Geochemical Survey of Soils in North Dakota

By

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North Dakota Geological Survey

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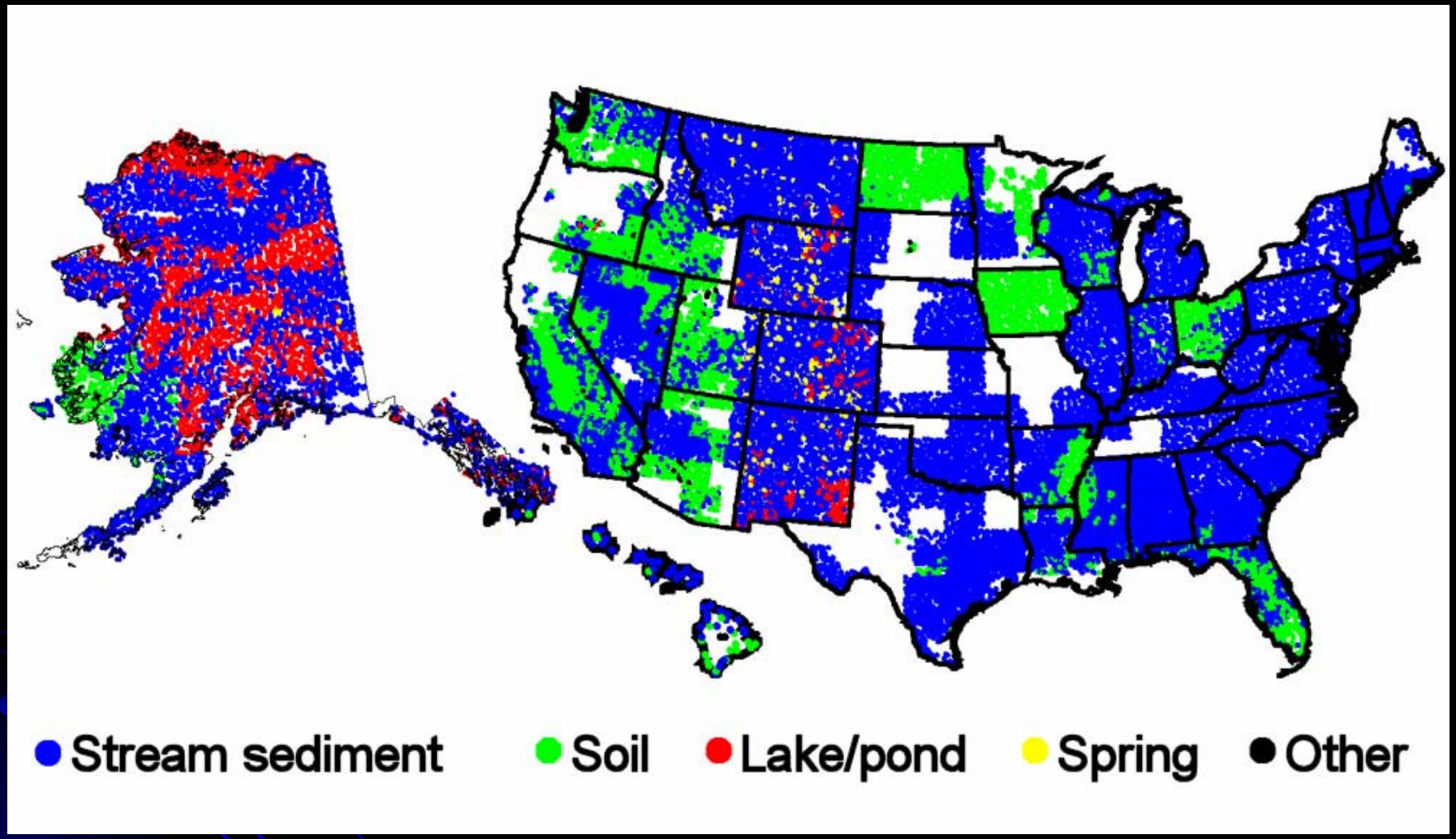
Introduction

- The USGS, as part of its Mineral Resource Surveys Program, is engaged in a project to conduct a nationwide solid-phase geochemical survey based on an approximately 17 x 17 km grid cell
- Requires the collection and analysis of about 35,000 stream sediment and soil samples for the continental US, Alaska, and Hawaii
- As of February 2006, 71% of the land area of the US had sample coverage. ~3/4 of the analyzed samples are stream sediments and the majority of the rest are soils



Sample media in the National Geochemical Survey

Source: http://tin.er.usgs.gov/geochem/doc/status.htm

Previous studies

- Boerngen & Shacklette (1981), Shacklette & Boerngen (1984)
  Republished by Gustavsson and others (2001)
  1,323 samples across the conterminous US (1 per 6000 km^2)
  29 samples in North Dakota

- National Uranium Resource Evaluation (NURE) (late 1970s)
  limited nationwide study
  Red River Valley and southwest ND only

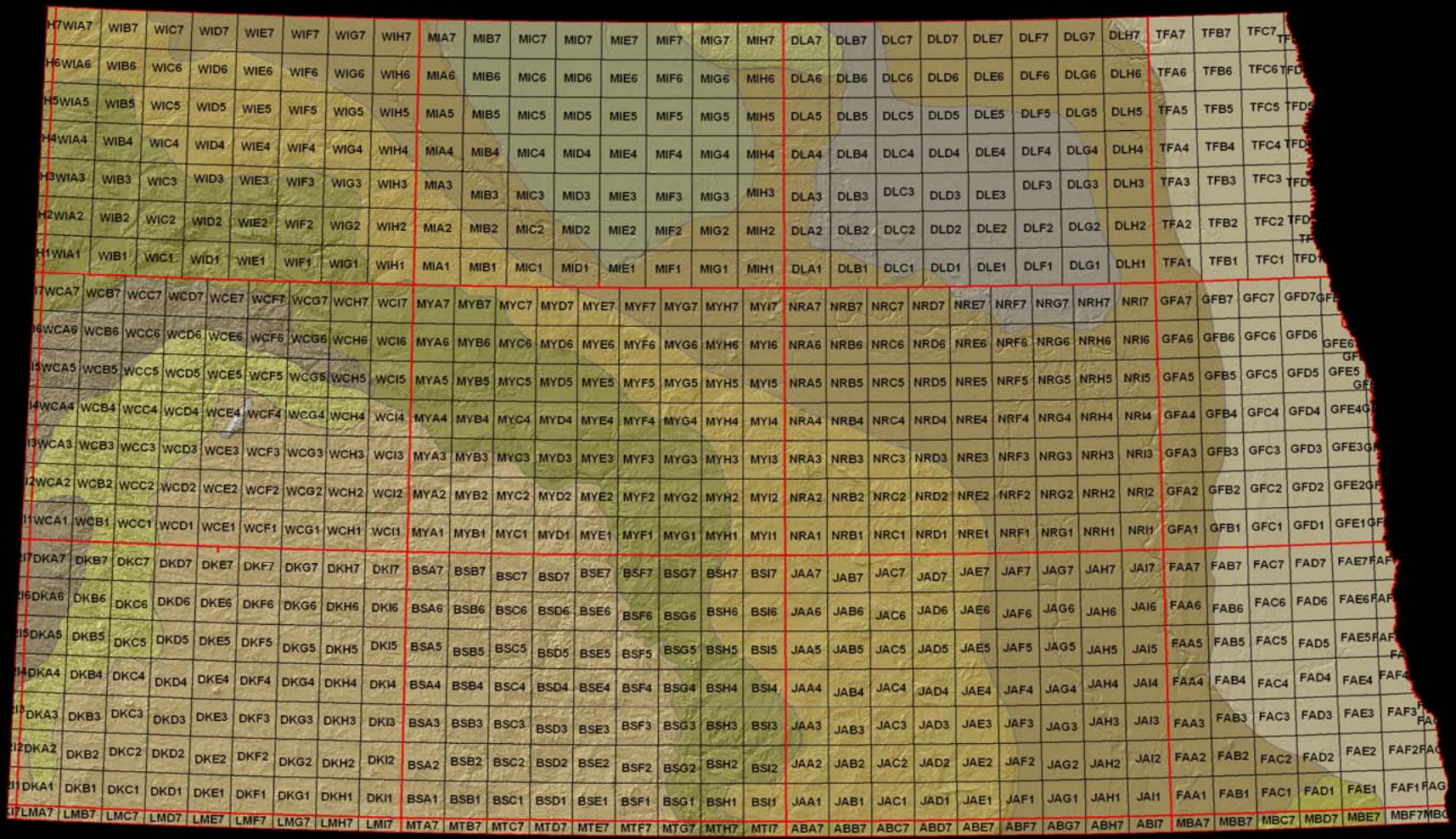
- Several studies at state level (not consolidated)

This study

- USGS/NDGS/NRCS/NDSU collaborative effort
- Soil samples collected using protocols based on standard NRCS soil sampling procedures
- Sample collection began in the summer of 2003 and was completed in October 2004
- 3,251 samples (1,758 analytical and 1,493 archival) representing 715 sites were collected
- Sample site density ≈ 1/300 km^2 (1/100 mi^2)

  20x Shacklette studies

Geochemical survey sample grid for North Dakota



Each black square represents an area of approximately 280 Km^2
Areas bordered in red depict 1:250,000 map coverages

Site selection

- Randomly preselected by USGS to maximize statistical reliability
- One sample site per 17 x 17 km cell, 33 ANOVA sites
- Field crews allowed to select soil within sampling area
- Only major, extensive soils within the MLRA were sampled
- Only stainless steel or plastic tools used
- Atypical or unusual landscapes were avoided

Site selection (contd.)

- Anthropogenic contamination avoided by sampling at least:
  - 5 miles downwind from power plants
  - 200 meters from US or state highways
  - 100 meters from rural roads
  - 100 meters from buildings, including abandoned ones
  - 50 meters from end rows or other areas where large amounts of fertilizer may have been deposited

Sample collection

- All soils sampled at:
  - 0 – 20 cm (plow zone)
  - 30 – 50 cm (dominant soil horizon)
- Plus, at every 10th site (excluding ANOVA):
  - Surface subsamples at 0 – 5 and 5 – 20 cm
  - C horizon (geologic material)
- 1 kg analytical samples, 5 kg archival samples
- Samples consisted of mineral soil material less than 2 mm

Sample analysis

- Inductively coupled plasma-atomic emission spectrometry (ICP40)
  Ag, Al, As, Au, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Eu, Fe, Ga, Ho, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Sc, Sn, Sr, Ta, Th, Ti, U, V, Y, Yb, Zn

- Hydride-generation atomic absorption spectrometry
  As, Se

- Cold vapor atomic absorption spectrometry
  Hg

- Flame or Graphite-Furnace Atomic Absorption Spectrometry
  Au

- Fire Assay - Atomic Absorption Spectrometry
  Au, Pd, Pt

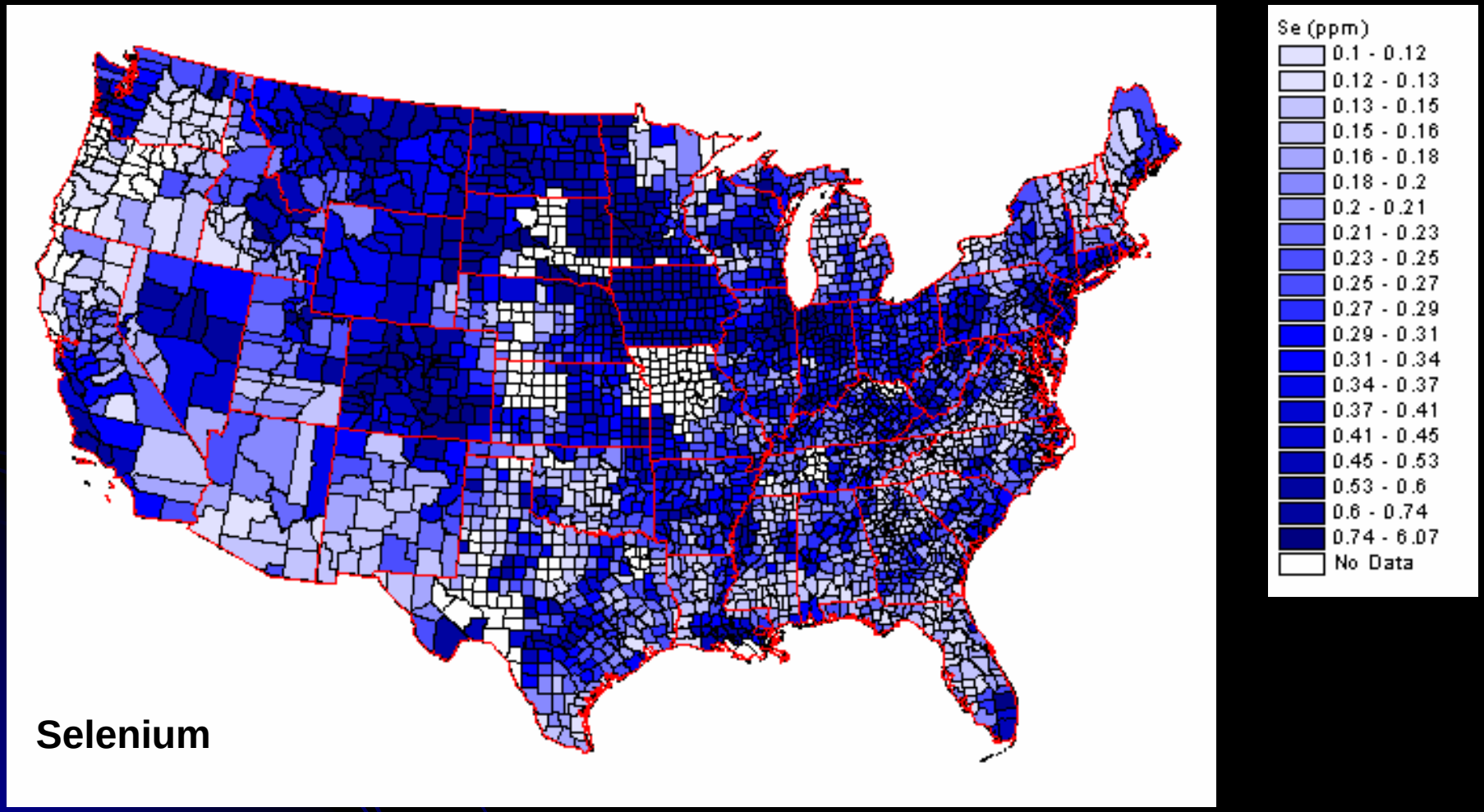
The National Geochemical Survey Database

http://tin.er.usgs.gov/geochem

Data is downloadable in the following formats:

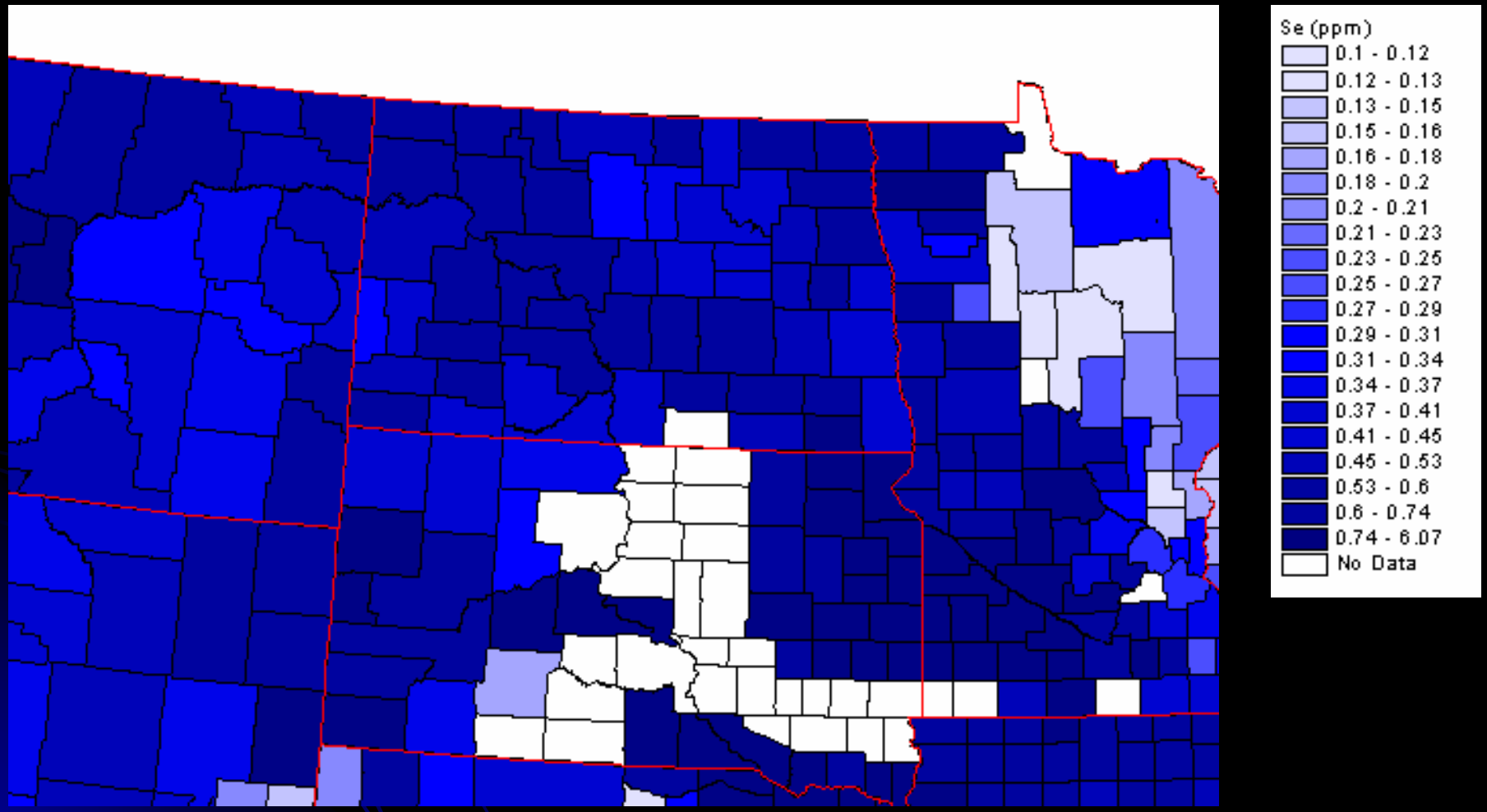
- **Shapefile**
- **dBase**
- **HTML**
- **Tab text**
- **CSV** (Comma Separated Values)
- **Google Earth**

Data by County



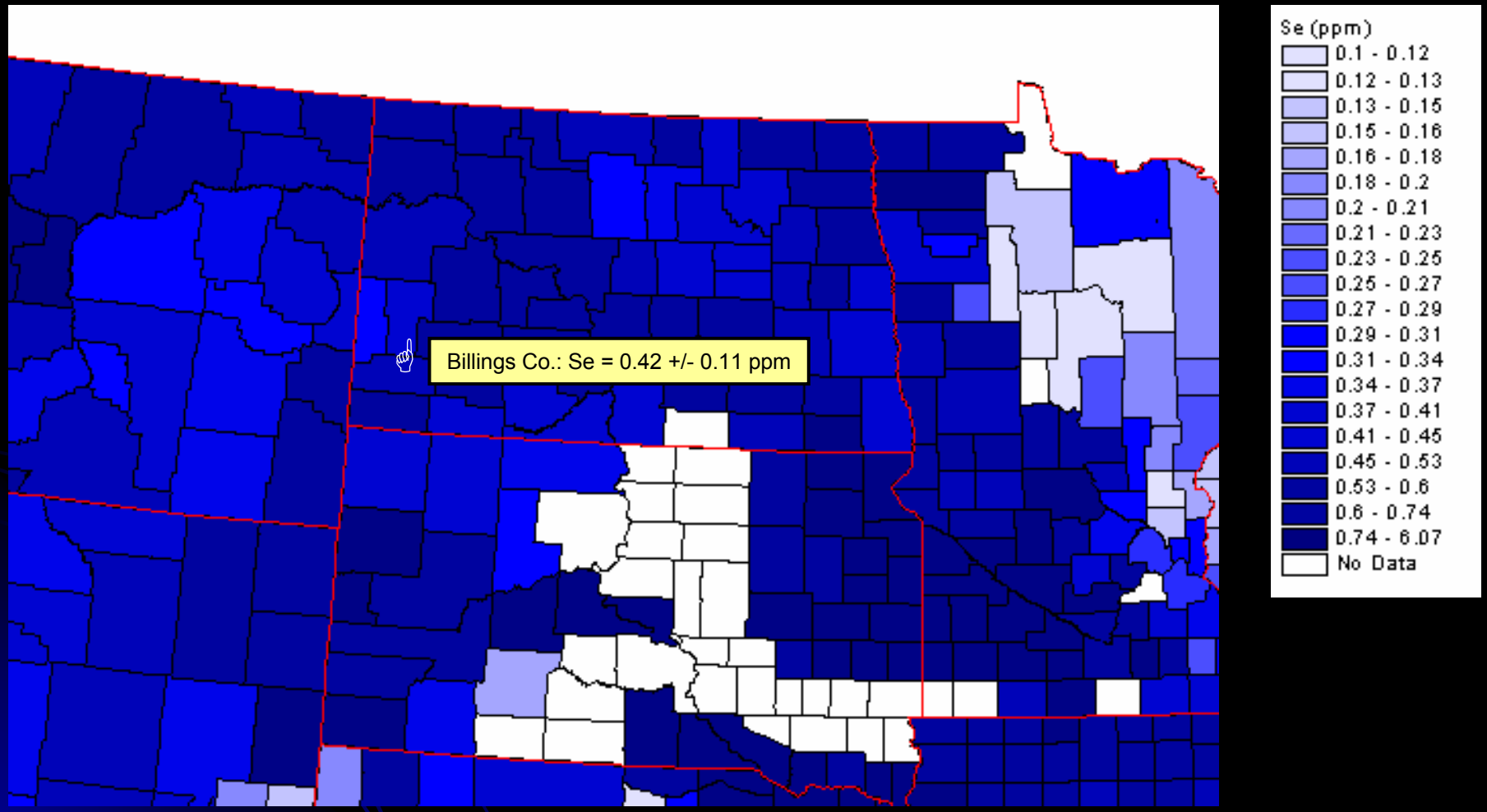
Source: http://tin.er.usgs.gov/geochem/doc/averages/se/usa.html

Data by County (contd.)



Source: http://tin.er.usgs.gov/geochem/doc/averages/se/north-central.html

Data by County (contd.)



Source: http://tin.er.usgs.gov/geochem/doc/averages/se/north-central.html

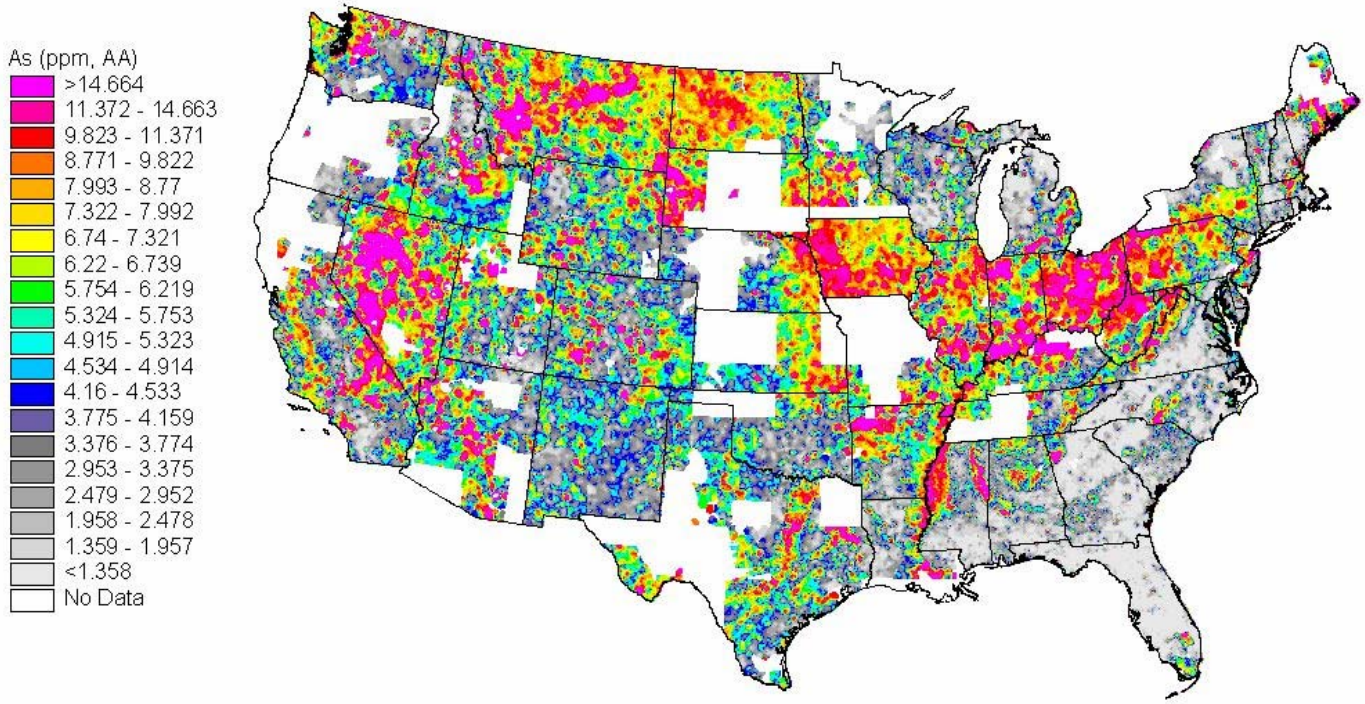
Average concentrations of elements in Billings County, North Dakota

(Calculated from cells in the geochemical grid plotting in this area.)

Element	Symbol	Mean	Std. dev.	Minimum	Maximum
Aluminum	Al (wt%)	5.728	0.397	4.673	7.26
Arsenic	As (ppm)	8.485	1.705	4.383	14.636
Calcium	Ca (wt%)	2.362	1.496	0.492	5.884
Copper	Cu (ppm)	20.186	4.264	9.117	38.962
Iron	Fe (wt%)	2.405	0.307	1.62	3.348
Mercury	Hg (ppm)	0.032	0.01	0.01	0.07
Magnesium	Mg (wt%)	1.135	0.48	0.488	2.47
Manganese	Mn (ppm)	591.286	189.592	291.022	1448.38
Sodium	Na (wt%)	0.932	0.16	0.455	1.629
Phosphorus	P (wt%)	0.068	0.007	0.048	0.086
Lead	Pb (ppm)	15.69	5.24	8.518	32.657
Selenium	Se (ppm)	0.42	0.109	0.148	0.758
Titanium	Ti (wt%)	0.275	0.034	0.184	0.376
Zinc	Zn (ppm)	70.123	10.142	35.588	101.456

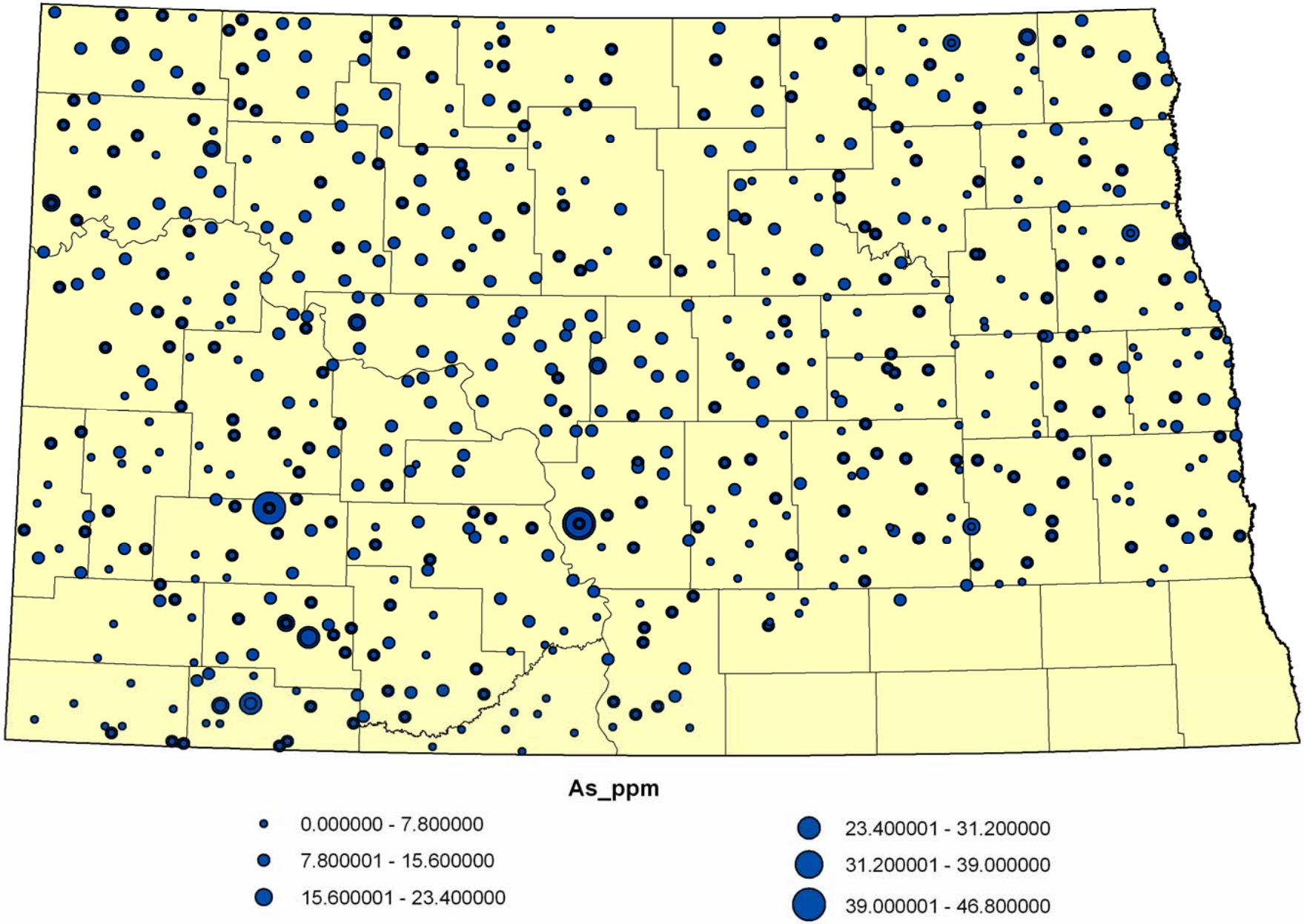
Source: http://tin.er.usgs.gov/geochem/county.php?place=f38007&el=Se&rf=north-central

Distribution of As in the conterminous US

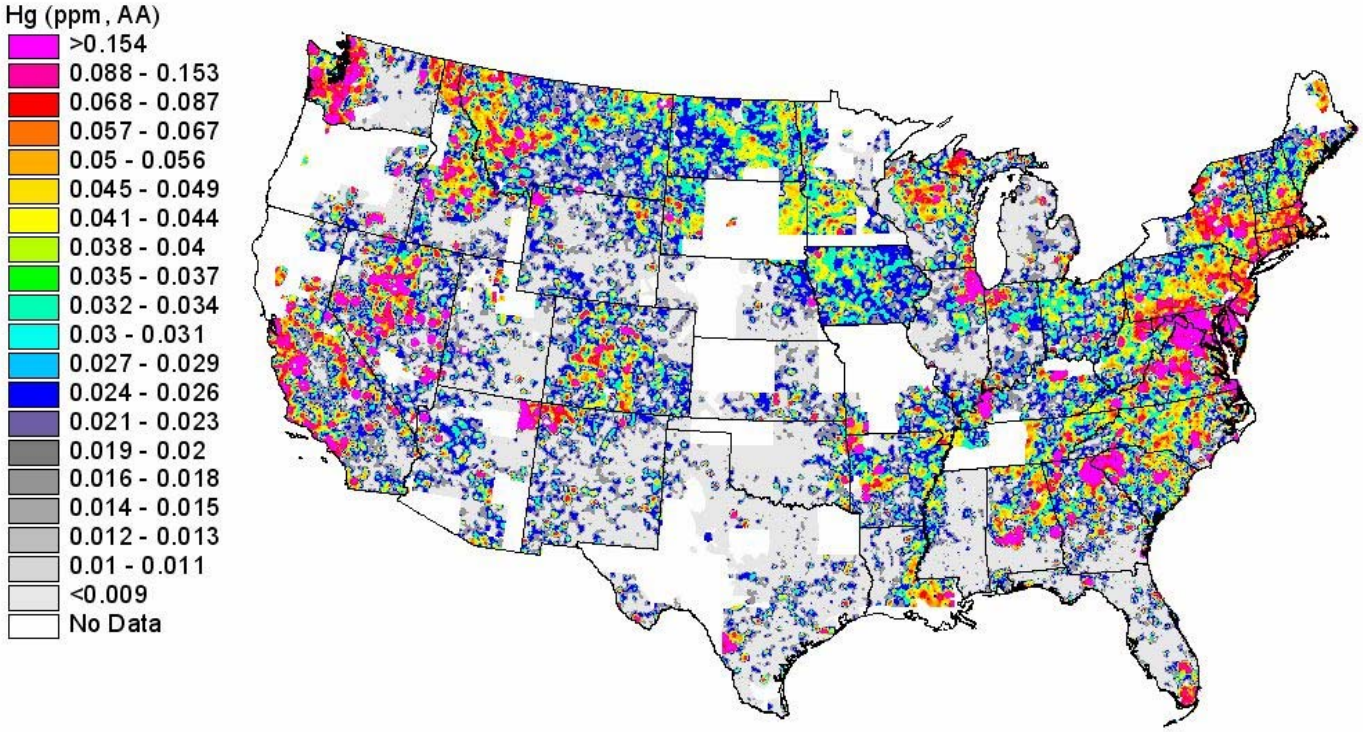


Documentation: http://tin.er.usgs.gov/geochem/doc/mapdoc.htm

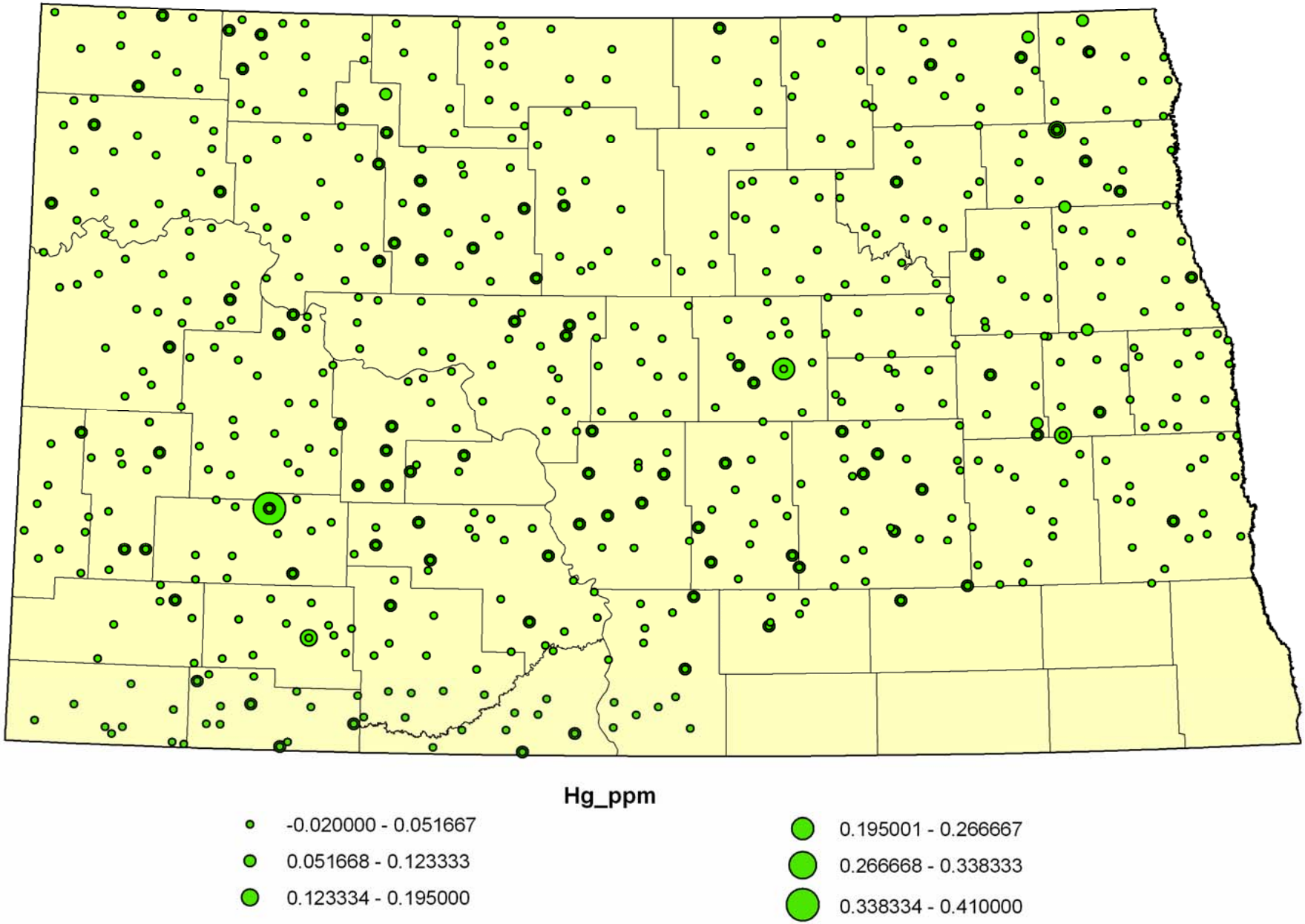
Arsenic


As_ppm
0.000000 - 7.800000
7.800001 - 15.600000
15.600001 - 23.400000
23.400001 - 31.200000
31.200001 - 39.000000
39.000001 - 46.800000

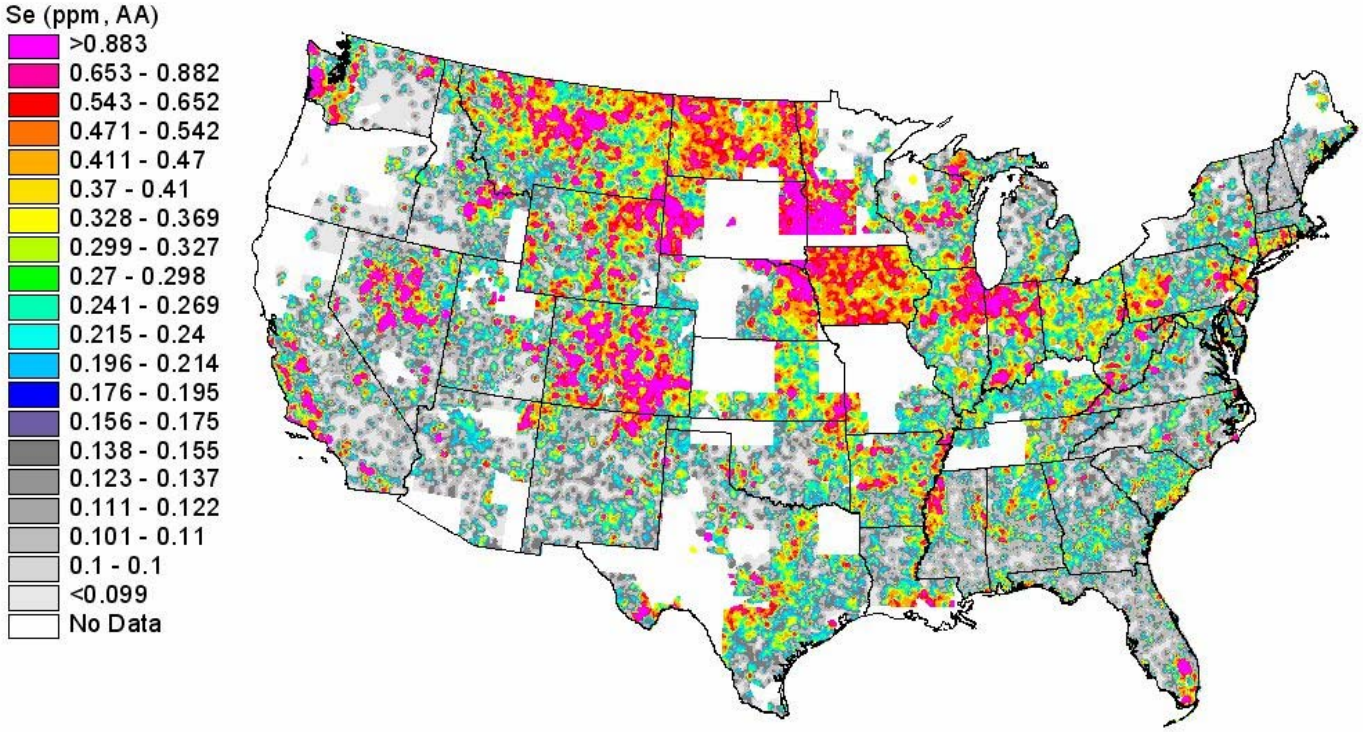
Distribution of Hg in the conterminous US



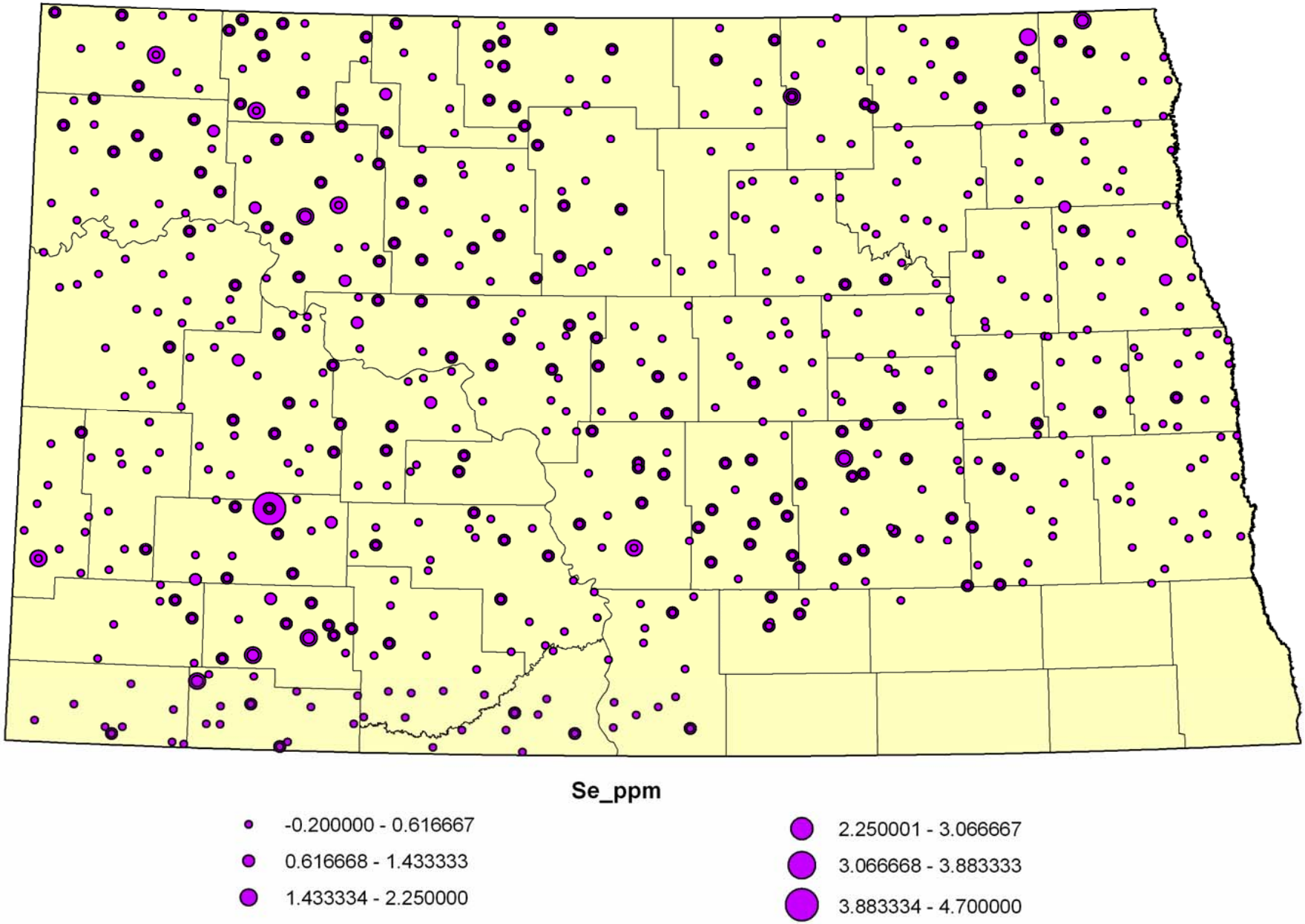
Mercury


Hg_ppm
-0.020000 - 0.051667
0.051668 - 0.123333
0.123334 - 0.195000
0.195001 - 0.266667
0.266668 - 0.338333
0.338334 - 0.410000

Distribution of Se in the conterminous US



Selenium


Se_ppm
-0.200000 - 0.616667
0.616668 - 1.433333
1.433334 - 2.250000
2.250001 - 3.066667
3.066668 - 3.883333
3.883334 - 4.700000

Data for DKG7L

Field name	DKG7L
Description	Cr horizon; Weathered lignite
Latitude	46.94699
longitude	-102.55816
As (ppm)	45.2 (2.7 ± 0.3)
Hg (ppm)	0.41 (0.040 ± 0.007)
Se (ppm)	4.7 (0.63 ± 0.19)

Figures in parentheses are averages for Stark County

Google Earth

Potential Applications

- **Baseline**
- **Agricultural** (Selenium in durum wheat, buckwheat and mustard)
- **Geologic** (Differentiation of tills, natural resources)
- **Soil characterization** (Geochemical fingerprints)
- **Health issues**
- **Environmental**
- **Other**

Questions?