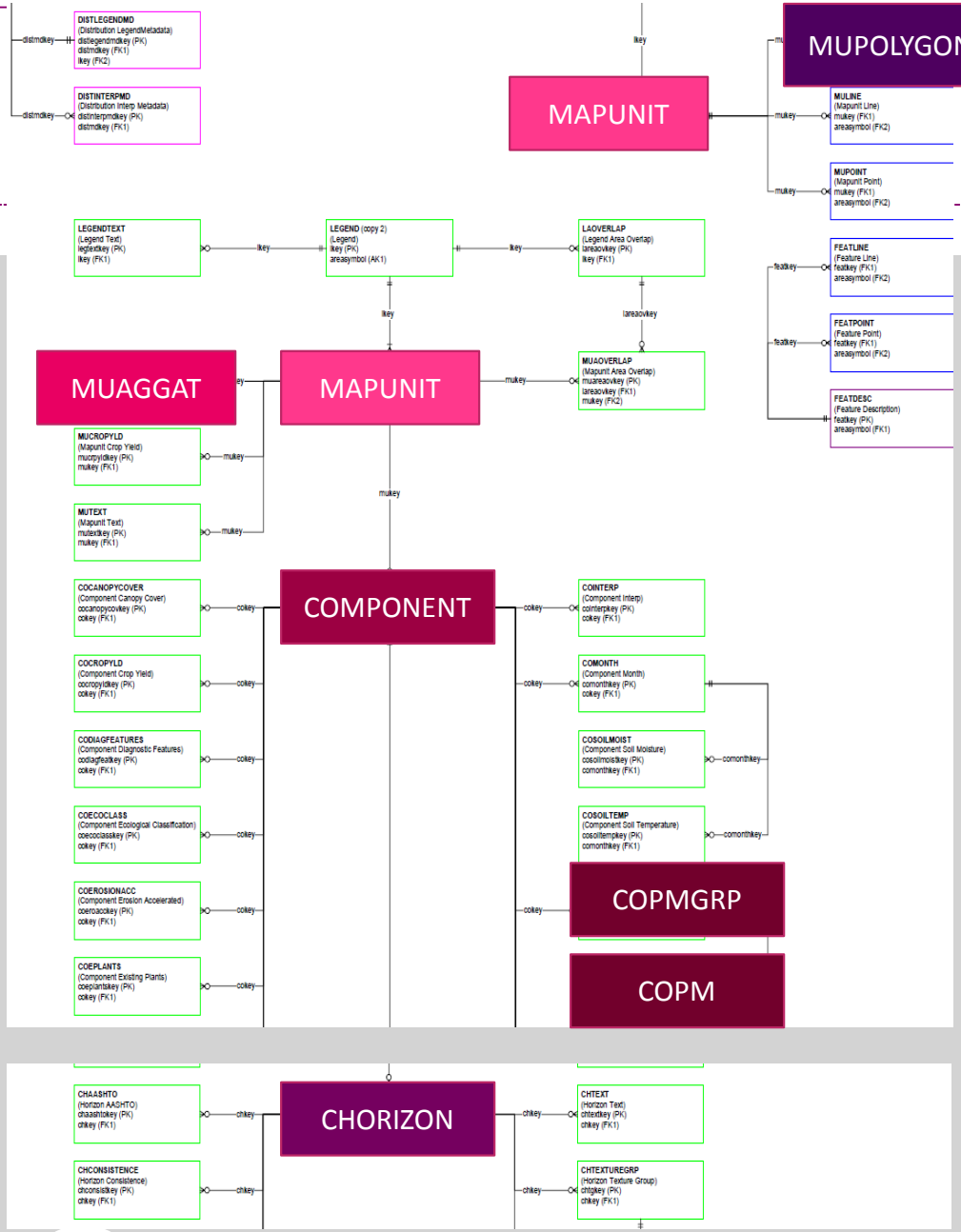


STATSGO/SSURGO Database Structure

- Soil Survey Databases
  - STATSGO 1:250,000
  - SSURGO 1:12,000 to 1:63,360
- >60 tables in gSSURGO
- Each table has 3 to 171 fields



STATSGO/gSSURGO Database Structure



STATSGO/gSSURGO Database Structure with some forensically relevant fields listed

MUAGGAT
Brockdepmin= Bedrock depth minimum
Slopegraddcp
Slopegradwta= Slope dominant / weighted avg.

MAPUNIT

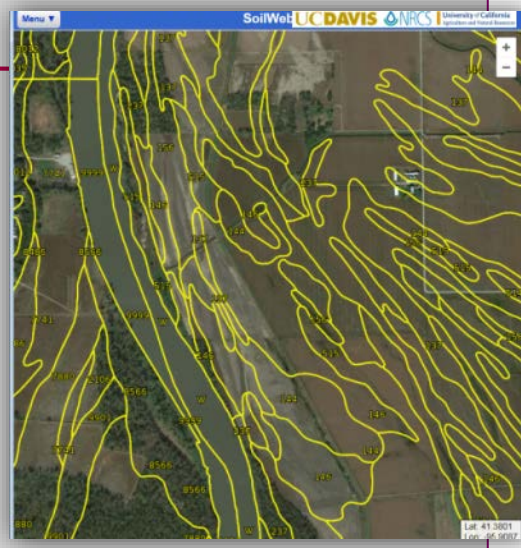
MUPOLYGON

COMPONENT

COPMGRP
Pmgroupname = Kind of deposit and/or Bedrock

CHORIZON
Hzdept_r = Horizon depth top
Hzdepb_r = Horizon depth bottom
Sandtotal_r, Silttotal_r, claytotal_r = % Sand Silt Clay
CaCO3_r = % $CaCO_3$
Gypsum_r = % Gypsum$CaCO_3$
pH1to1H2O_r = pH 1:1 soil:water
sar_r = sodium in soil water

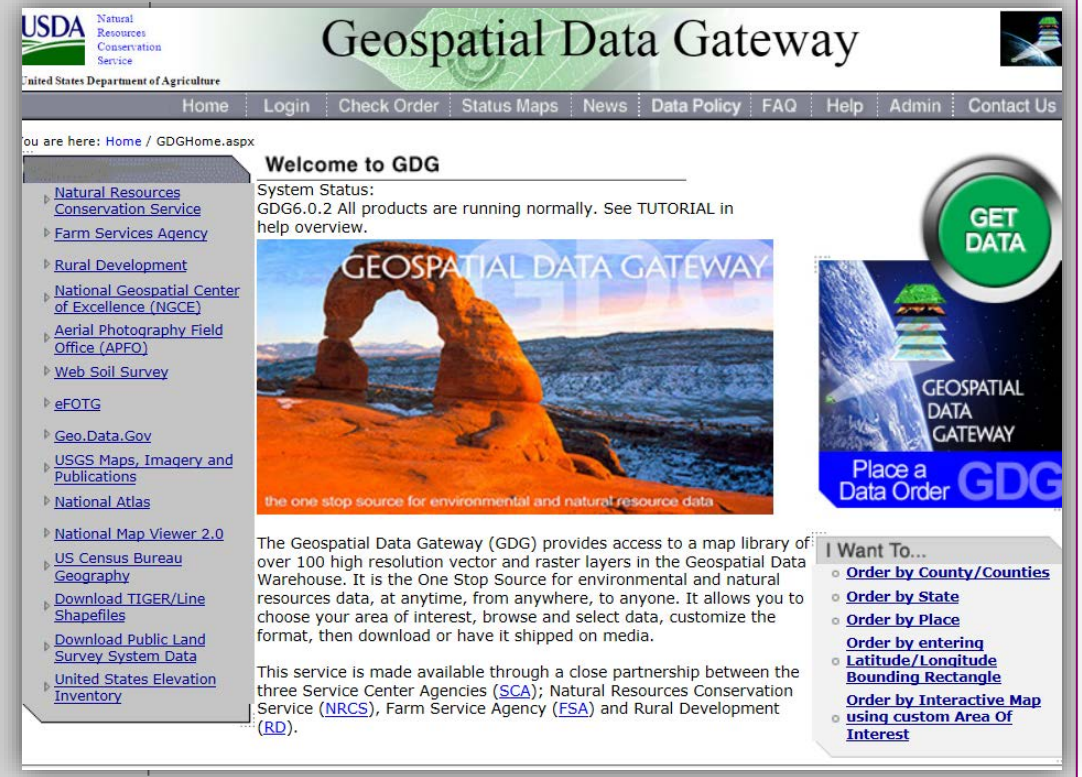
COPM
PmKind = Kind of deposit
PmOrigin = Bedrock



_r = representative value

Three ways access USDA soil survey data

- **Geospatial Data Gateway**
  https://gdg.sc.egov.usda.gov
  - Download geodatabase county-, AOI-, state-level (gSSURGO)
  - Best for use in GIS software
- Web Soil Survey
- Soil Web



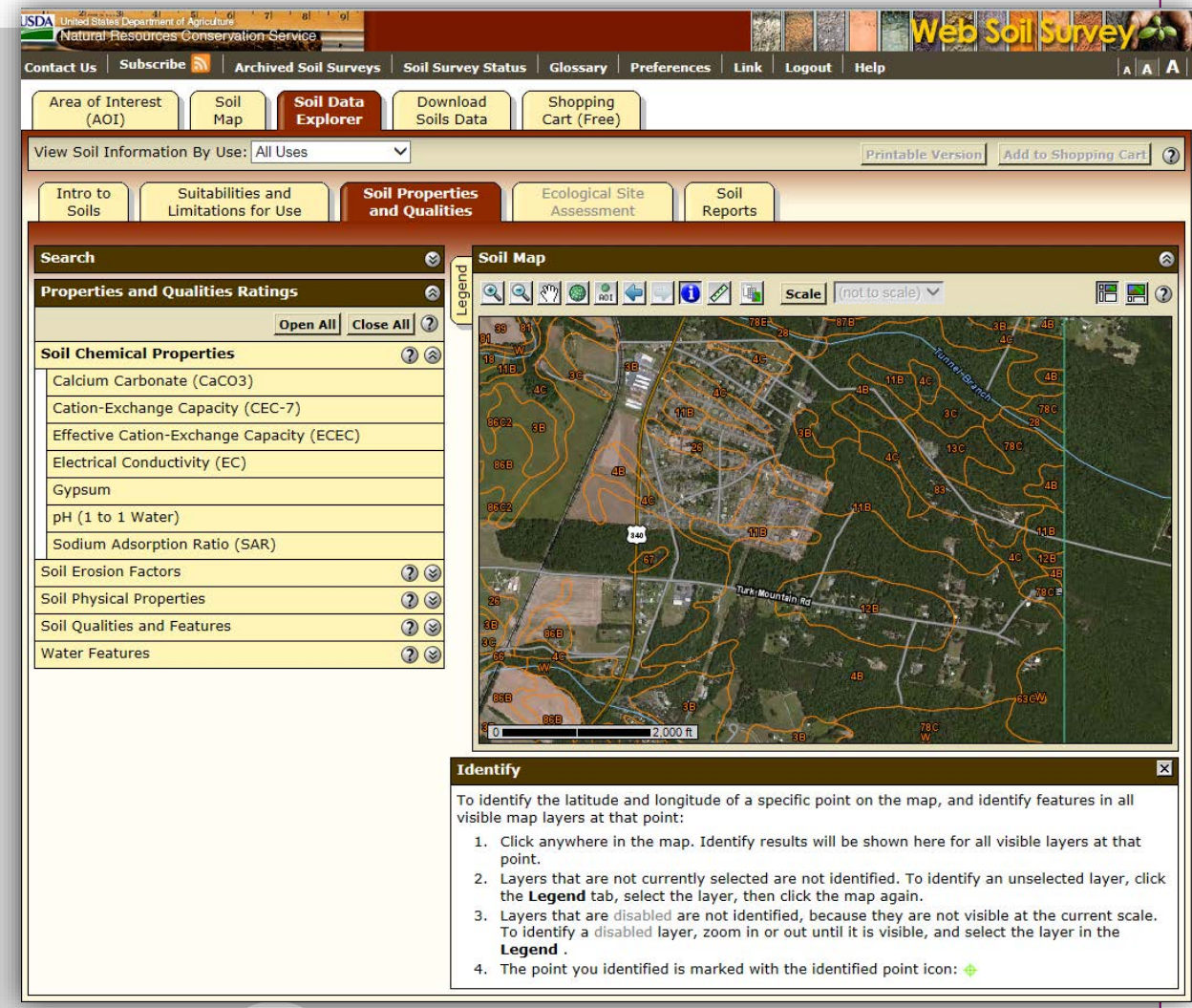
Three ways access USDA soil survey data

- Geospatial Data Gateway
- **Web Soil Survey**

http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

  - specific parameters at specific locations

- Soil Web

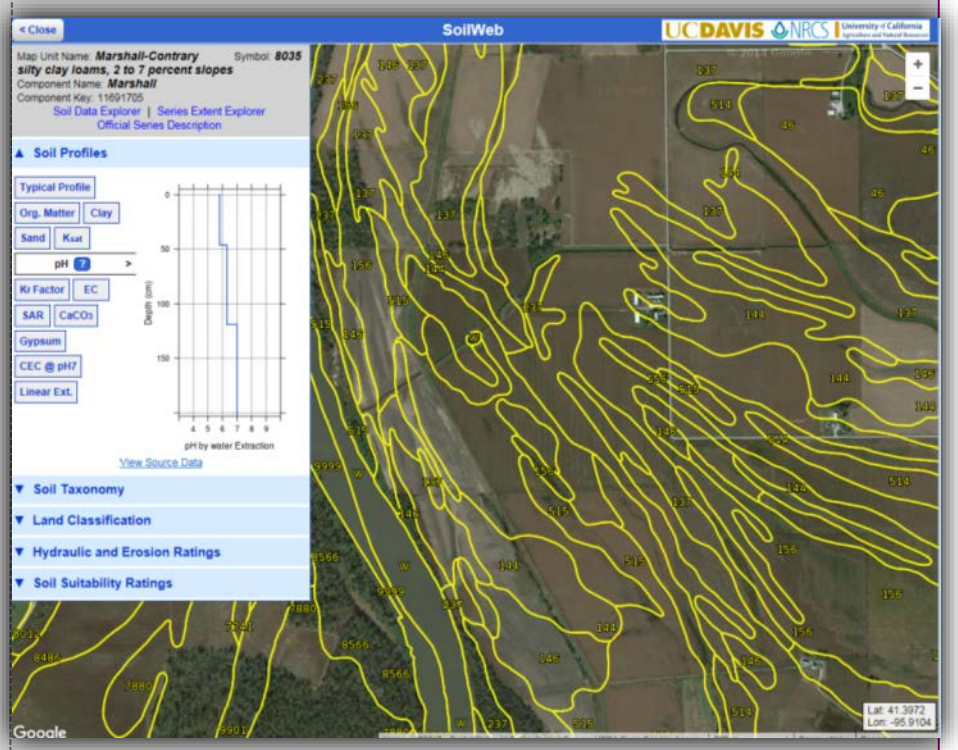


Three ways access USDA soil survey data

- Geospatial Data Gateway
- Web Soil Survey
- **SoilWeb**

http://casoilresource.lawr.ucdavis.edu/gmap/

  - Specific parameters at specific locations
  - Displays variations with depth
  - VERY easy to use



What is this USDA soil survey data?

- Map of “Map units”
- 1 or more “Components” comprise a map unit
- Components correspond (usually) to “Official Soil Series” https://soilseries.sc.egov.usda.gov/osdname.aspx

- Component A - 90% -- O.S.D.
- Component B - 5%
- Component C -5 %

O.S.D.

- Describes the "typical" and range of properties of this soil series.
- Ranges of properties
  - Color
  - Texture
  - +/- minerals
  - Parent material
- Competing and associated soils

and around rock fragments

R layer
Cementation: Strongly cemented or indurated with weakly to moderately cemented interbeds
Identifiable calcium carbonates: kind-cemented primary and secondary calcium carbonates, location-in fractures and on rock fragments

COMPETING SERIES: There are no competing series currently in the same family. Similar soils are Aledo (TX), Altuda (TX), Eckrant (TX), Ector (TX), Oplin (TX), Prade (TX), and Purves (TX).
Aledo, Altuda, Ector and Oplin soils: Have less than 35 percent clay in the fine-earth fraction and have carbonatic mineralogy.
Eckrant soils: Do not have a calcic horizon.
Prade soils: Have a petrocalcic horizon.
Purves soils: Have less than 35 percent coarse fragments in the control section.

GEOGRAPHIC SETTING:
Parent material: Residuum derived from limestone of Lower Cretaceous age, including interbedded chalk and marl.
Landscape: Dissected plateaus
Landform: Summits, shoulders, and backslopes of ridges
Slope: 1 to 50 percent, but is commonly 1 to 8 percent
Climate: Dry subhumid
Soil moisture: Typic ustic soil moisture regime. The soil moisture control section is dry in some or all parts for more than 90 but less than 150 cumulative days in normal years. June through August and December through February are the driest months. These soils are intermittently moist in September through November and March through May.
Precipitation Pattern: The majority of the yearly amount occurs during the fall and spring months. The winter and summer months are normally drier.
Mean annual air temperature: 17 to 21 degrees C (62 to 70 degrees F)
Mean annual precipitation: 508 to 864 mm (20 to 34 in)
Frost free period: 230 to 260 days
Elevation: 305 to 746 m (1,000 to 2,450 ft)
Thornthwaite annual P-E indices: 30 to 44

GEOGRAPHICALLY ASSOCIATED SOILS: These are Brackett (TX), Campwood (TX), Eckrant (TX), Kavett (TX), and Valera (TX) series.
Brackett soils: Occur on backslope positions.
Campwood soils: Are very deep alluvial soils on stream terraces.
Eckrant, Kavett, and Real soils: Occur on similar landform positions.

DRAINAGE AND PERMEABILITY: Well drained. Permeability is moderately slow. Runoff is negligible on 0 to 1 percent slopes, very low on 1 to 3 percent slopes, low on 3 to 5 percent slopes, medium on 5 to 12 percent slopes, high on 12 to 20 percent slopes and very high on 20 to 50 percent slopes.

USE AND VEGETATION: Mainly rangeland and wildlife habitat. The climax plant community is a tall grass savannah with motts of live oak throughout the landscape. The dominant grasses are little bluestem and sideoats grama. Other grasses include yellow Indiangrass, fall witchgrass, wildrye, green sprangletop, meadow dropseed, cane and pinhole bluestem, hairy grama, Texas wintergrass, curly mesquite and buffalograss. Woody plants include live oak, shin oak, evergreen sumac, hackberry, elbowbush, redbud, and white honeysuckle. Forbs, such as orange zexmenia, Engelmann daisy, bundleflower, snout bean, and bushsunflower, are present. With continued over grazing, the site could potentially deteriorate to a plant population sideoats grama, buffalograss, hairy grama, dropseeds, and the woody plants. If this destructive grazing practice continues, the site will deteriorate to a plant population of Ashe juniper, Texas persimmon, live oak, Texas grama, hairy tridens, curly mesquite, threeawns, prairie coneflower, and broomweed.

DISTRIBUTION AND EXTENT: West-Central Texas and Oklahoma. Central Great Plains Winter Wheat and Range Region, LRR-H: MLRA 78A-Rolling Limestone Prairie; MLRA 78B-Central Rolling Red Plains, Western Part; and MLRA 80B-Texas North-Central Prairies. Southwest Plateaus and Plains Range and Cotton Region, LLR-I: MLRA 81A-Edwards Plateau, Western Part; MLRA 81B-Edwards Plateau, Central Part; MLRA 81C-Edwards Plateau, Eastern Part. Southwestern Prairies Cotton and Forage Region, LLR-J: MLRA 85-Grand Prairie. This series is extensive with about 3,400,000 acres.

USDA Official Soil Series Descriptions + Soil Surveys

STRENGTHS (for forensics)

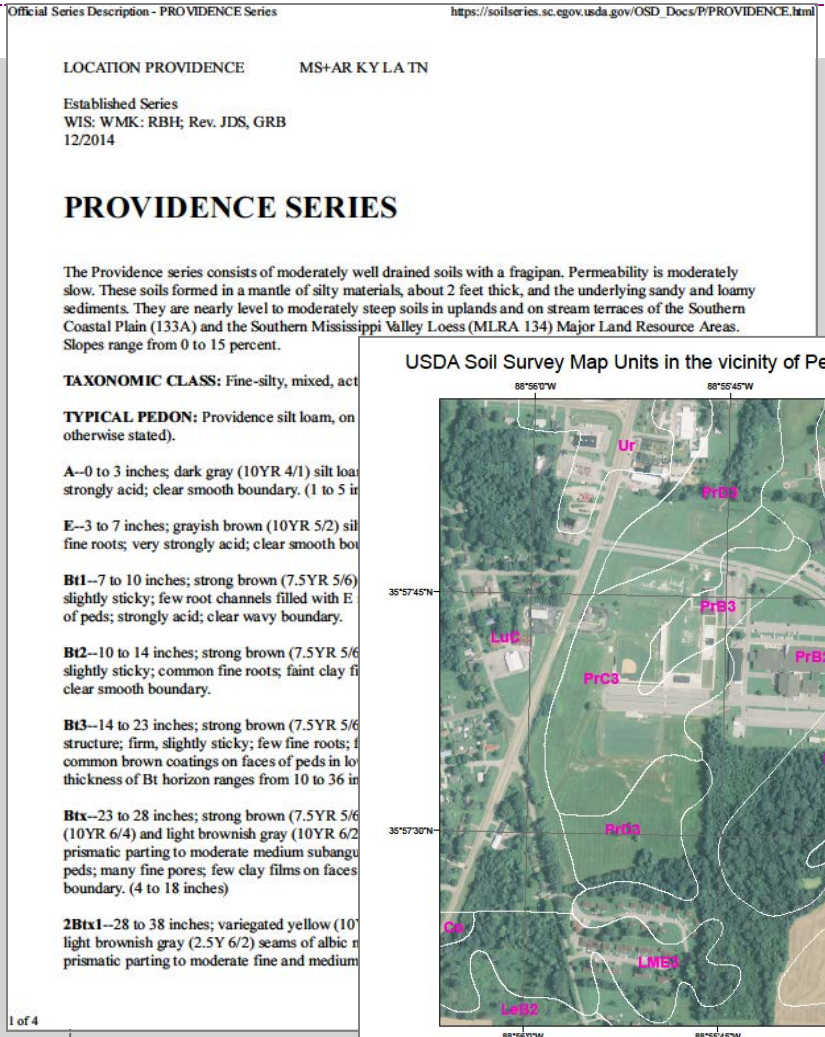
- Numerous fields of interest for forensic geology exams (ranges in color, pH, texture…+/- mineralogy)
- Spatially continuous data for nearly entire L48 states
- Mapped very finely

WEAKNESSES (for forensics)

- Continuous data give the appearance of ground truth at all locations, but these maps are interpolations / interpretations
- Color is NOT linked in the gSSURGO database

Example 1 of soil survey data augmenting reports of examination

- Baseball field torn up by vehicle
- Forensic soil comparison noted similar (and unusual) soil characteristics between crime scene and soil from suspect's vehicle
- USDA Soil survey maps and Official Soil Series Descriptions show that the natural soils of the region have colors and textures that are very distinct from the artificial soil in the baseball infield.
  - Adds to the weight of the evidence by illustrating that the natural soils in the region are very different than the soil evidence



Official Series Description - PROVIDENCE Series https://soilseries.sc.egov.usda.gov/OSD_Docs/P/PROVIDENCE.html

LOCATION PROVIDENCE MS+AR KY LA TN

Established Series
WIS: WMK: RBH; Rev. JDS, GRB
12/2014

PROVIDENCE SERIES

The Providence series consists of moderately well drained soils with a fragipan. Permeability is moderately slow. These soils formed in a mantle of silty materials, about 2 feet thick, and the underlying sandy and loamy sediments. They are nearly level to moderately steep soils in uplands and on stream terraces of the Southern Coastal Plain (133A) and the Southern Mississippi Valley Loess (MLRA 134) Major Land Resource Areas. Slopes range from 0 to 15 percent.

TAXONOMIC CLASS: Fine-silty, mixed, act

TYPICAL PEDON: Providence silt loam, on otherwise stated).

A--0 to 3 inches; dark gray (10YR 4/1) silt loa strongly acid; clear smooth boundary. (1 to 5 i

E--3 to 7 inches; grayish brown (10YR 5/2) sil fine roots; very strongly acid; clear smooth bo

Bt1--7 to 10 inches; strong brown (7.5YR 5/6) slightly sticky; few root channels filled with E of peds; strongly acid; clear wavy boundary.

Bt2--10 to 14 inches; strong brown (7.5YR 5/6 slightly sticky; common fine roots; faint clay fi clear smooth boundary.

Bt3--14 to 23 inches; strong brown (7.5YR 5/6 structure; firm, slightly sticky; few fine roots; f common brown coatings on faces of peds in lo thickness of Bt horizon ranges from 10 to 36 in

Btx--23 to 28 inches; strong brown (7.5YR 5/6 (10YR 6/4) and light brownish gray (10YR 6/2 prismatic parting to moderate medium subangu peds; many fine pores; few clay films on faces boundary. (4 to 18 inches)

2Btx1--28 to 38 inches; variegated yellow (10' light brownish gray (2.5Y 6/2) seams of albic n prismatic parting to moderate fine and medium

1 of 4

Example2 of soil survey data augmenting reports of examination

CASE SCENARIO

- Soil comparison case -
  - Could soil on evidence have been derived from crime scene?
- Only one comparison soil sample submitted
  - How spatially variable should the soil properties be along road? Is the "known" soil exemplar representative?
  - Spatial heterogeneity within ~2000 m x 200 m area

PUBLISHED DATA SUBMITTED AS SUPPORTING INFORMATION

- Bedrock Geology
- Soil Survey + O.S.D.

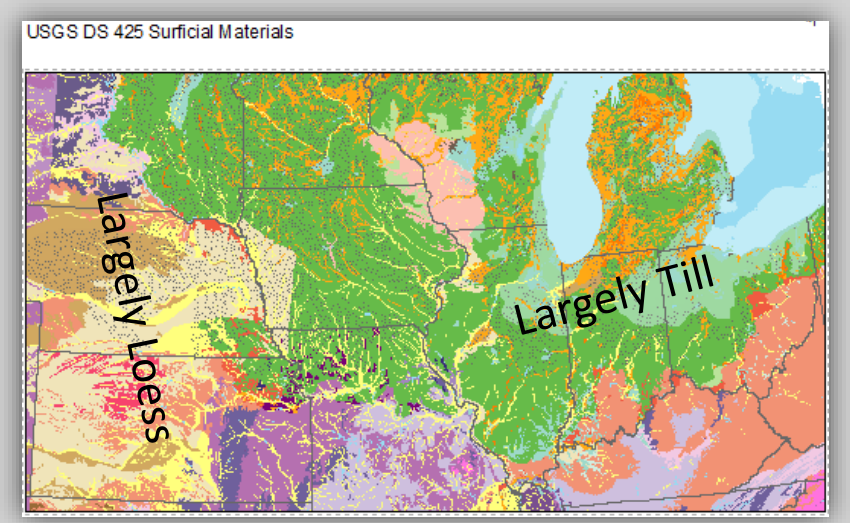
  Published soil properties in vicinity are *mapped* as similar to the "known" exemplar submitted as evidence.

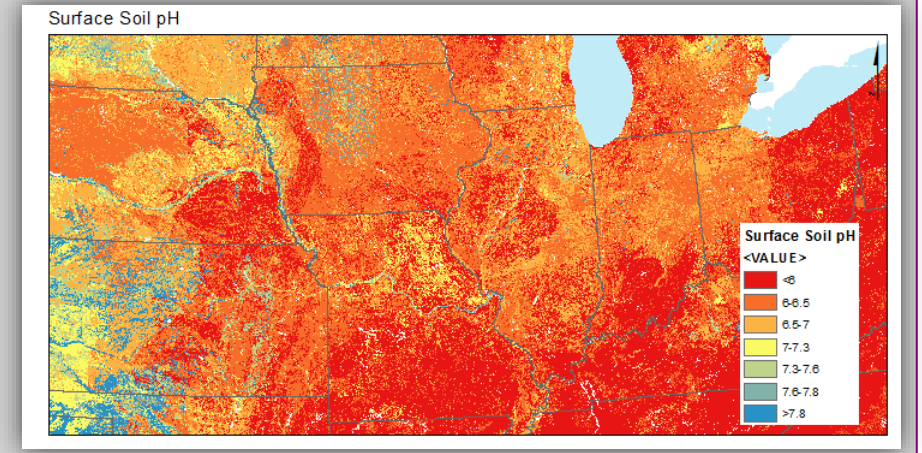
MAPPED SOIL AND GEOLOGY DATA WERE PRESENTED IN A DAUBERT HEARNING. SOIL EVIDENCE WAS JUDGED ADMISSIBLE.

Permission to release case details was not approved in advance of this presentation

Example 3 of soil survey data augmenting geographic attribution

- Two possible source regions – Upper Midwest versus upper Great Plains.
- Exact location unknown
- Distinguishing might corroborate or refute statement





Summary of use of non-forensic databases for forensic soil examinations

- No need for forensic investments in databases of how to identify minerals
- Databases of "typical" soil properties exist for most of the US.
  - Need to know how best to use USDA NRCS/NCSS data can to enhance forensic soil examinations
  - Soil databases estimate the common soil properties (pH, texture), but not the unusual minerals or features, which are most diagnostic in forensic soil comparisons
  - Soil color is only indirectly linked to databases
- Soil, surficial geology and bedrock geology maps are interpretations / interpolations.
  - Useful for putting results of forensic soil examinations in context.
  - However, they cannot predict the EXACT characteristics at all locations