



# Non-Forensic Databases for Interpretation of Forensic Soils

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*Presented at 2016 NIST Workshop on Trace Evidence Data  
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*Some of these databases listed in this presentation have been 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.*

# Outline

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- **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

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- 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

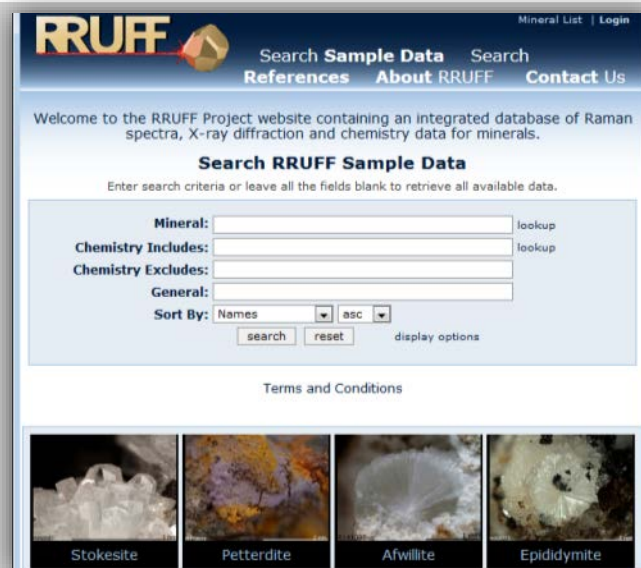
- Reflected light microscopy
  - # of soil sources in sample
  - Aggregate size shape
  - Grain coatings
- Polarized light microscopy
  - Mineral / Lithic fragment ID
  - Grain size/shape/inclusions/surface texture
- Color
- Powder XRD
  - Mineral ID (particularly for clay-sized particles)
- SEM
  -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



The screenshot shows the RRUFF Project website search interface. At the top, there is a navigation bar with the RRUFF logo and links for "Mineral List" and "Login". Below the navigation bar, there are search options for "Sample Data", "References", "About RRUFF", and "Contact Us". A welcome message states: "Welcome to the RRUFF Project website containing an integrated database of Raman spectra, X-ray diffraction and chemistry data for minerals." The main section is titled "Search RRUFF Sample Data" and includes a search form with fields for "Mineral:", "Chemistry Includes:", "Chemistry Excludes:", and "General:". There are "lookup" buttons next to the "Mineral:" and "Chemistry Includes:" fields. Below the search form, there are "search" and "reset" buttons, and a "display options" link. At the bottom of the search form, there is a "Terms and Conditions" link. Below the search form, there are four small images of minerals: Stokesite, Petterdite, Afwillite, and Epididymite.



The screenshot shows the ICDD website homepage. At the top, there is a navigation bar with the ICDD logo and links for "HOME", "About ICDD", "Products", "Membership", "Education", "Resources", "Developers", "Conferences", and "Submission". Below the navigation bar, there is a banner for "Top Selling Pharmaceuticals" with the text "Identify and quantitate more drug substances and formulations". The main content area features a large advertisement for "The Powder Diffraction File™ & Related Products" with a "SALES CATALOG 2015-2016" and a "AVAILABLE NOW" badge. To the left of the advertisement, there is a sidebar with "Most Visited Pages:" including "ICDD Product Info", "Sales Catalog", "Licensed Distributors", "Order/Quotation Form", "License Extension Procedure", "eStore", "Technical Bulletins", "Tutorials", "ICDD Events", "Calendar", "PPXRD-14", "Denver X-ray Conference", "Advances in X-ray Analysis", "Powder Diffraction Journal", "Grant-in-Aid Program", "Genie - Data Submission", "ICDD Awards", and "Freyel Scholarship Drive". To the right of the advertisement, there is a "NEWS" section with "What's New at ICDD", "PPXRD-14 Program", "2016 DXC Program", "NEW TUTORIALS UPDATE", "2015-2016 Latest Releases PDF Databases NEW FEATURES & CAPABILITIES", and "Check out our YouTube Channel Press Releases and Newsletters - sign up to get our mailing!". At the bottom right, there is an "Upcoming Events:" section.

# 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 ✓

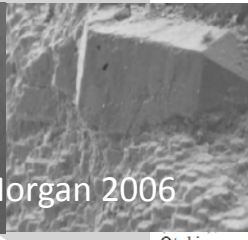
- Grain coatings



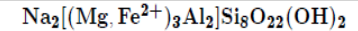
Krinsley & Doornkamp 1973



Bull and Morgan 2006



### Glaucophane



©2001 Mineral Data Publishing, version 1.2

**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. α = 1.594–1.630 β = 1.612–1.648 γ = 1.619–1.652 2V(meas.) = 0°–50°

**Cell Data:** *Space Group:* C2/m. a = 9.595 b = 17.798 c = 5.307 β = 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 <sub>2</sub>	58.04	56.28	FeO	6.12	10.34	K <sub>2</sub> O	0.02
TiO <sub>2</sub>	0.66	0.17	MnO	0.07	0.25	F	0.02
Al <sub>2</sub> O <sub>3</sub>	10.31	12.16	MgO	11.71	8.41	Cl	0.01
Fe <sub>2</sub> O <sub>3</sub>	2.89	1.72	CaO	1.37	0.62	H <sub>2</sub> O <sup>+</sup>	1.98
Cr <sub>2</sub> O <sub>3</sub>		0.11	Na <sub>2</sub> O	6.97	7.04	H <sub>2</sub> O <sup>-</sup>	0.00
						Total	100.17
							97.21

(1) Tiburon Peninsula, California, USA; corresponds to (Na<sub>1.96</sub>Ca<sub>0.04</sub>)<sub>Σ=2.00</sub>(Mg<sub>2.39</sub>Al<sub>1.62</sub>Fe<sub>0.61</sub>Fe<sub>0.19</sub>)<sub>Σ=3.00</sub>Si<sub>8</sub>O<sub>22</sub>(OH)<sub>2</sub>. (2) Kodiak Islands, Alaska, USA; by electron microprobe, Fe<sup>2+</sup>:Fe<sup>3+</sup> calculated, corresponds to (Na<sub>1.96</sub>Ca<sub>0.09</sub>K<sub>0.02</sub>)<sub>Σ=2.01</sub>(Al<sub>1.82</sub>Mg<sub>1.74</sub>Fe<sub>1.20</sub>Fe<sub>0.18</sub>Mn<sub>0.03</sub>Ti<sub>0.02</sub>Cr<sub>0.01</sub>)<sub>Σ=3.00</sub>(Si<sub>7.83</sub>Al<sub>0.17</sub>)<sub>Σ=8.00</sub>O<sub>22</sub>(OH)<sub>2</sub>.

**Polymorphism & Series:** Forms a series with ferroglaucophane.

**Mineral Group:** Amphibole (alkali) group: Fe<sup>2+</sup>/(Fe<sup>2+</sup> + Mg) < 0.5; Fe<sup>2+</sup>/(Fe<sup>2+</sup> + Al<sup>vi</sup>) < 0.3; (Na + K)<sub>A</sub> < 0.5; Na<sub>B</sub> ≥ 1.34.

**Occurrence:** Characteristic of the blueschist facies, in former subduction zones in mountain belts of the Franciscan Complex, and in eclogites that have undergone retrograde metamorphism.

**Associated Minerals:** Crossite, chlorite, epidote, pumpellyite, lawsonite, omphacite, jadeite, actinolite, albite, piemontite, aragonite.

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

# Re-appropriating existing databases: Geology

## USGS Geologic Map Database

[http://ngmdb.usgs.gov/ngmdb/ngmdb\\_home.html](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.



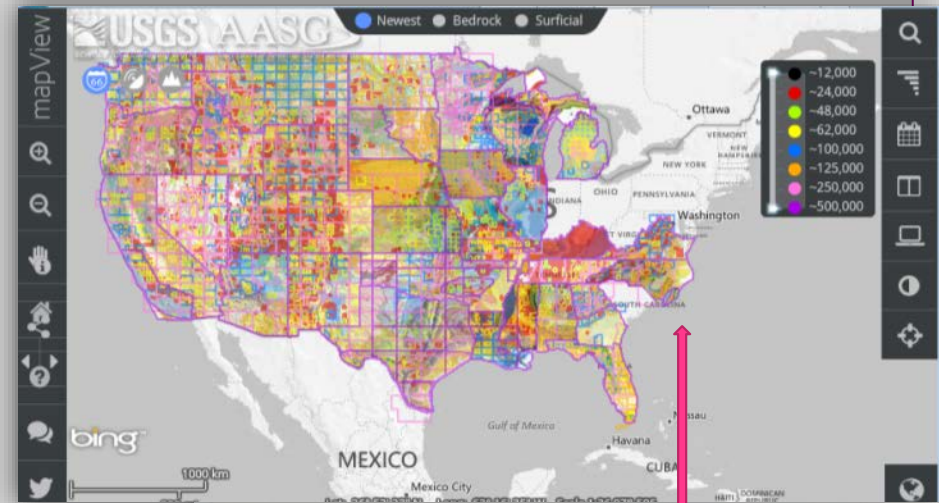
**AASG**  
Association of American State Geologists  
LOG-IN

The Association of American State Geologists (AASG) represents the State Geologists of the 50 United States and Puerto Rico. Founded in 1908, AASG seeks to advance the science and practical application of geology and related earth sciences in the United States and its territories, commonwealths, and possessions.

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Comments to the [AASG Webmaster](#).



**USGS AASG**  
Association of American State Geologists

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**The National Geologic Map Database**

Developing a distributed archive of standard geoscience information for the nation.

Publications

Keyword(s)

Title:  Author:  Map Number:

Themes Choose theme(s), or skip to search all

Geology Geophysics Marine Resources Hazards Other

Map Catalog  
Find over 90,000 products from over 600 publishers



Stratigraphy  
Find geologic names, charts, and guidelines



MapView  
Discover geologic maps through our map interface

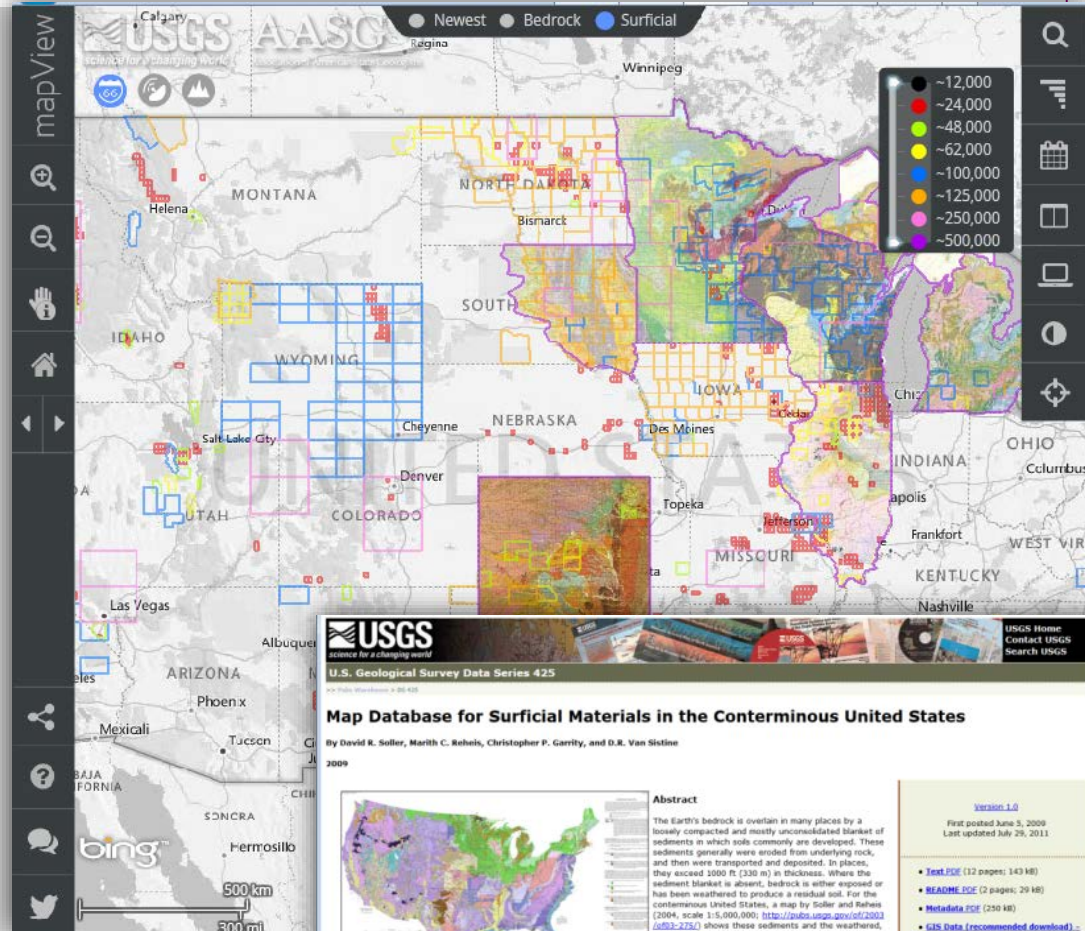


TopoView  
Access the Historical Topographic Map Collection



# 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)



metropolitan areas are experiencing rapid growth). To help establish these priorities, a quickly prepared, modern, synoptic overview of the geology was needed. The Soller and Reheis (2004) map was made in response to that need, and provides an overview of current knowledge of the composition and distribution of surficial materials in the conterminous United States. The map also serves to illustrate for educational and planning purposes the general nature and distribution of the Nation's surficial materials at land surface, but does not offer information useful for local decisions because it is not intended to be used at a larger (greater detail) scale than 1:5,000,000. Please refer to the map's "Methodology" and "Caveats" section, and to the database's metadata, for details on how this map was created, how surficial materials were defined, and how the database was constructed.

**Version 1.0**  
 First posted June 3, 2009  
 Last updated July 29, 2011

- [Text PDF](#) (12 pages; 143 KB)
- [README PDF](#) (2 pages; 29 KB)
- [Metadata PDF](#) (250 KB)
- [GIS Data \(recommended download\) - ESRI map document, GeoDatabase format \(5.9 MB compressed; 51.4 MB expanded\)](#)
- [GIS Data - ESRI shapefile format](#) (112.9 MB compressed; 166.5 MB expanded)

This report is available only on the Web.

For additional information, or to request geospatial data in a legacy format contact:  
 David Soller and Christopher Garrity  
 National Geologic Map Database

Part of this report is presented in Portable Document Format (PDF); at least version 7 of Adobe Reader or similar software is required to view it. Download the latest version of Adobe



# 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](#)]

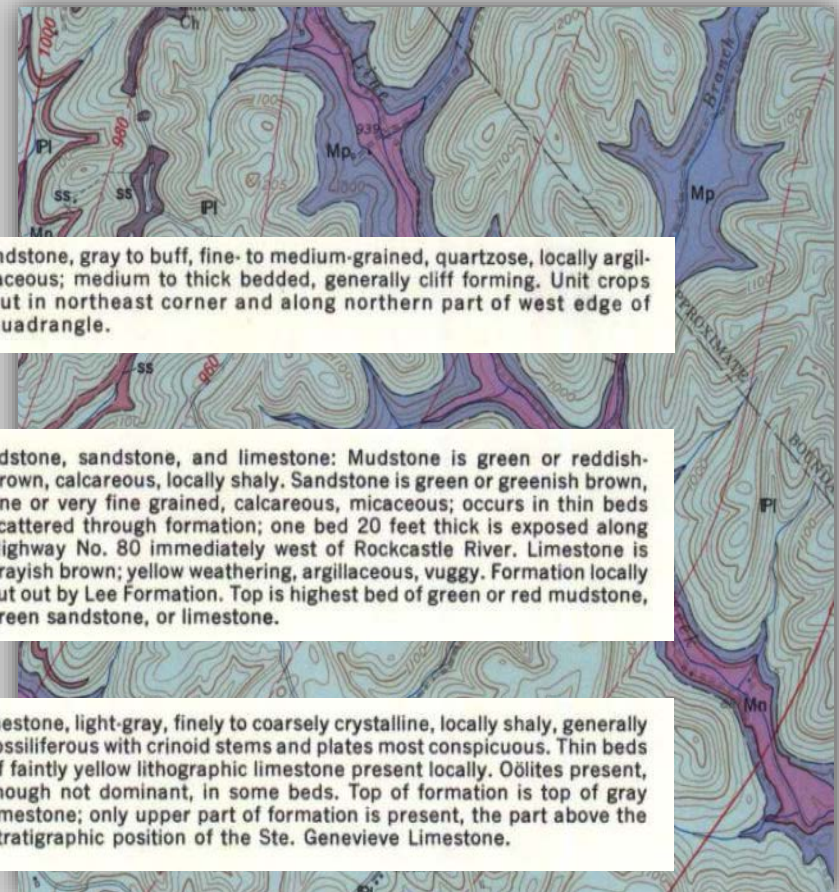
**Author(s):** Hatch, N.L.

**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.



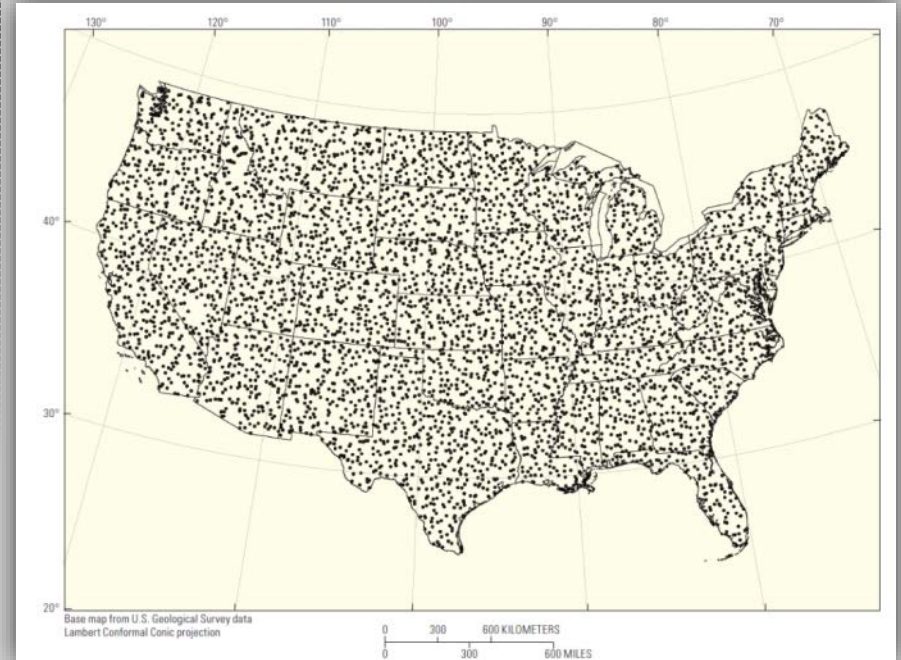
# USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

- 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<sup>2</sup>



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

## GEOCHEMISTRY

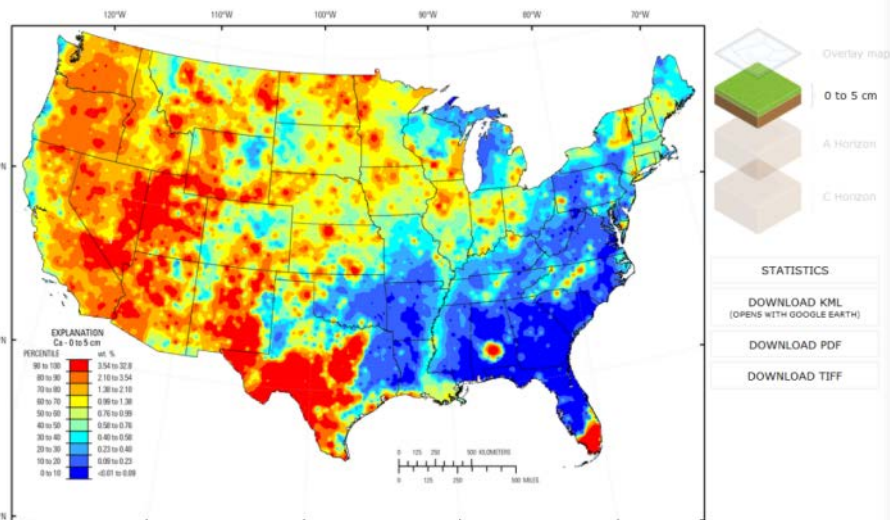
H Hydrogen																	He Helium																														
Li Lithium	Be Beryllium											B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine	Ne Neon																														
Na Sodium	Mg Magnesium											Al Aluminum	Si Silicon	P Phosphorus	S Sulfur	Cl Chlorine	Ar Argon																														
K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton																														
Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon																														
Cs Cesium	Ba Barium	La-Lu Lanthanum-Lutetium	Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium	Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon																														
Fr Francium	Ra Radium	Ac-Lr Actinide-Lanthanide	Rf Rutherfordium	Db Dubnium	Sg Seaborgium	Bh Bohrium	Hs Hassium	Mt Meitnerium	Ds Darmstadtium	Rg Roentgenium	Cn Copernicium	Uut Ununtrium	Fl Flerovium	Uup Ununpentium	Lv Livermorium	Uus Ununseptium	Uuo Ununoctium																														
<table border="1"> <tr> <td>La Lanthanum</td> <td>Ce Cerium</td> <td>Pr Praseodymium</td> <td>Nd Neodymium</td> <td>Pm Promethium</td> <td>Sm Samarium</td> <td>Eu Europium</td> <td>Gd Gadolinium</td> <td>Tb Terbium</td> <td>Dy Dysprosium</td> <td>Ho Holmium</td> <td>Er Erbium</td> <td>Tm Thulium</td> <td>Yb Ytterbium</td> <td>Lu Lutetium</td> </tr> <tr> <td>Ac Actinium</td> <td>Th Thorium</td> <td>Pa Protactinium</td> <td>U Uranium</td> <td>Np Neptunium</td> <td>Pu Plutonium</td> <td>Am Americium</td> <td>Cm Curium</td> <td>Bk Berkelium</td> <td>Cf Californium</td> <td>Es Einsteinium</td> <td>Fm Fermium</td> <td>Md Mendelevium</td> <td>No Nobelium</td> <td>Lr Lawrencium</td> </tr> </table>																		La Lanthanum	Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium	Ac Actinium	Th Thorium	Pa Protactinium	U Uranium	Np Neptunium	Pu Plutonium	Am Americium	Cm Curium	Bk Berkelium	Cf Californium	Es Einsteinium	Fm Fermium	Md Mendelevium	No Nobelium	Lr Lawrencium
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# USGS Geochemical & Mineralogical Maps for Soils of the Conterminous United States

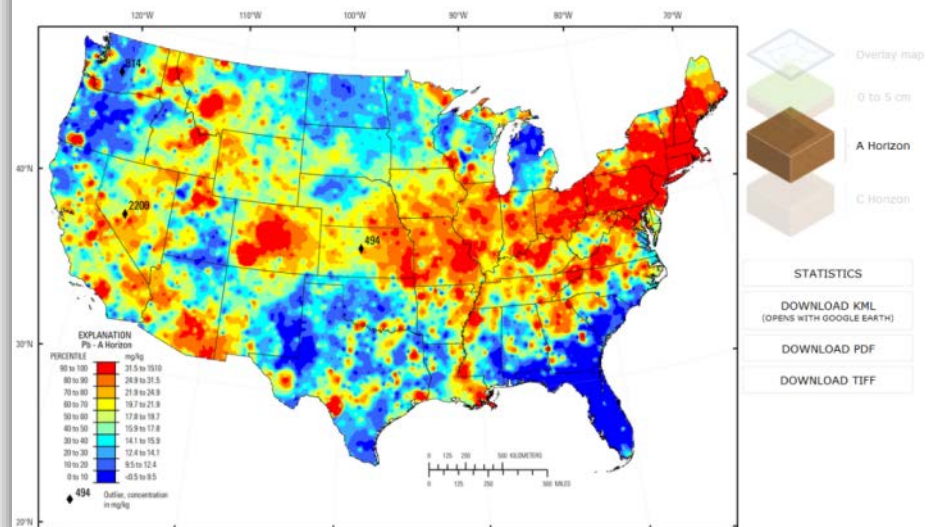
- Available both as tabular/point data and interpolated maps



CALCIUM

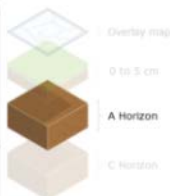
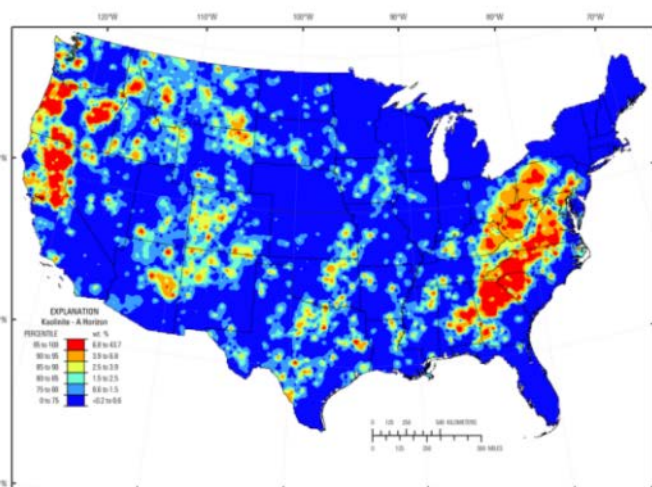


LEAD



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

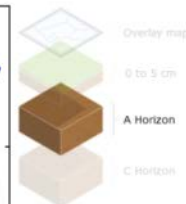
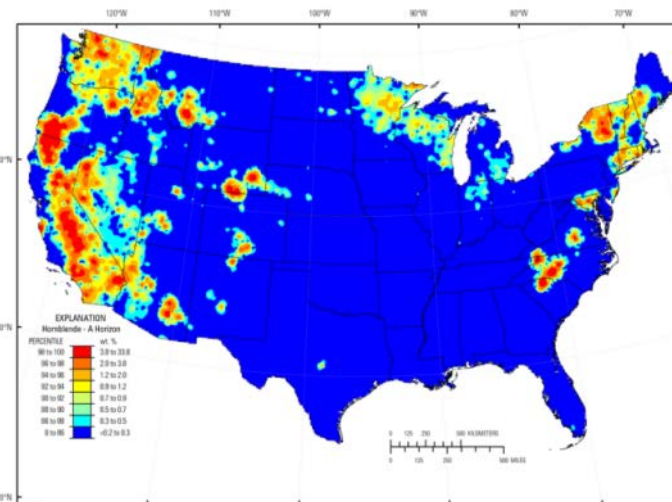
## KAOLINITE



STATISTICS

- DOWNLOAD KML (OPENS WITH GOOGLE EARTH)
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- DOWNLOAD TIFF

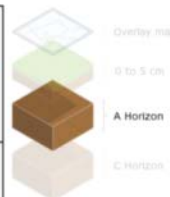
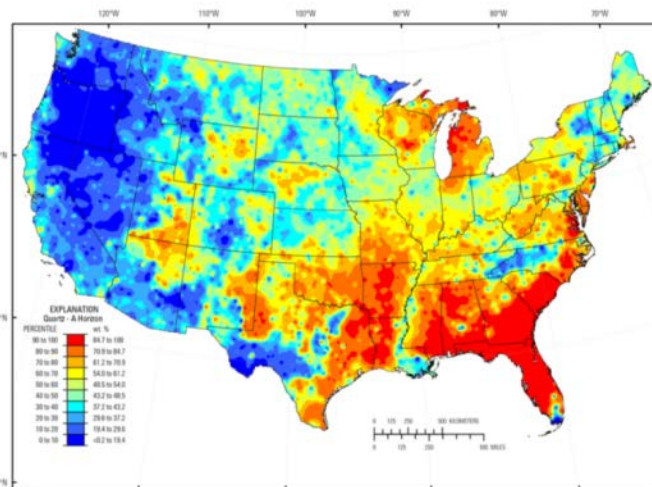
## HORNBLLENDE



STATISTICS

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- DOWNLOAD TIFF

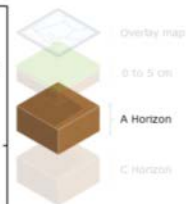
## QUARTZ



STATISTICS

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- DOWNLOAD TIFF

## SERPENTINE



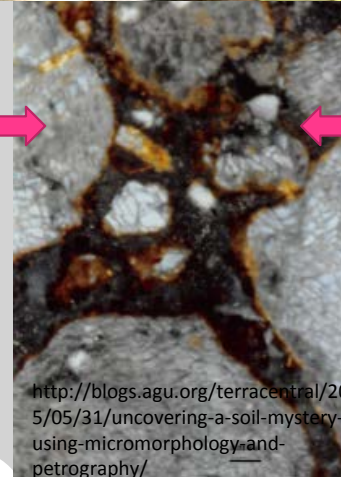
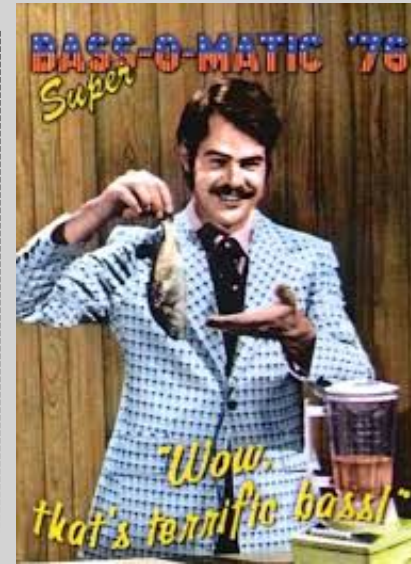
STATISTICS

- DOWNLOAD KML (OPENS WITH GOOGLE EARTH)
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# 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



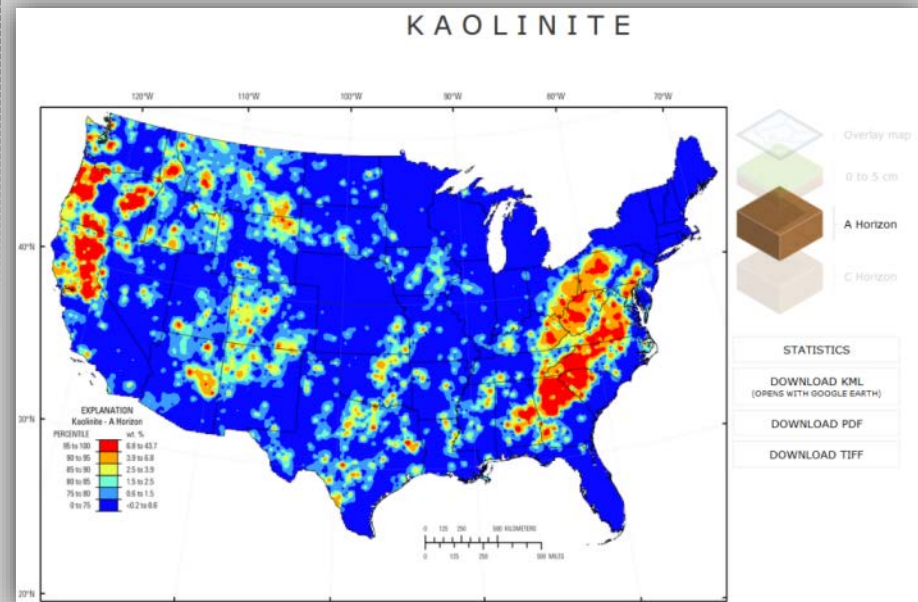
<http://blogs.agu.org/terracecentral/2015/05/31/uncovering-a-soil-mystery-using-micromorphology-and-petrography/>



**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

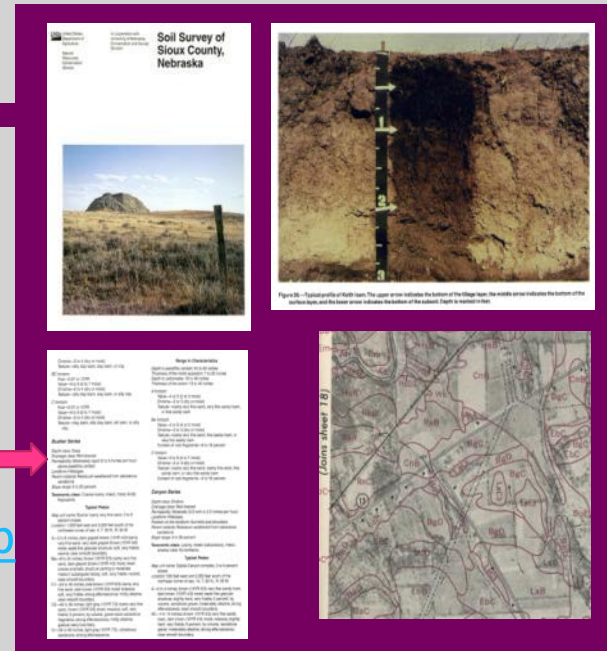
- Historical printed county soil surveys
- Soil spatial databases
  - ✦ STATSGO coarsely mapped at 1:250,000
  - ✦ **gSSURGO** mapped at a scale of 1:12,000 to 1:63,360

- Official Soil Series Descriptions

<https://soilseries.sc.egov.usda.gov/osdnamequery.asp>

- National Cooperative Soil Survey (NCSS) Soil Characterization Database:

<http://ncsslabsdatamart.sc.egov.usda.gov/querypage.aspx>





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

**Lab Report**

pH & Carbonates		-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-		
		pH					Carbonate		Gypsum					
		CaCl <sub>2</sub>					As CaCO <sub>3</sub>		As CaSO <sub>4</sub> ·2H <sub>2</sub> O Resist					
Layer	Depth (cm)	Horz	Prep	KCl	H <sub>2</sub> O	Sat	<2mm	<20mm	<20mm	ohms				
				1:2	1:1	Paste	Oxid	NaF	cm <sup>-1</sup>					
				4C1a2a	4C1a2a				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 (< 0.02 mm)		-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	
		X-Ray																		
Layer	Depth (cm)	Horz	Fract ion	7A2i	7A3b	7C3														
				peak size	peak size	peak size														
				ion	ion	ion														
				ion	ion	ion														
78P00216	20.0-46.0	Bt1	toly	KK 3	VR 1	KK 42	GI 1													
78P00217	46.0-72.0	Bt2	toly	KK 4	VR 1	GE 1	KK 36	GI 1	18.6											
78P00219	97.0-132.0	Bt4	toly	KK 3	VR 1	KK 40														
78P00220	132.0-157.0	C	toly	KK 3	VR 1	KK 42														

FRACTION INTERPRETATION:  
toly - 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

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 porous 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



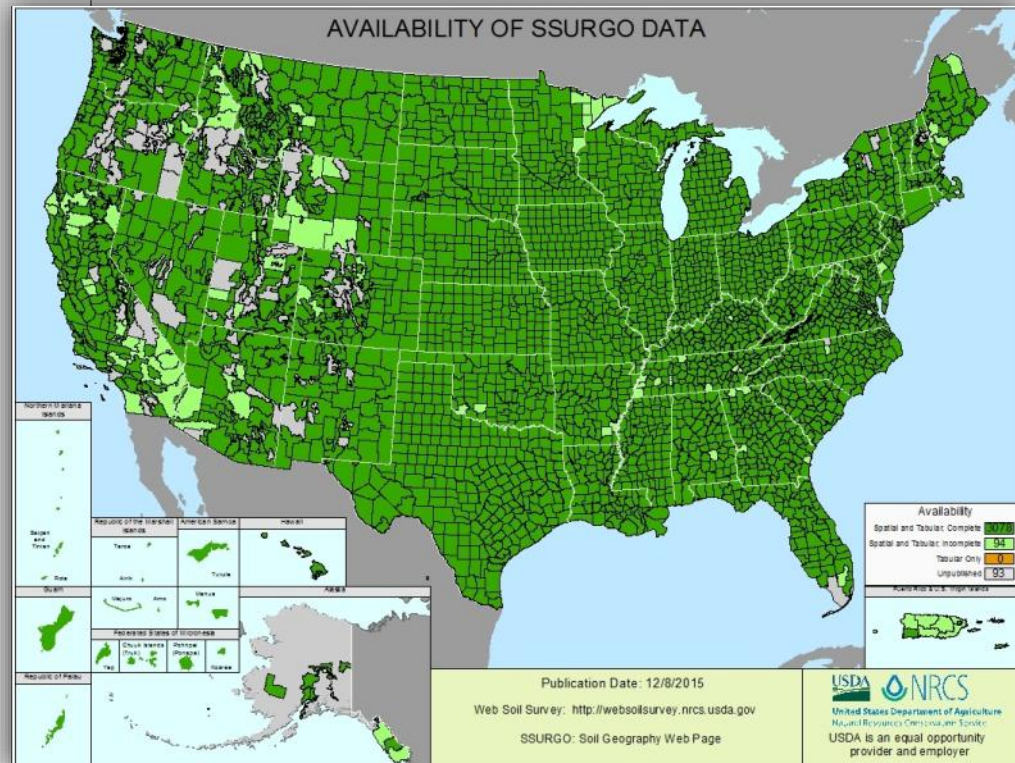
Parameters characterized vary from site-to-site

# USDA NRCS Soil Databases

- Soil Survey Databases

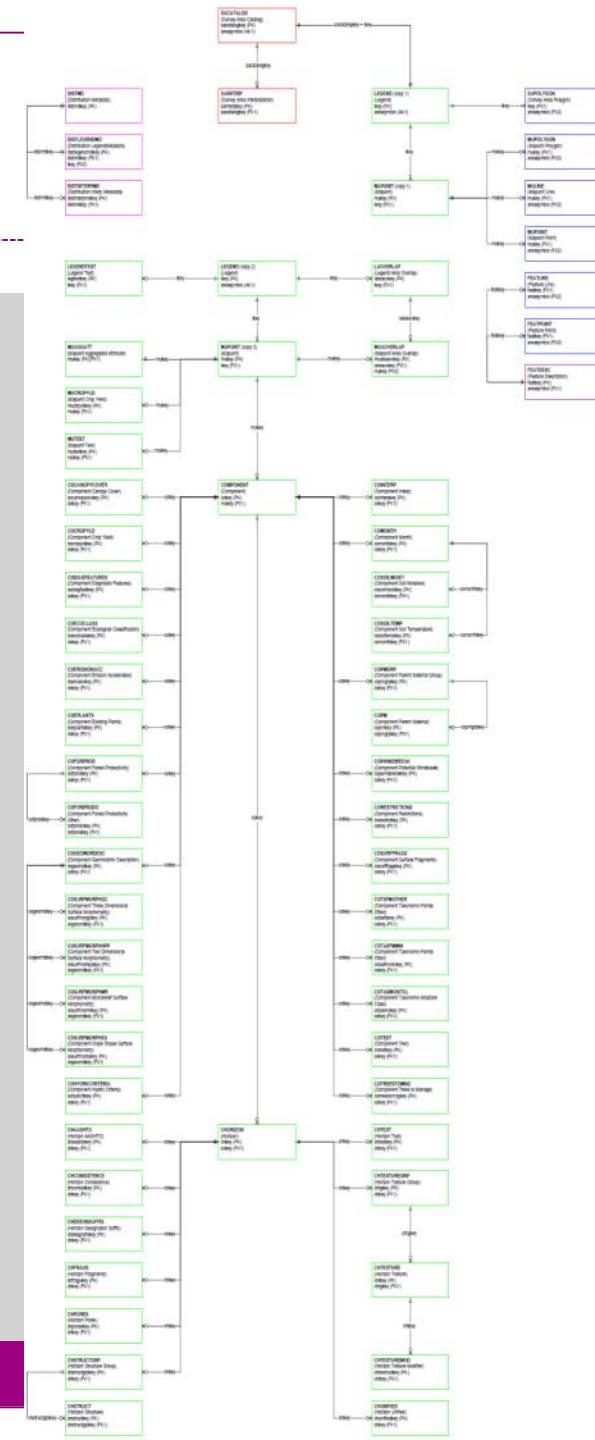
- STATSGO 1:250,000
- SSURGO 1:12,000 to 1:63,360
- gSSURGO (SSURGO as 10 m grid)

- Similar Data Structure

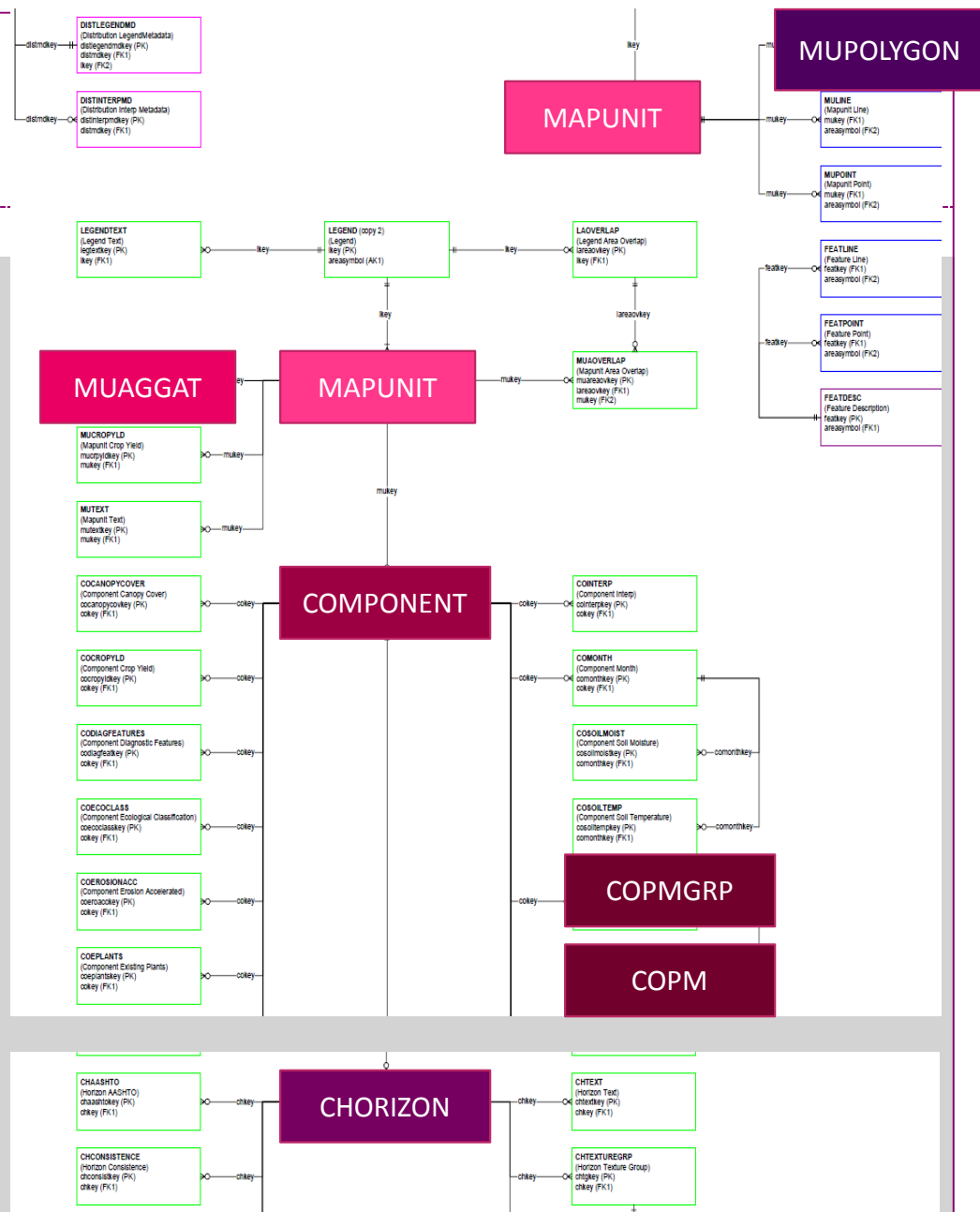


# STATSGO/SSURGO Database Structure

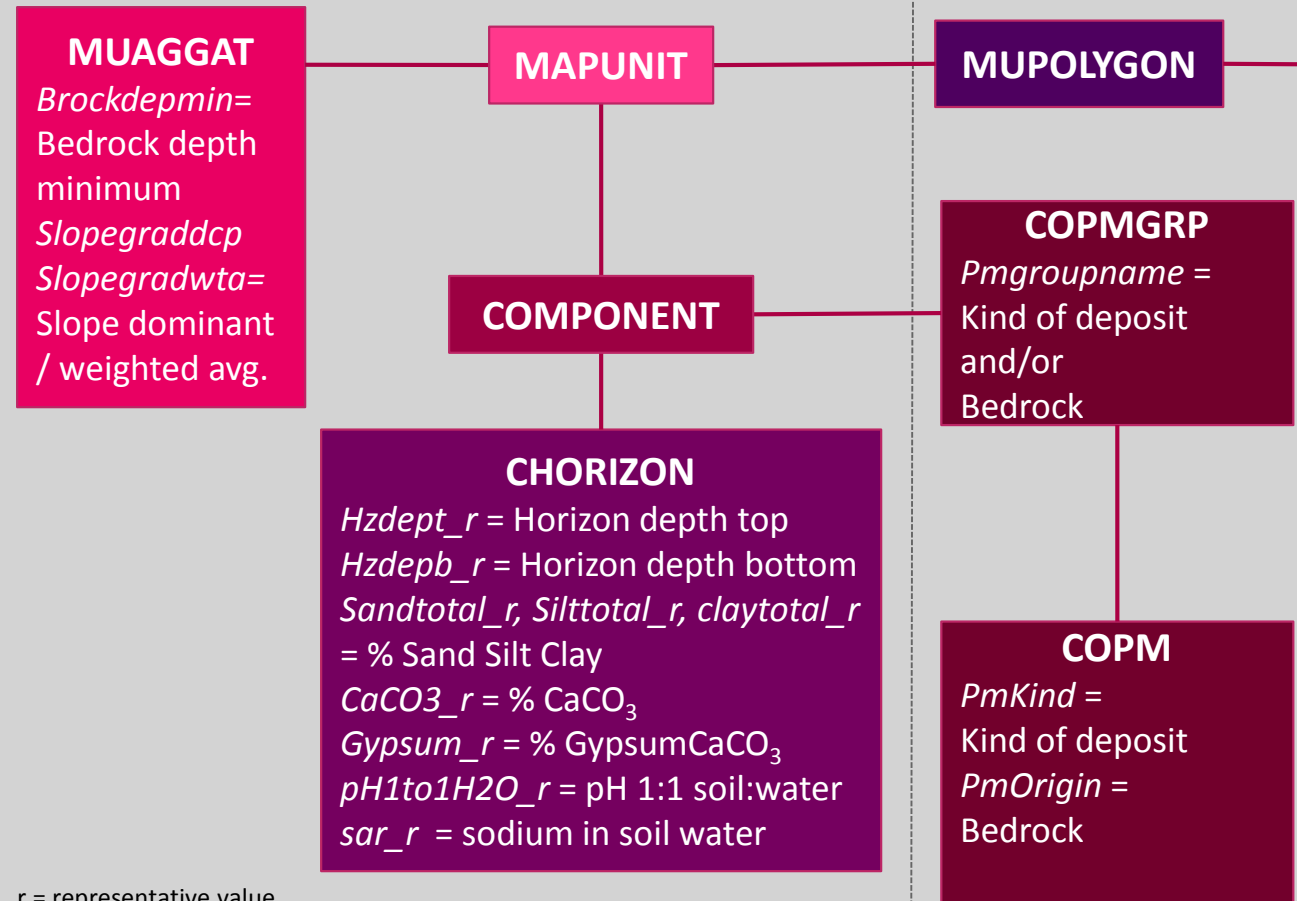
- Soil Survey Databases
  - STATSGO 1:250,000
  - SSURGO 1:12,000 to 1:63,360
- >60 tables in gSSURGO
- Each table has 3 to 171 fields



# STATSGO/gSSURGO Database Structure



# STATSGO/gSSURGO Database Structure with some forensically relevant fields listed



# 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**

The screenshot shows the Geospatial Data Gateway (GDG) website. At the top, the USDA logo and the text 'Natural Resources Conservation Service' are visible. The main heading is 'Geospatial Data Gateway'. Below this is a navigation bar with links: Home, Login, Check Order, Status Maps, News, Data Policy, FAQ, Help, Admin, and Contact Us. The main content area features a 'Welcome to GDG' message with a system status update: 'System Status: GDG6.0.2 All products are running normally. See TUTORIAL in help overview.' A large image of a natural rock archway is displayed with the text 'GEOSPATIAL DATA GATEWAY' and 'the one stop source for environmental and natural resource data'. To the right, there is a 'GET DATA' button and a 'Place a Data Order' section with the GDG logo. A sidebar on the left contains a list of links: Natural Resources Conservation Service, Farm Services Agency, Rural Development, National Geospatial Center of Excellence (NGCE), Aerial Photography Field Office (APFO), Web Soil Survey, eFOTG, Geo.Data.Gov, USGS Maps, Imagery and Publications, National Atlas, National Map Viewer 2.0, US Census Bureau Geography, Download TIGER/Line Shapefiles, Download Public Land Survey System Data, and United States Elevation Inventory. At the bottom right, there is a section titled 'I Want To...' with a list of options: Order by County/Countries, Order by State, Order by Place, Order by entering Latitude/Longitude Bounding Rectangle, and Order by Interactive Map using custom Area Of Interest.

# 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

The screenshot displays the USDA Web Soil Survey web application. At the top, the USDA logo and 'Natural Resources Conservation Service' are visible. The main navigation bar includes 'Contact Us', 'Subscribe', 'Archived Soil Surveys', 'Soil Survey Status', 'Glossary', 'Preferences', 'Link', 'Logout', and 'Help'. Below this, there are buttons for 'Area of Interest (AOI)', 'Soil Map', 'Soil Data Explorer', 'Download Soils Data', and 'Shopping Cart (Free)'. The 'View Soil Information By Use:' dropdown is set to 'All Uses'. The 'Soil Properties and Qualities' tab is selected, showing a list of properties: Calcium Carbonate (CaCO<sub>3</sub>), Cation-Exchange Capacity (CEC-7), Effective Cation-Exchange Capacity (ECEC), Electrical Conductivity (EC), Gypsum, pH (1 to 1 Water), Sodium Adsorption Ratio (SAR), Soil Erosion Factors, Soil Physical Properties, Soil Qualities and Features, and Water Features. The 'Soil Map' window shows a map with soil boundaries and labels, including 'Turk Mountain Rd' and 'Turk Mountain Branch'. The 'Identify' window provides instructions on how to use the map's identify tool.

**Identify**

To identify the latitude and longitude of a specific point on the map, and identify features in all visible map layers at that point:

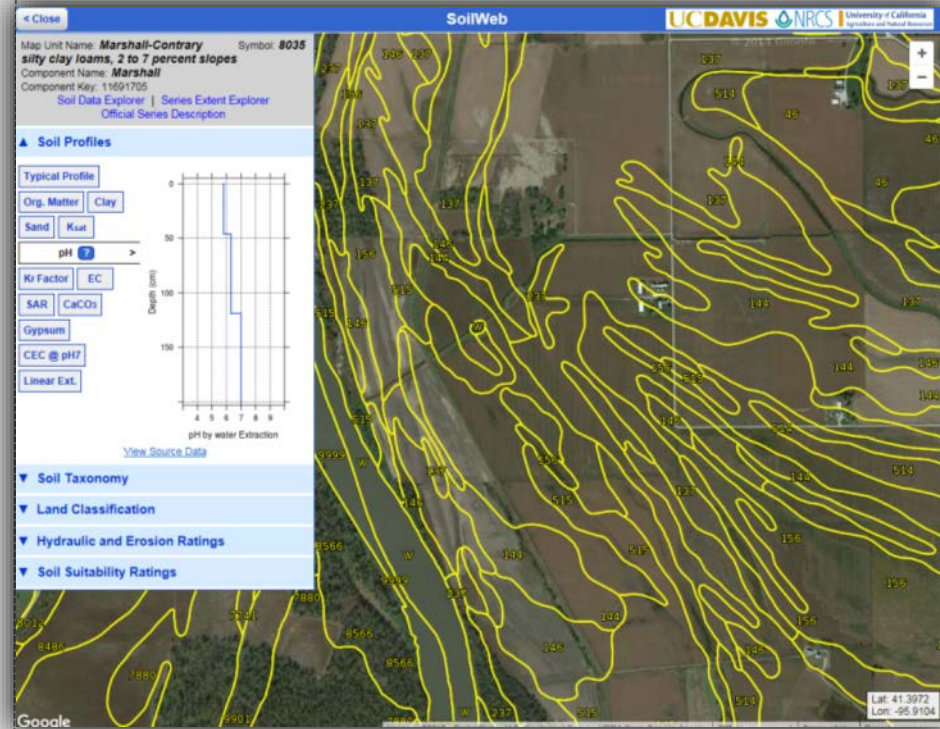
1. Click anywhere in the map. Identify results will be shown here for all visible layers at that point.
2. Layers that are not currently selected are not identified. To identify an unselected layer, click the **Legend** tab, select the layer, then click the map again.
3. Layers that are disabled are not identified, because they are not visible at the current scale. To identify a disabled layer, zoom in or out until it is visible, and select the layer in the **Legend**.
4. The point you identified is marked with the identified point icon: 

# 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.

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, LRR-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, LRR-J: MLRA 85-Grand Prairie. This series is extensive with about 3,400,000 acres.

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

# 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](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 loam; strongly acid; clear smooth boundary. (1 to 5 in

**E**—3 to 7 inches; grayish brown (10YR 5/2) silt loam; fine roots; very strongly acid; clear smooth bot

**Bt1**—7 to 10 inches; strong brown (7.5YR 5/6) silt loam; 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) silt loam; slightly sticky; common fine roots; faint clay film; clear smooth boundary.

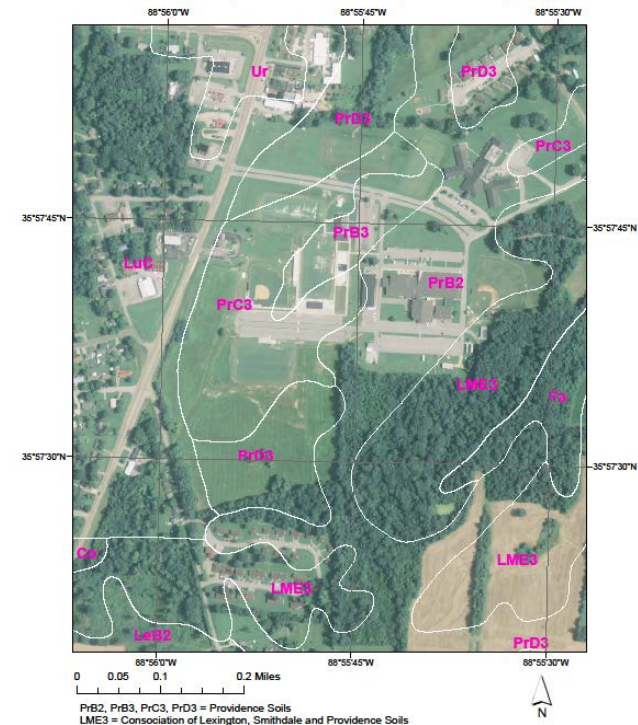
**Bt3**—14 to 23 inches; strong brown (7.5YR 5/6) silt loam; structure; firm, slightly sticky; few fine roots; few common brown coatings on faces of peds in lot thickness of Bt horizon ranges from 10 to 36 in

**Btx**—23 to 28 inches; strong brown (7.5YR 5/6) silt loam; (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 (10YR 8/6) light brownish gray (2.5Y 6/2) seams of albic r prismatic parting to moderate fine and medium

1 of 4

USDA Soil Survey Map Units in the vicinity of Peabody High School



# Example 2 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.

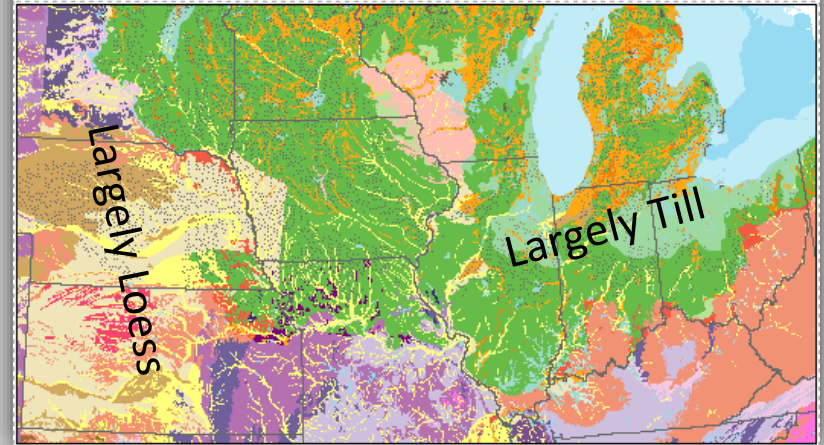
MAPPED SOIL AND GEOLOGY DATA WERE PRESENTED IN A DAUBERT HEARING. SOIL EVIDENCE WAS JUDGED ADMISSIBLE.

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

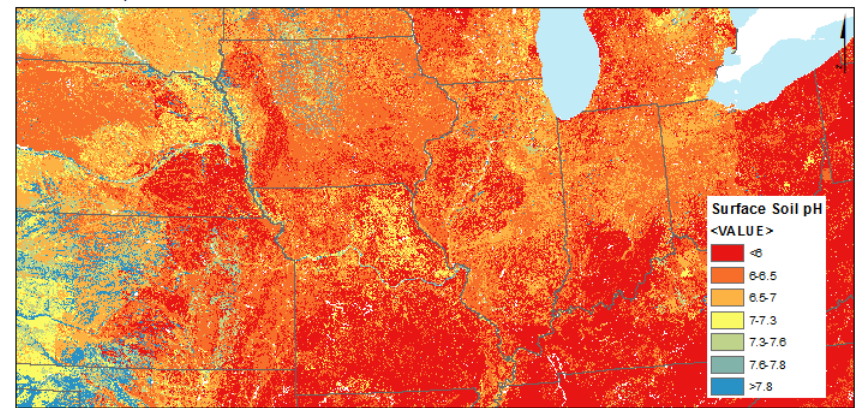
# Example 3 of soil survey data augmenting geographic attribution

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

USGS DS 425 Surficial Materials



Surface Soil pH



# 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

