Concentrations and Distribution of Inorganic Elements in Connecticut C-horizon soils

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Geochemical Landscapes Project

USGS and CT Geological Survey

- Define and understand the geochemical baseline concentrations for soils
- Samples analyzed for 42 major and trace constituents
- ICP-AES ICP-MS following a four-acid extraction
- single element determinations for As, Hg, and Se as well as analysis of total C, carbonate C, and total S
- Arsenic was analyzed by hydride generation atomic absorption spectrometry

Soil sample collection in CT

- Specific to CT (CT DEEP)--randomly selected samples on a 130-km^2 grid, C horizon, A horizon, upper 2 cm soil
- Represents largest soils geochemistry data set available for CT
- Samples collected by CT GS according to USGS GLP protocols
- C-horizon– 80 soil samples collected at 79 sites
- A horizon-- 88 samples collected from 86 sites
- Upper 0 to 2 cm--102 samples collected at 100 sites

Primary Objectives

- Establish baseline concentrations for C-horizon soils

  -useful in determining cleanup standards and in exposure assessments

  -plant productivity/ aquatic habitat

  -assume not related to overlying land use

Summary of 42 Analytical Constituents

* Elements of environmental concern

⇒ Elements of Interest to DEP Remediation Division

⇨ Additional Elements of USGS Interest

	Element	Lower reporting limit	Upper reporting limit
	Aluminum, Al	0.01%	15%
⇨	Calcium, Ca	0.01%	15%
⇒	Iron, Fe *	0.01%	15%
	Potassium, K	0.01%	15%
	Magnesium, Mg	0.01%	15%
⇒	Sodium, Na	0.01%	15%
	Phosphorus, P	50 ppm	1%
	Titanium, Ti	0.01%	15%
	Silver, Ag	1 ppm	10 ppm
⇒	Arsenic, As *	1 ppm	1%
⇒	Barium, Ba	5 ppm	1%
	Beryllium, Be	0.1 ppm	100 ppm
	Bismuth, Bi	0.04 ppm	1%
⇒	Cadmium, Cd *	0.1 ppm	1%
	Cerium, Ce	0.05 ppm	0.10%
	Cobalt, Co *	0.1 ppm	1%
⇒	Chromium, Cr *	1 ppm	1%
	Cesium, Cs	0.05 ppm	0.10%
⇨	Copper, Cu *	0.5 ppm	1%
	Gallium, Ga	0.05 ppm	500 ppm
	Indium, In	0.02 ppm	0.05%
	Lanthanum, La	0.5 ppm	0.10%
⇒	Lithium, Li *	1 ppm	5%
⇒	Manganese, Mn *	5 ppm	1%
⇒	Mercury,Hg *	.01 ppm	
	Molybdenum, Mo*	0.05 ppm	1%
	Niobium, Nb	0.1 ppm	0.10%
⇒	Nickel, Ni *	0.5 ppm	1%
⇒	Lead, Pb *	0.5 ppm	1%
	Rubidium, Rb	0.2 ppm	1%
⇨	Sulfur, S	0.01%	5%
⇒	Antimony, Sb	0.05 ppm	1%
	Scandium, Sc	0.1 ppm	0.10%
	Tin, Sn *	0.1 ppm	0.10%
⇒	Strontium, Sr	0.5 ppm	1%
	Tellurium, Te	0.1 ppm	0.05%
⇒	Thallium, Tl	0.1 ppm	1%
	Thorium, Th	0.2 ppm	1%
⇒	Uranium, U*	0.1 ppm	1%
	Vanadium, V*	1 ppm	1%
	Tungsten, W	0.1 ppm	1%
	Yttrium, Y	0.1 ppm	1%
⇨	Zinc, Zn *	1 ppm	1%

Primary Objectives

- Establish baseline concentrations for C-horizon soils

  -useful in determining cleanup standards and in exposure assessments

  -potential plant productivity

  -assume not related to overlying land use

- Determine if soil chemistry relates to underlying geology

Soil Origin

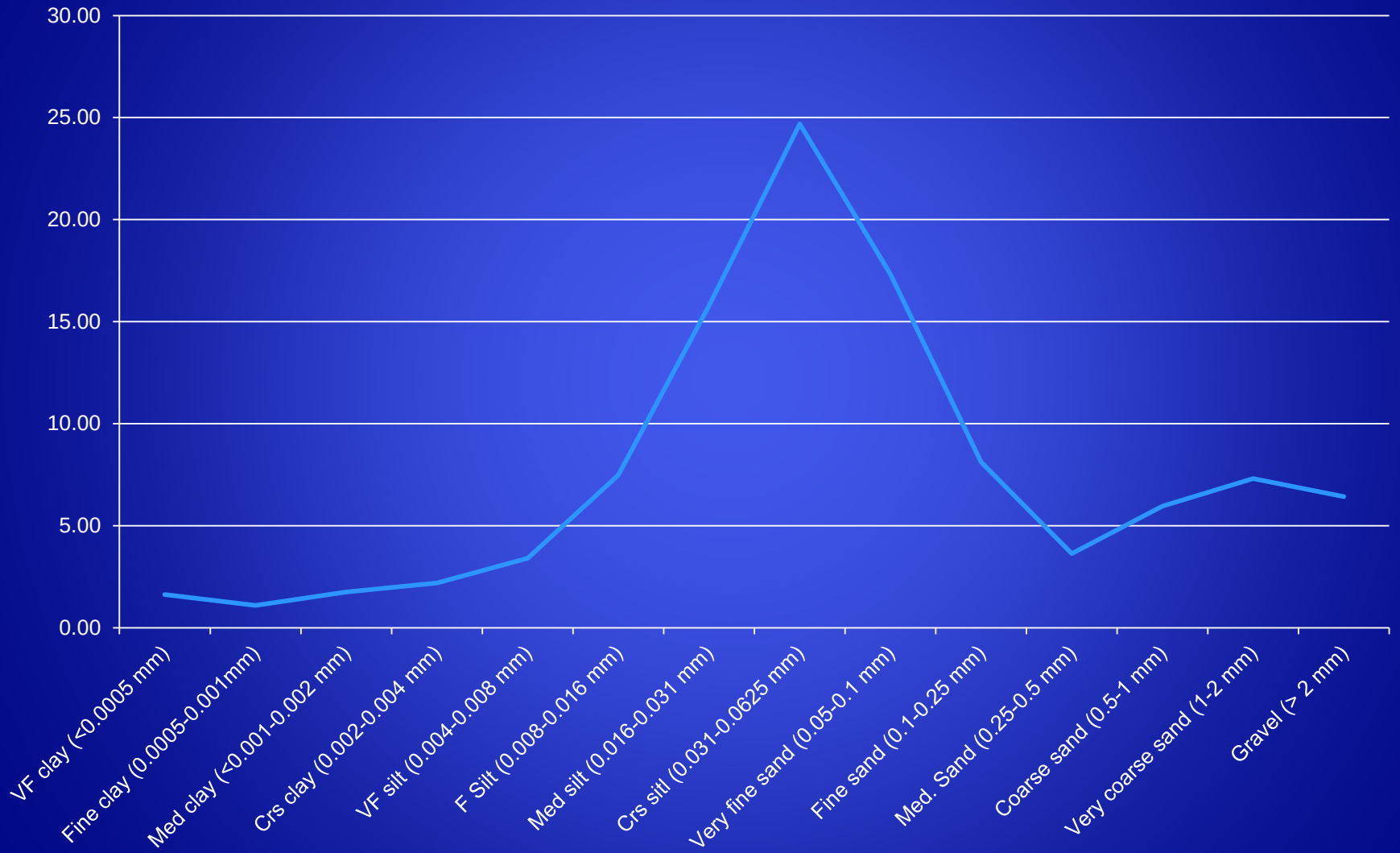
- Could not establish precise origin of C-horizon soil

  -soils were not described in great enough detail to distinguish glacial setting, till vs drift

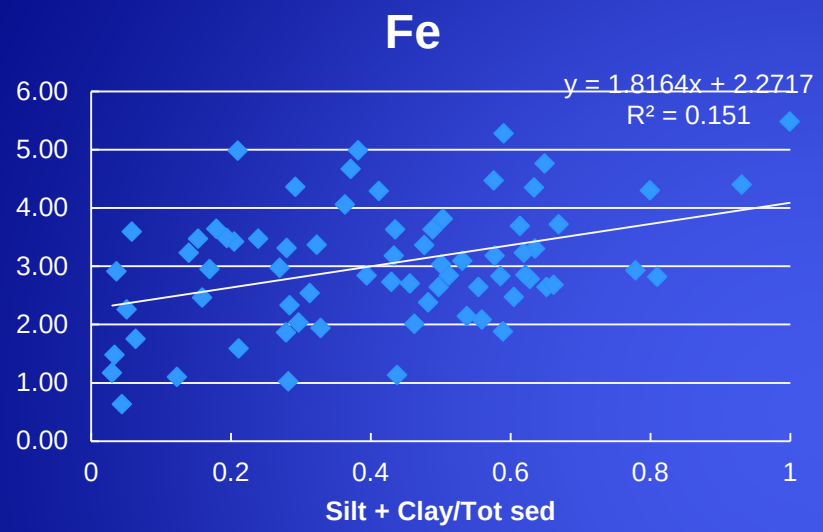
- Samples were submitted for grain-size analysis

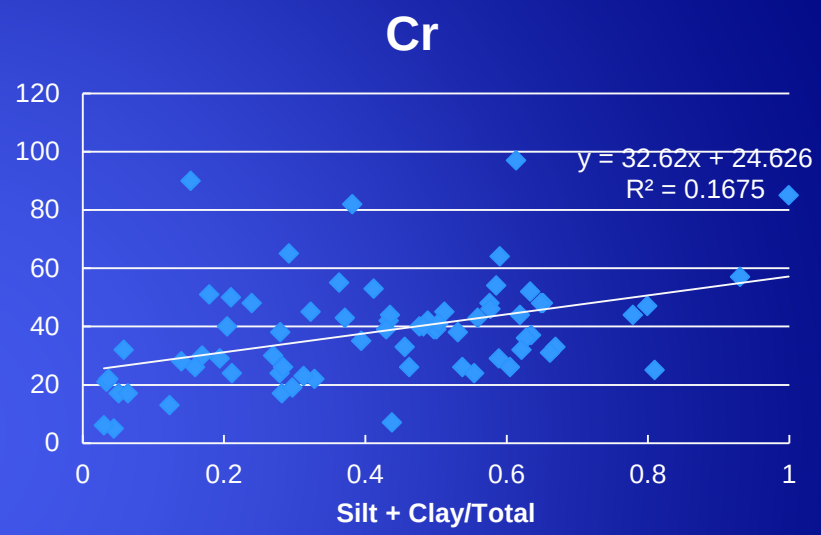
  -is grain size related to element concentrations

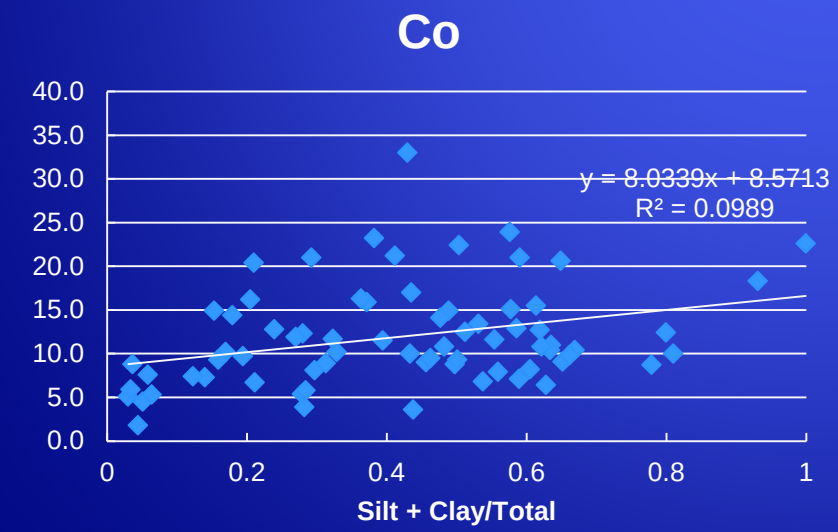
Grain-size analysis

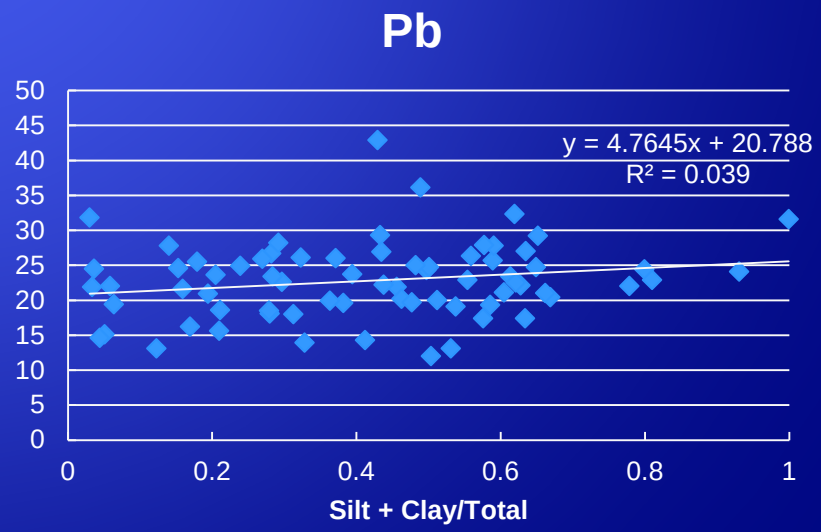


Grain-size analysis



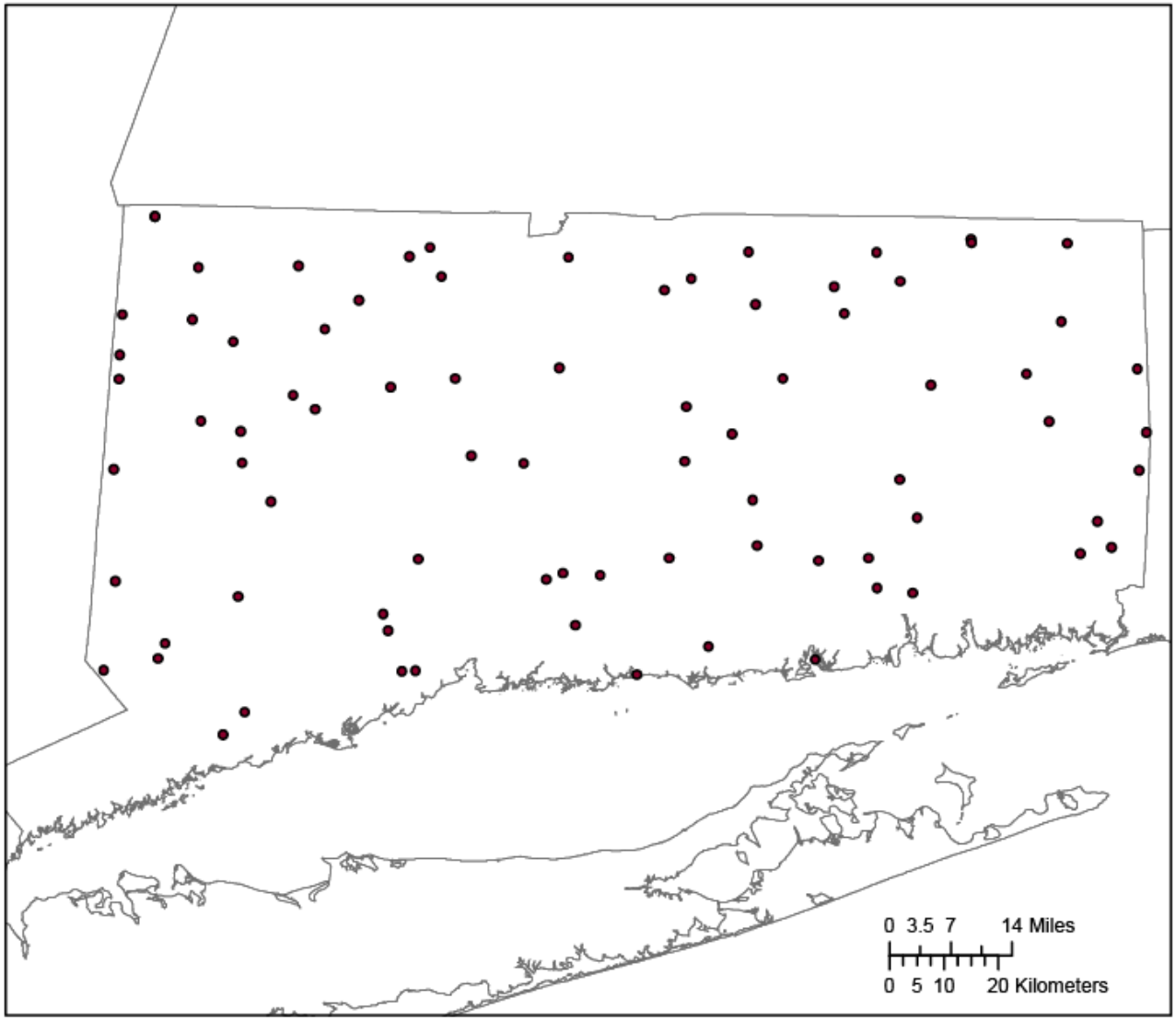






Approach

- Compare soils chemistry with existing geologic and lithogeochemical maps and other sediment chemistry data using GIS and statistical analysis

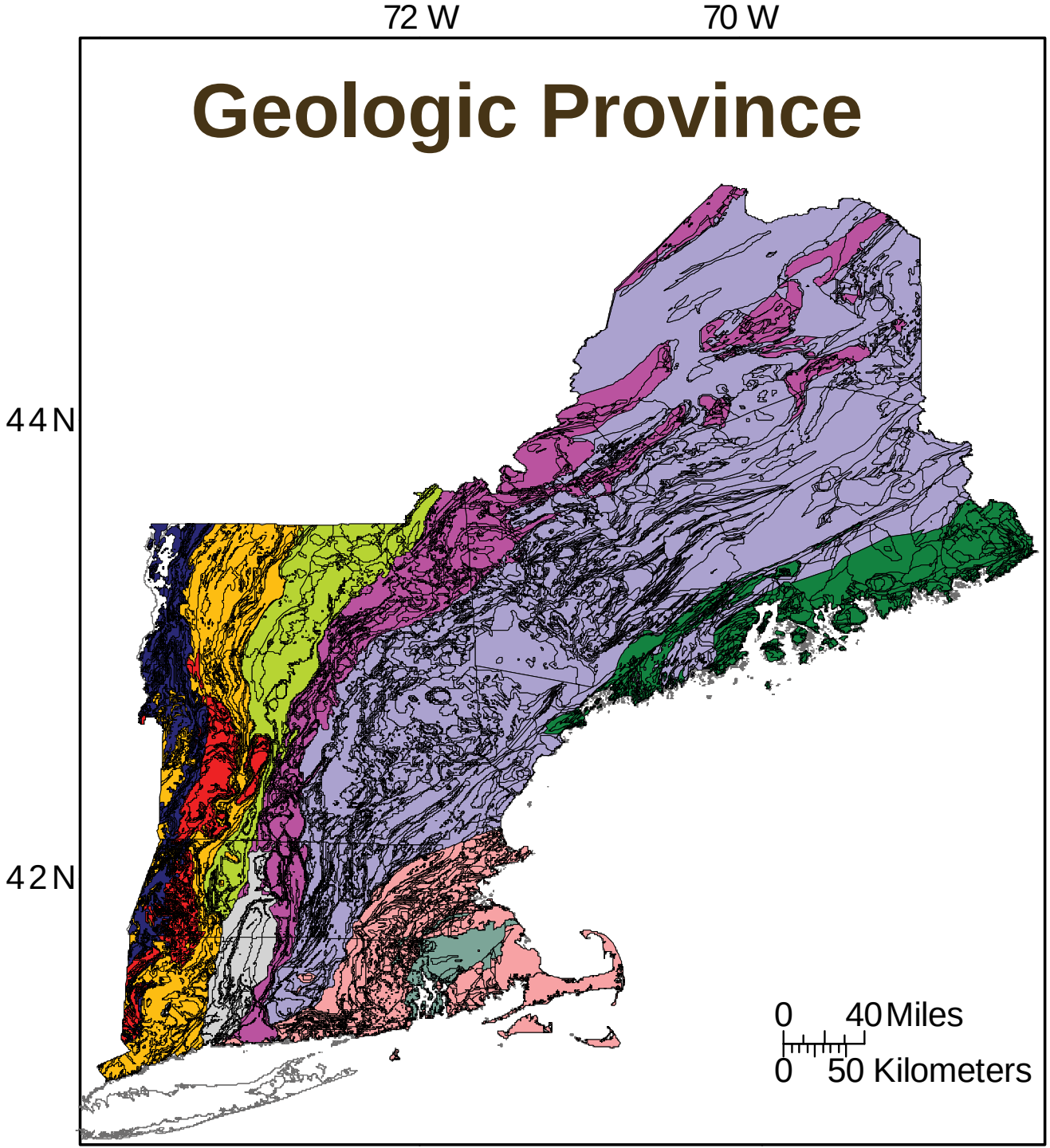

0 3.5 7 14 Miles
0 5 10 20 Kilometers

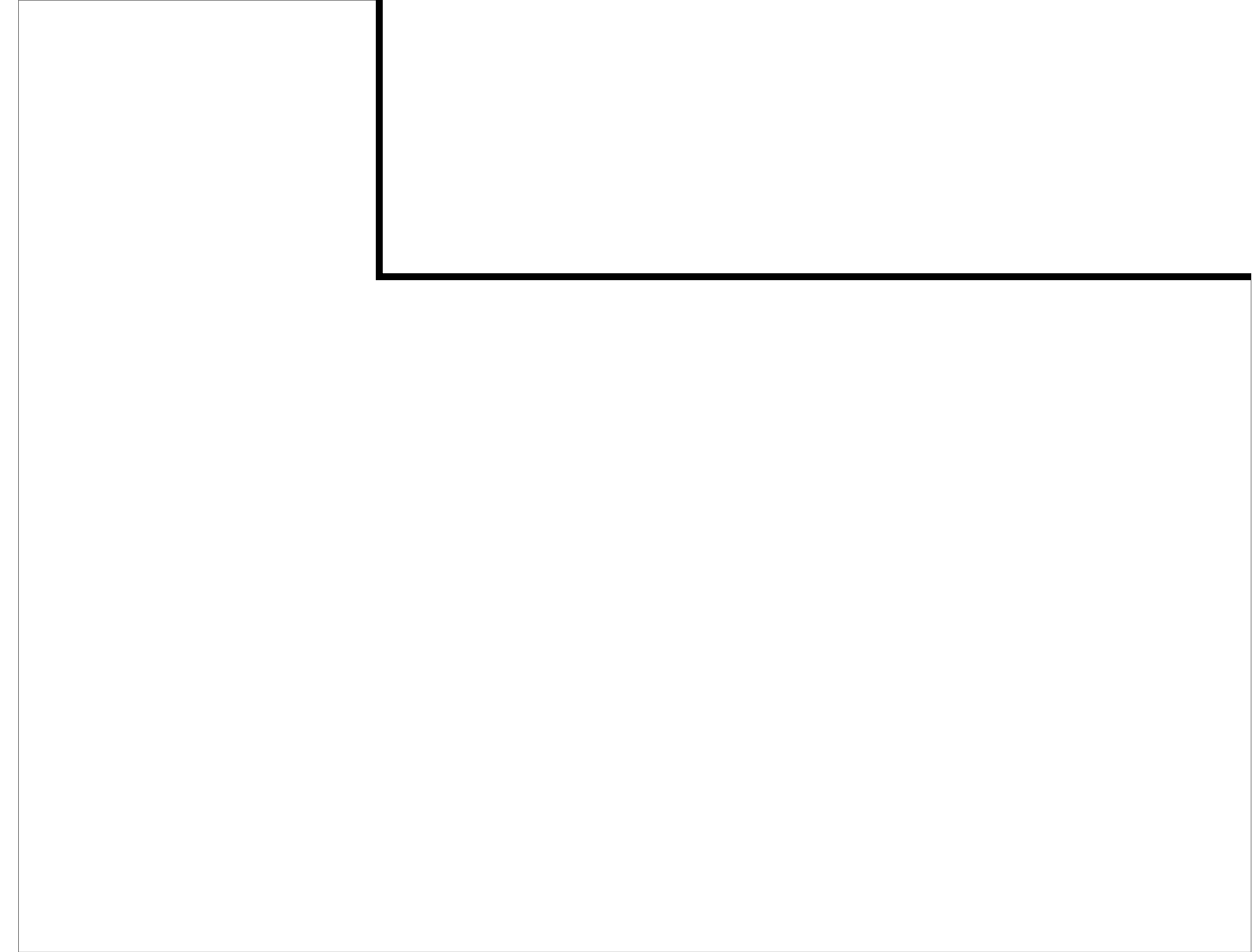
Compiled geologic map of CT

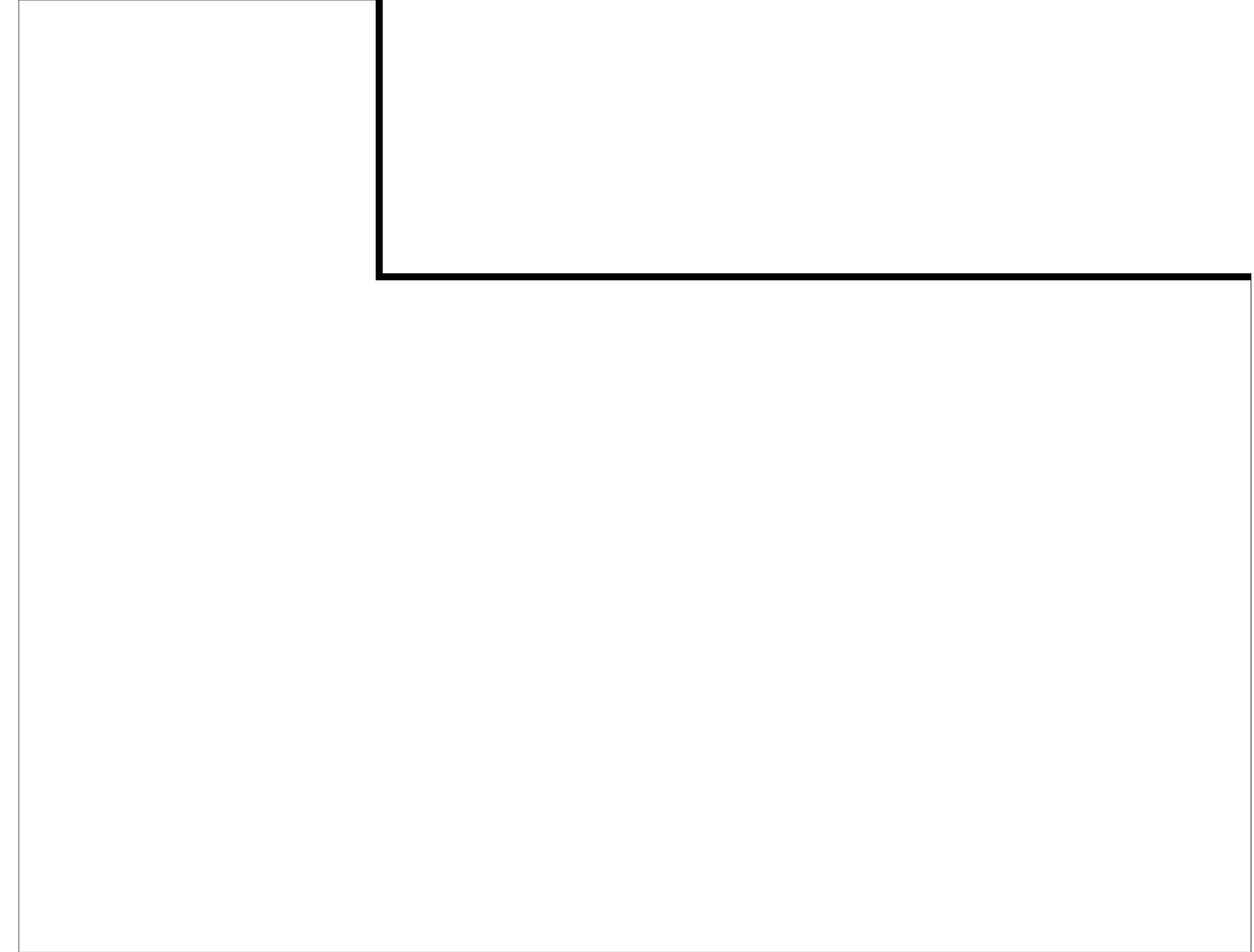
Rodgers (1985)

Connecticut Geologic terrane

Rodgers (1985)

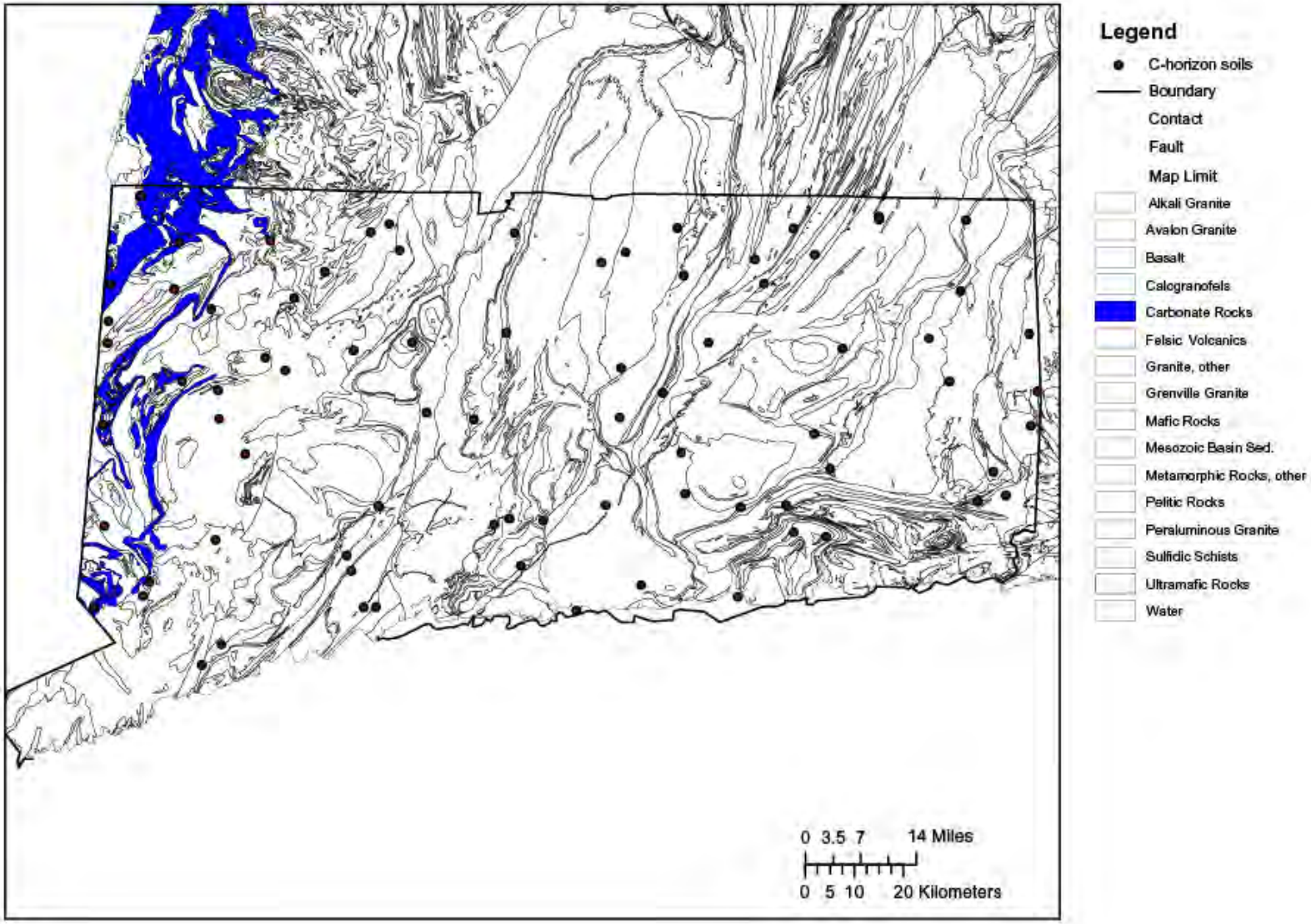

72 W
70 W
Geologic Province
44N
42N
0 40 Miles
0 50 Kilometers

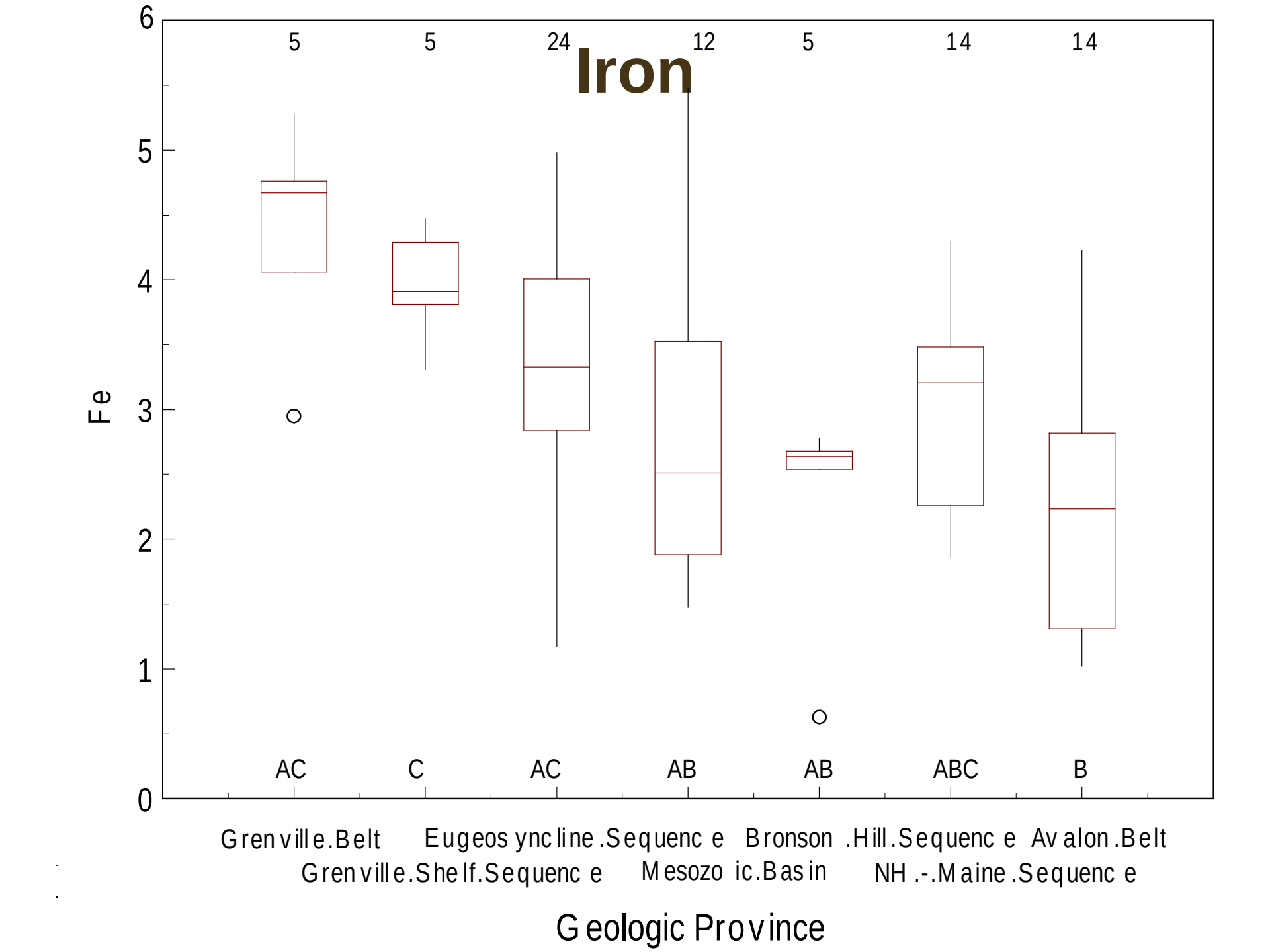


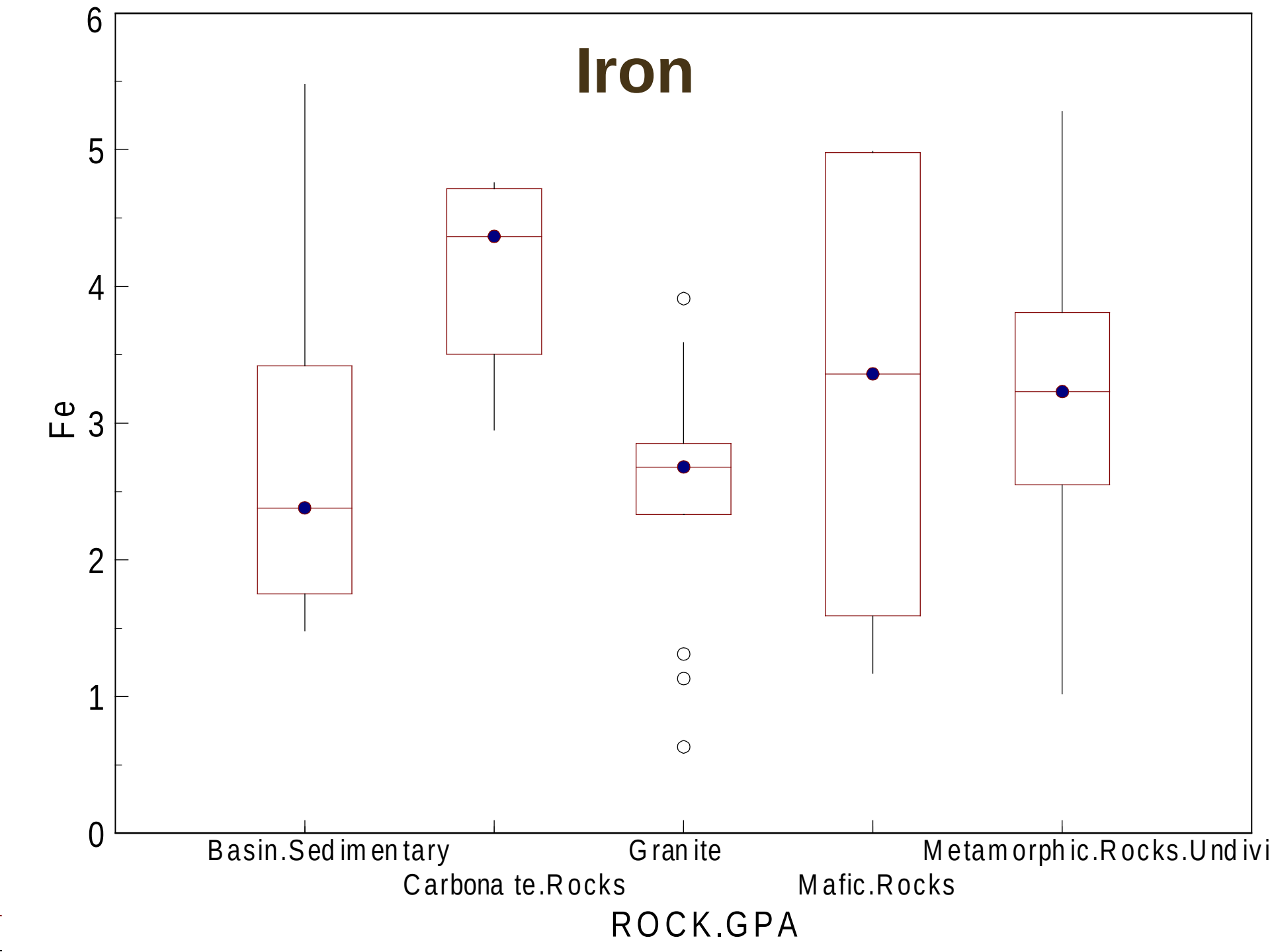


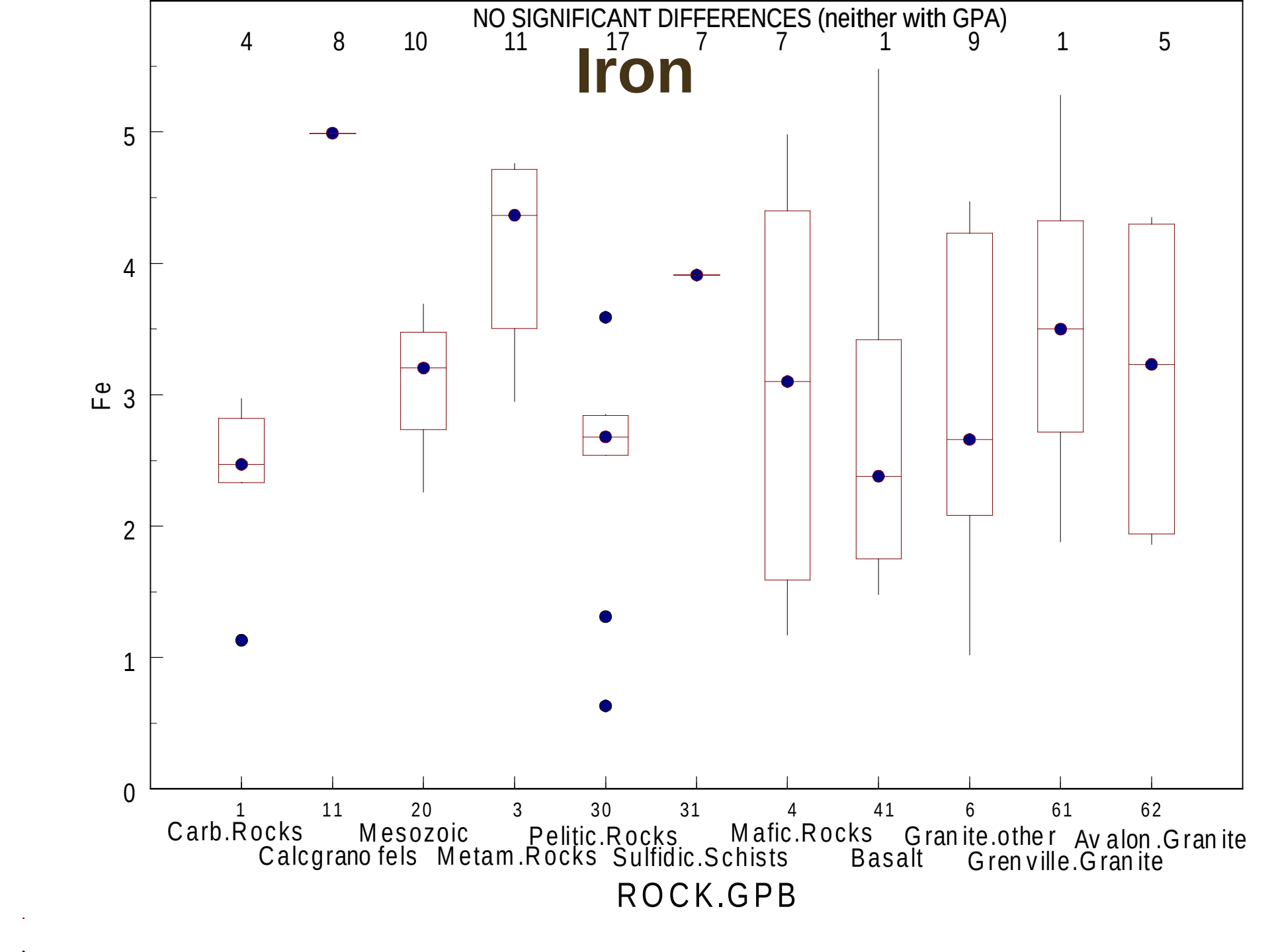
Rock Group B

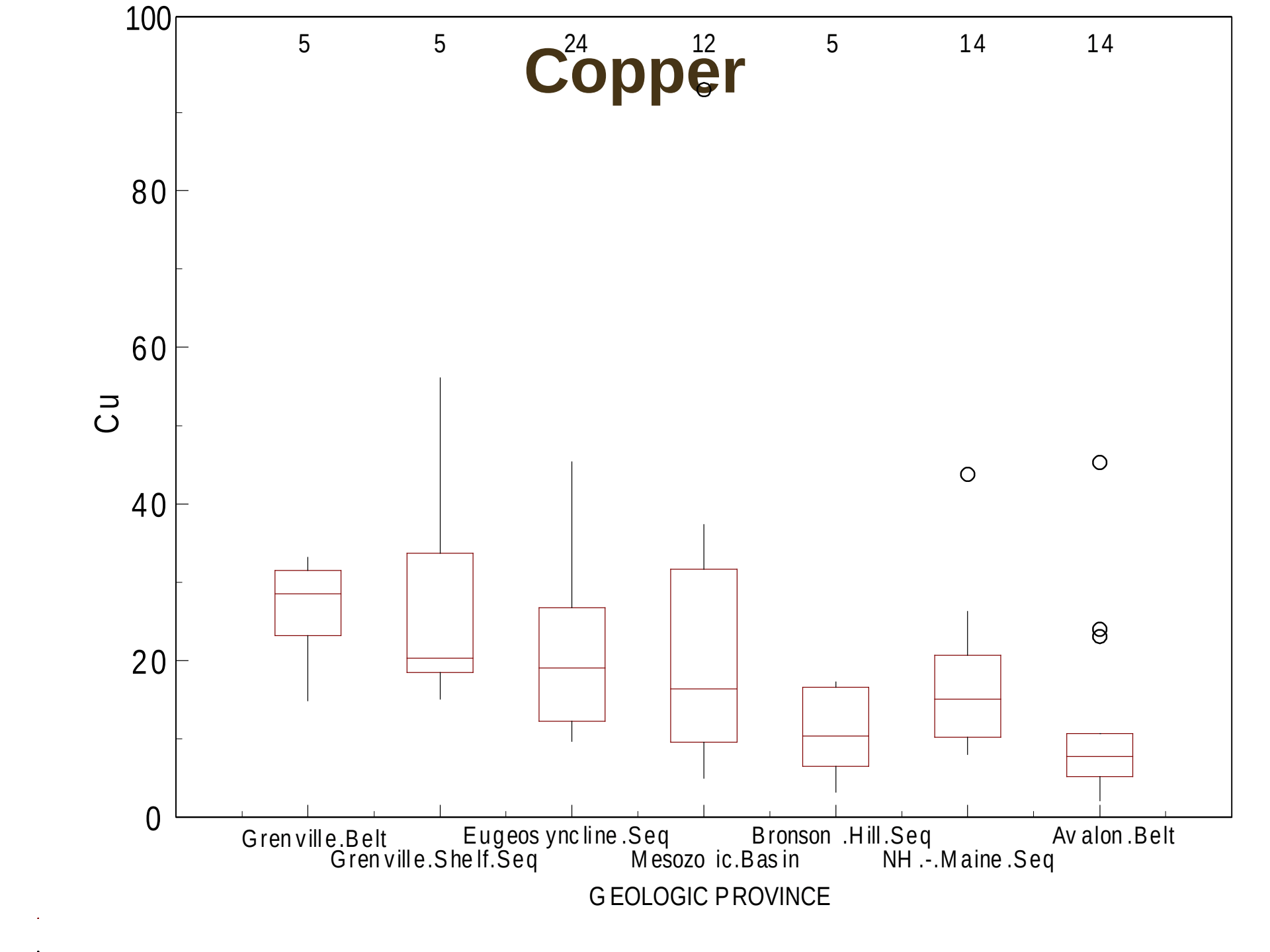
Carbonates

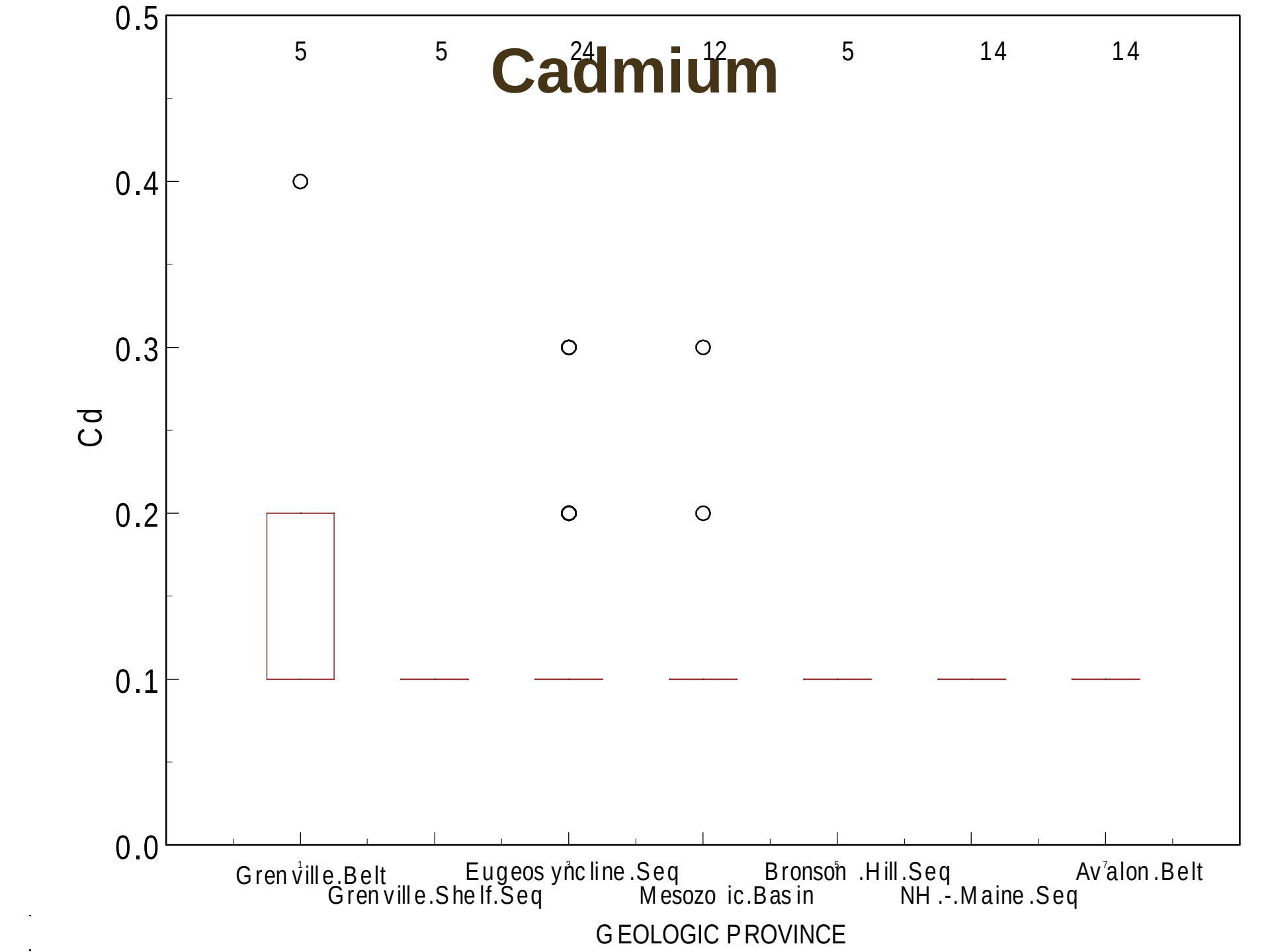

Legend
C-horizon soils
Boundary
Contact
Fault
Map Limit
Alkali Granite
Avalon Granite
Basalt
Calcgranofels
Carbonate Rocks
Felsic Volcanics
Granite, other
Grenville Granite
Mafic Rocks
Mesozoic Basin Sed.
Metamorphic Rocks, other
Pelitic Rocks
Peraluminous Granite
Sulfidic Schists
Ultramafic Rocks
Water
0 3.5 7 14 Miles
0 5 10 20 Kilometers

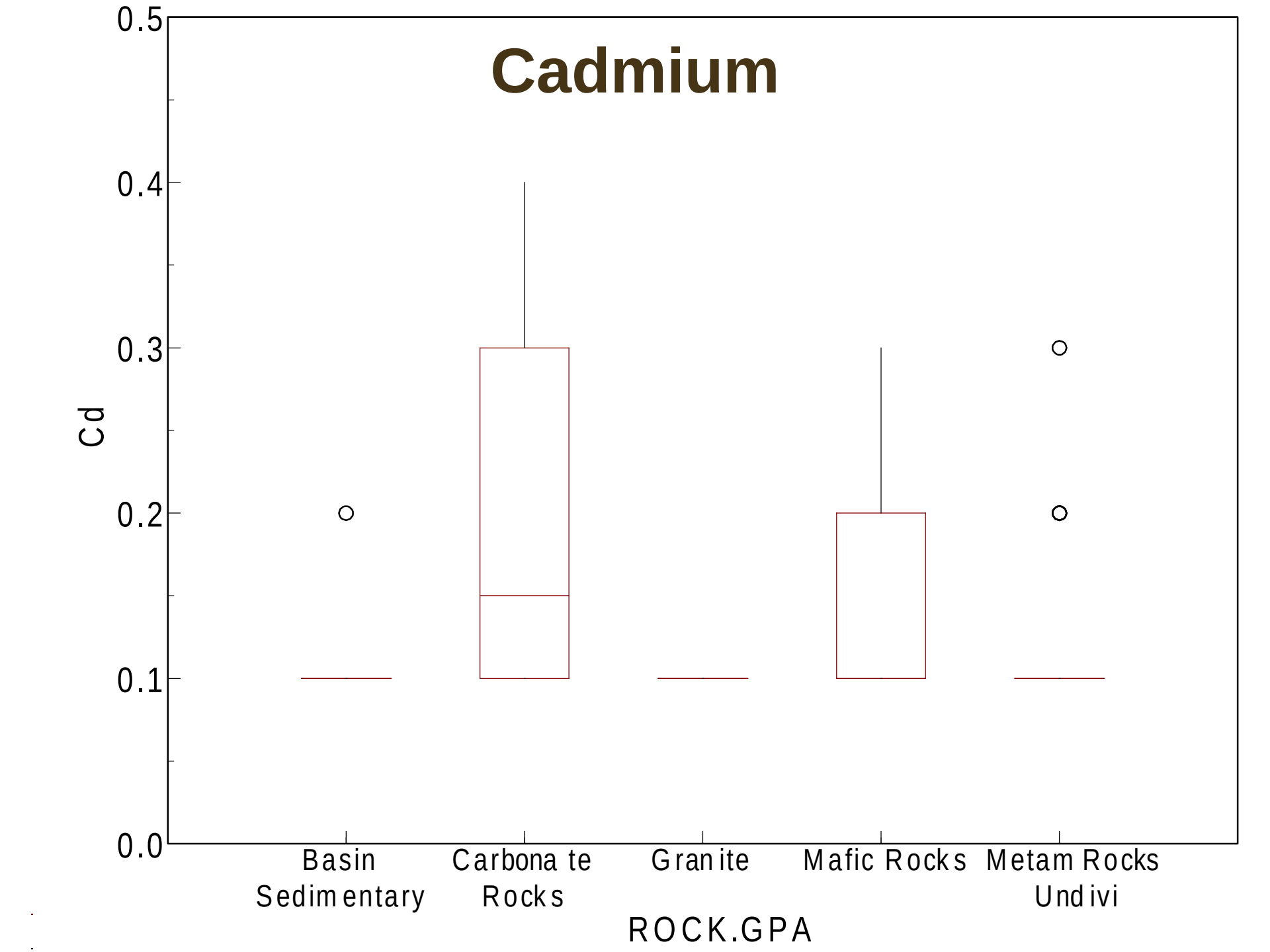

Iron
5
5
24
12
5
14
14
Fe
6
5
4
3
2
1
0
AC
C
AC
AB
AB
ABC
B
Grenville.Belt
Grenville.Shelf.Sequence
Eugeosyncline.Sequence
Mesozoic.Basin
Bronson.Hill.Sequence
NH.-.Maine.Sequence
Avalon.Belt
Geologic Province

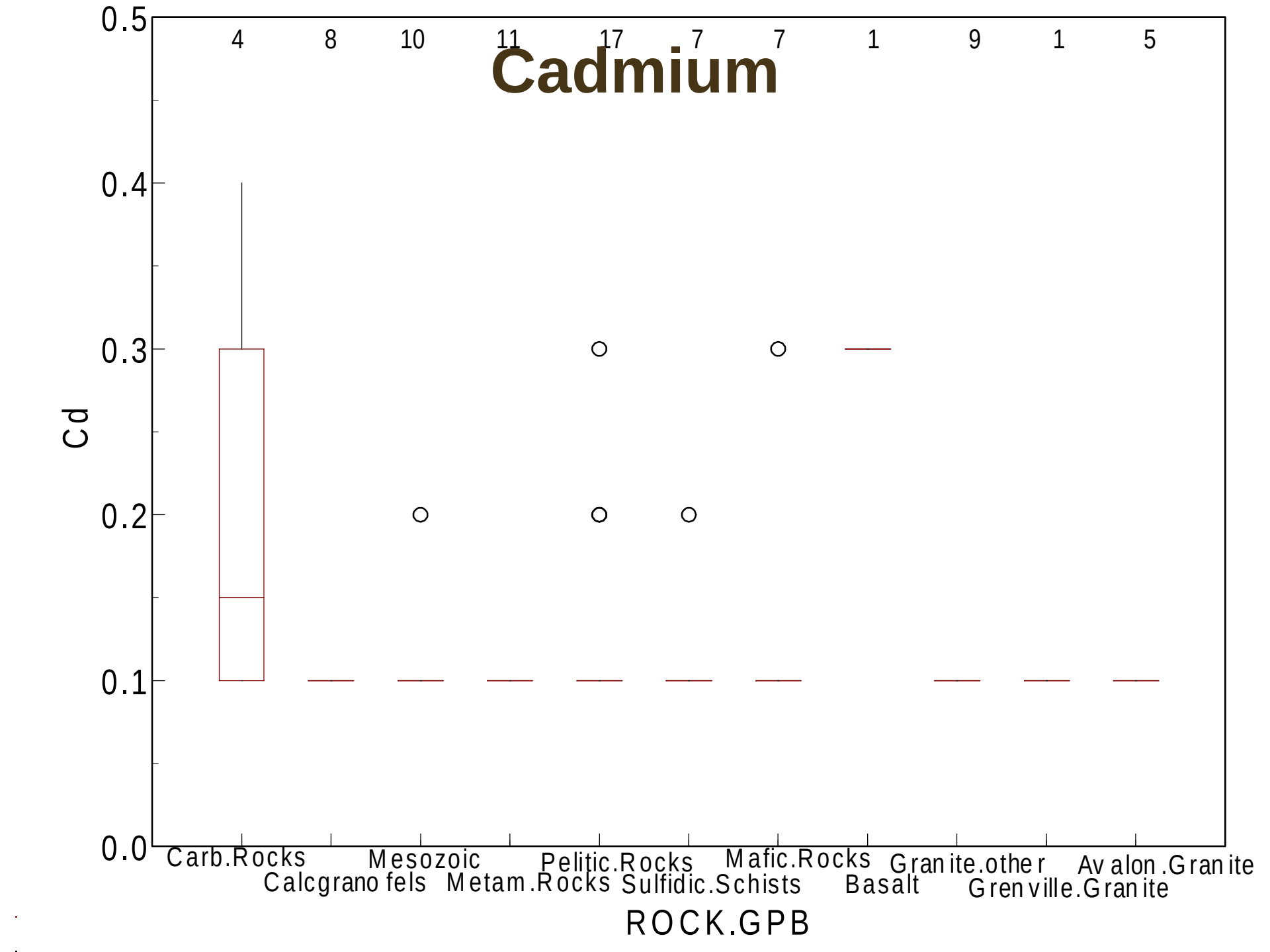

Iron
Fe
0
1
2
3
4
5
6
Basin.Sedimentary
Carbona te.Rocks
Granite
Mafic.Rocks
Metamorphic.Rocks.Undivi
ROCK.GPA

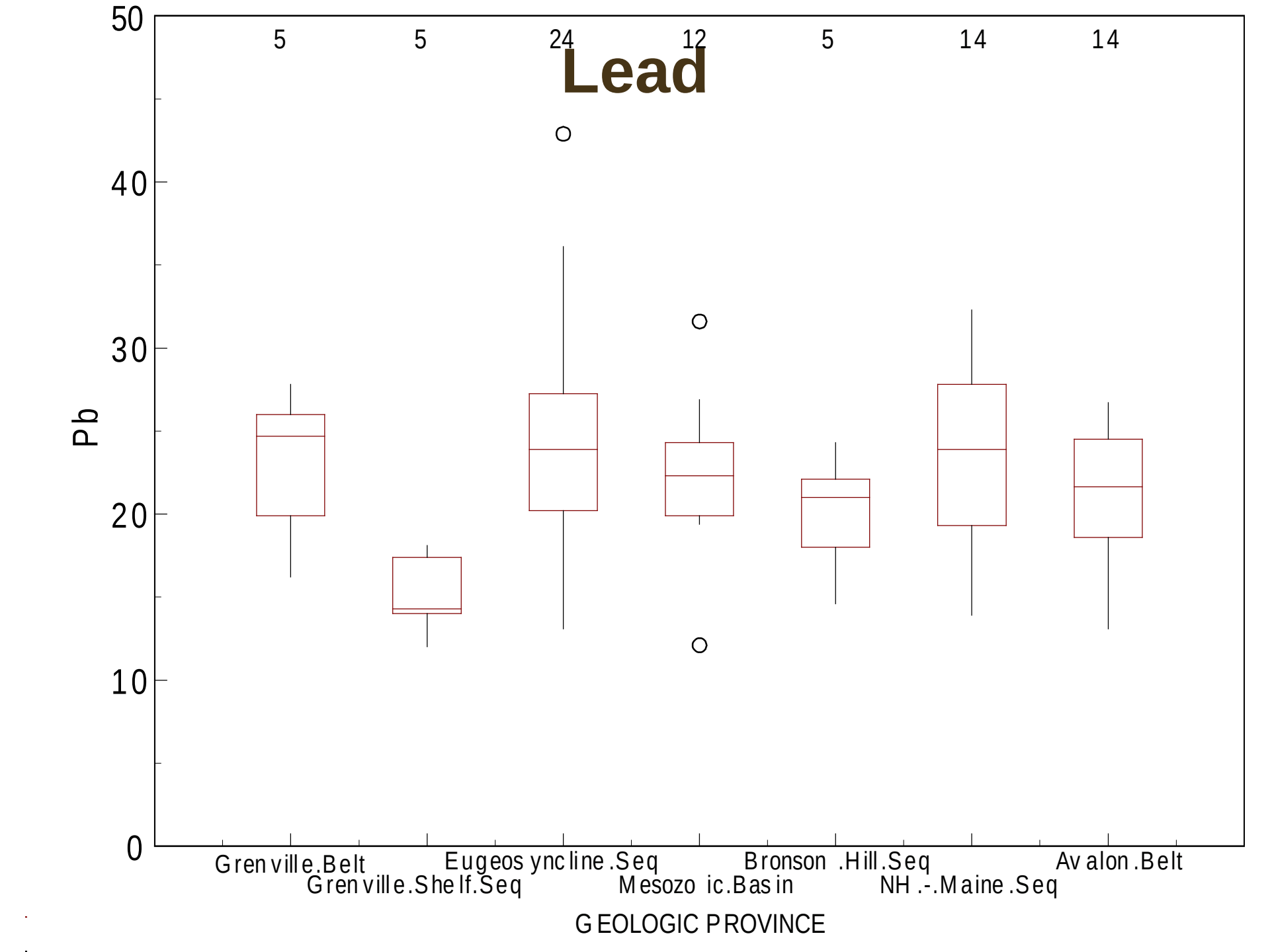

NO SIGNIFICANT DIFFERENCES (neither with GPA)
Iron
4 8 10 11 17 7 7 1 9 1 5
Fe
0 1 2 3 4 5
1 11 20 3 30 31 4 41 6 61 62
Carb.Rocks Calcgranofels
Mesozoic Metam.Rocks
Pelitic.Rocks Sulfidic.Schists
Mafic.Rocks Basalt
Granite.other Grenville.Granite
Avalon.Granite
ROCK.GPB


Copper
5
5
24
12
5
14
14
100
80
60
40
20
0
Cu
Grenville.Belt
Grenville.Shelf.Seq
Eugeosyncline.Seq
Mesozoic.Basin
Bronson.Hill.Seq
NH.-.Maine.Seq
Avalon.Belt
GEOLOGIC PROVINCE


Cadmium
5
5
24
12
5
14
14
0.5
0.4
0.3
0.2
0.1
0.0
Cd
1
Grenville.Belt
Grenville.Shelf.Seq
2
Eugeosyncline.Seq
Mesozoic.Basin
5
Bronson .Hill.Seq
NH .-.Maine.Seq
7
Avalon.Belt
GEOLOGIC PROVINCE


Cadmium
0.5
0.4
0.3
0.2
0.1
0.0
Cd
Basin Sedimentary
Carbonate Rocks
Granite
Mafic Rocks
Metam Rocks Undivi
ROCK.GPA


Cadmium
4
8
10
11
17
7
7
1
9
1
5
0.5
0.4
0.3
0.2
0.1
0.0
Cd
Carb.Rocks
Calcgranofels
Mesozoic
Metam.Rocks
Pelitic.Rocks
Sulfidic.Schists
Mafic.Rocks
Basalt
Granite.other
Grenville.Granite
Avalon.Granite
ROCK.GPB

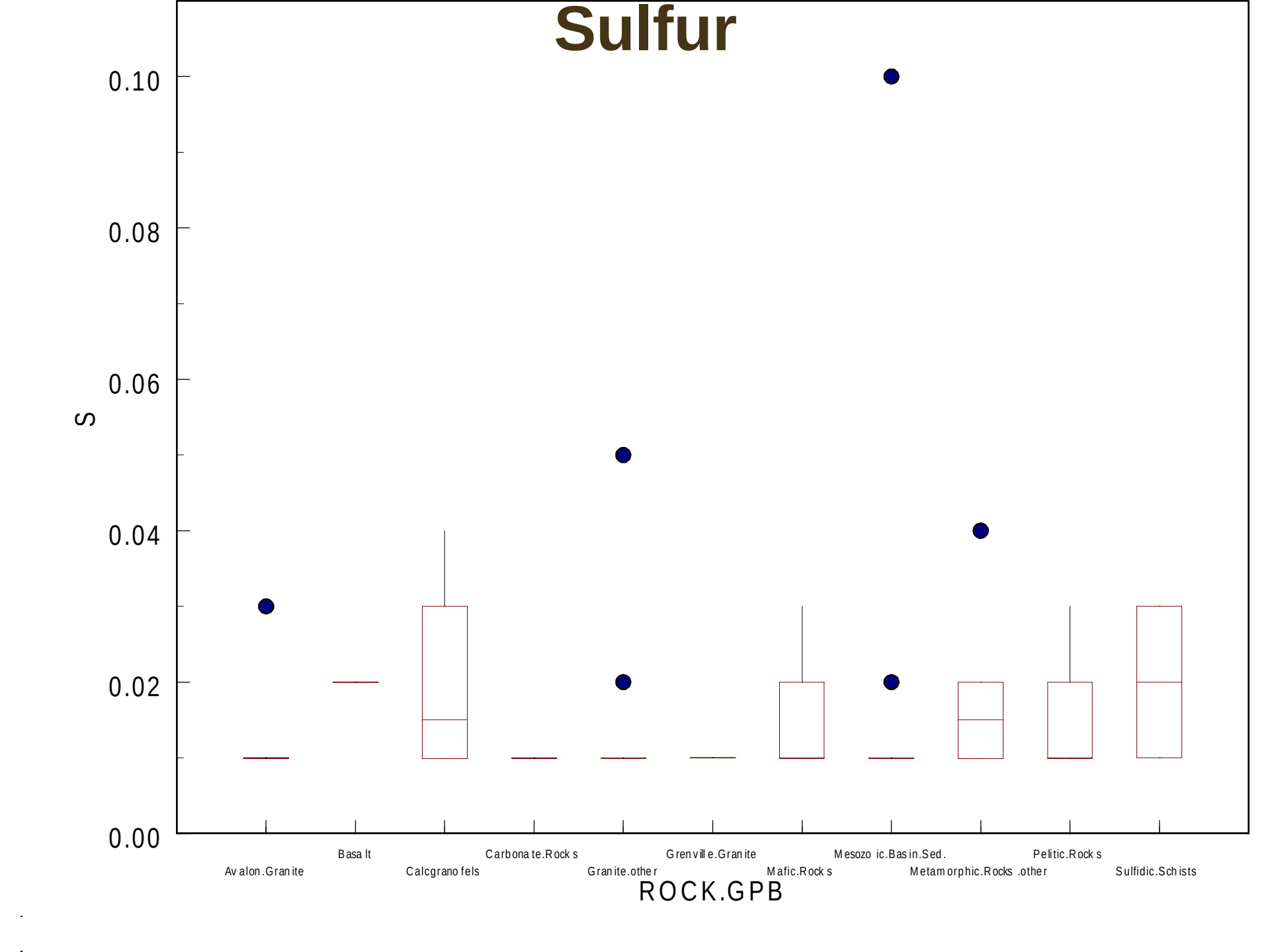

Lead
5
5
24
12
5
14
14
50
40
30
20
10
0
Pb
Grenville.Belt
Grenville.Shelf.Seq
Eugeosyncline.Seq
Mesozoic.Basin
Bronson .Hill.Seq
NH .-.Maine.Seq
Avalon.Belt
GEOLOGIC PROVINCE

Statistics

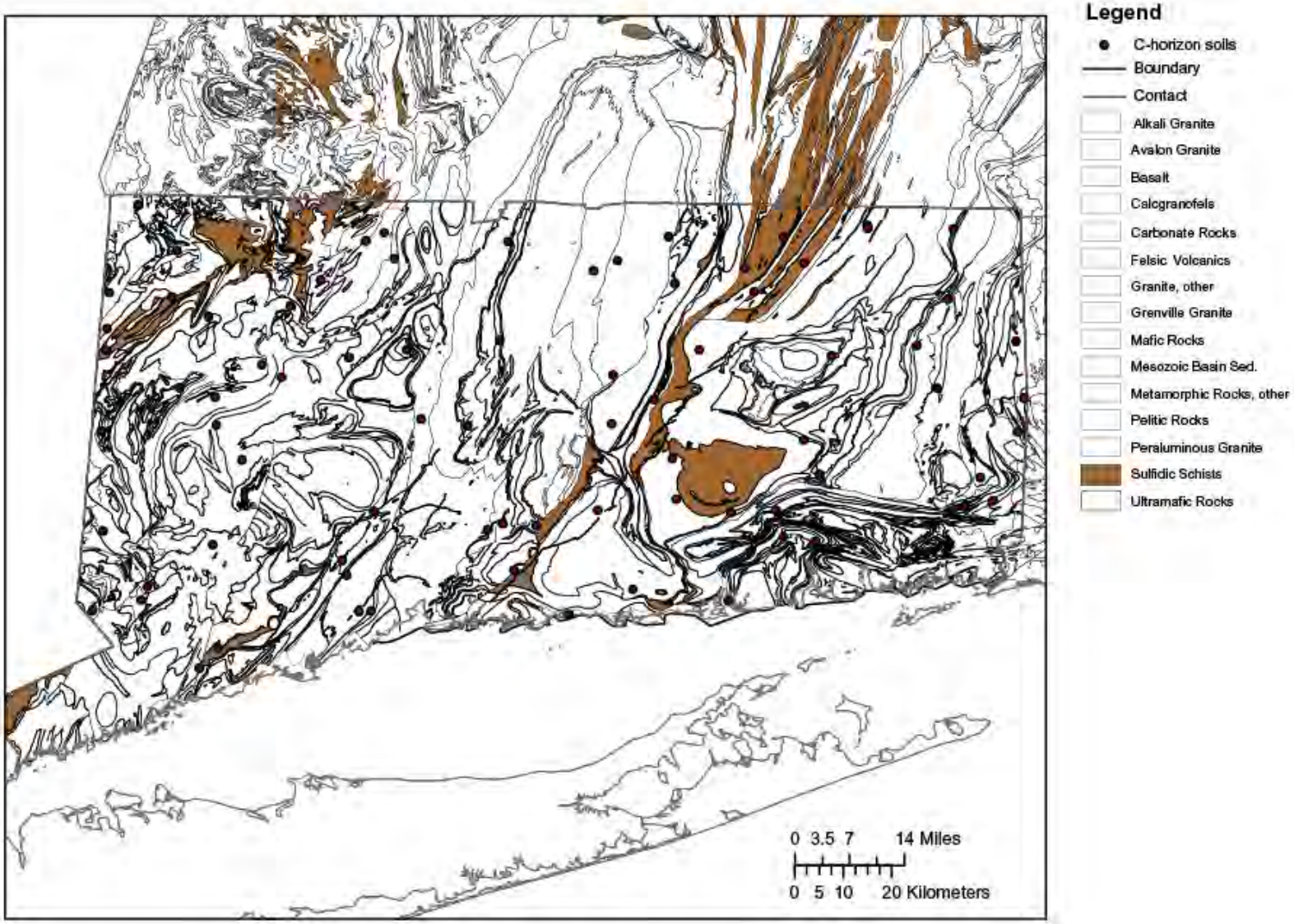
- Kruskal Wallis Rank-Sum test – whether concentration means are significantly different among different bedrock groupings
- Tukey’s honest significance difference test – used to discriminate which group or groups of data by underlying bedrock type differed
- Spearman's rank correlation – measure the association between C-horizon soil chemistry and that of (1) B-horizon soils (2) surficial soil samples, and (3) stream sediment chemistry data

C-horizon soils

- Within the 7 geologic provinces in CT, differences in mean concentrations of Ca, Mg, Na, K, Al, Ba, Ce, Co, Cr, Cu, Fe, Ga, Li, Mn, Nb, Ni, P, Pb, Sc, Sn, Sr, Ti, V, Y, and Zn


Sulfur
S
0.10
0.08
0.06
0.04
0.02
0.00
Avalon.Granite
Basalt
Calcgranofels
Carbonate.Rocks
Granite.other
Grenville.Granite
Mafic.Rocks
Mesozoic.Basin.Sed.
Metamorphic.Rocks.other
Pelitic.Rocks
Sulfidic.Schists
ROCK.GPB

Sulfidic schists

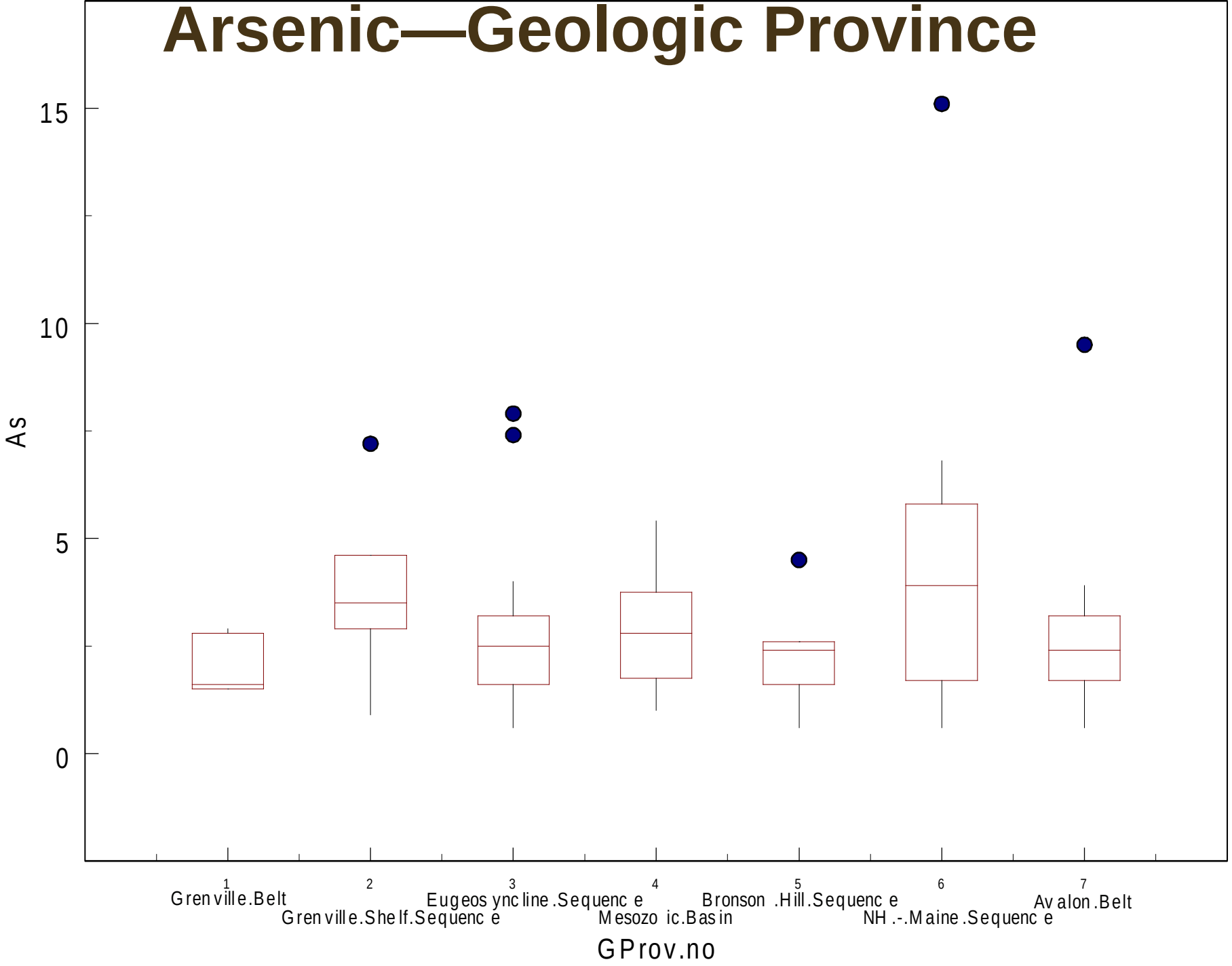


C-horizon soils

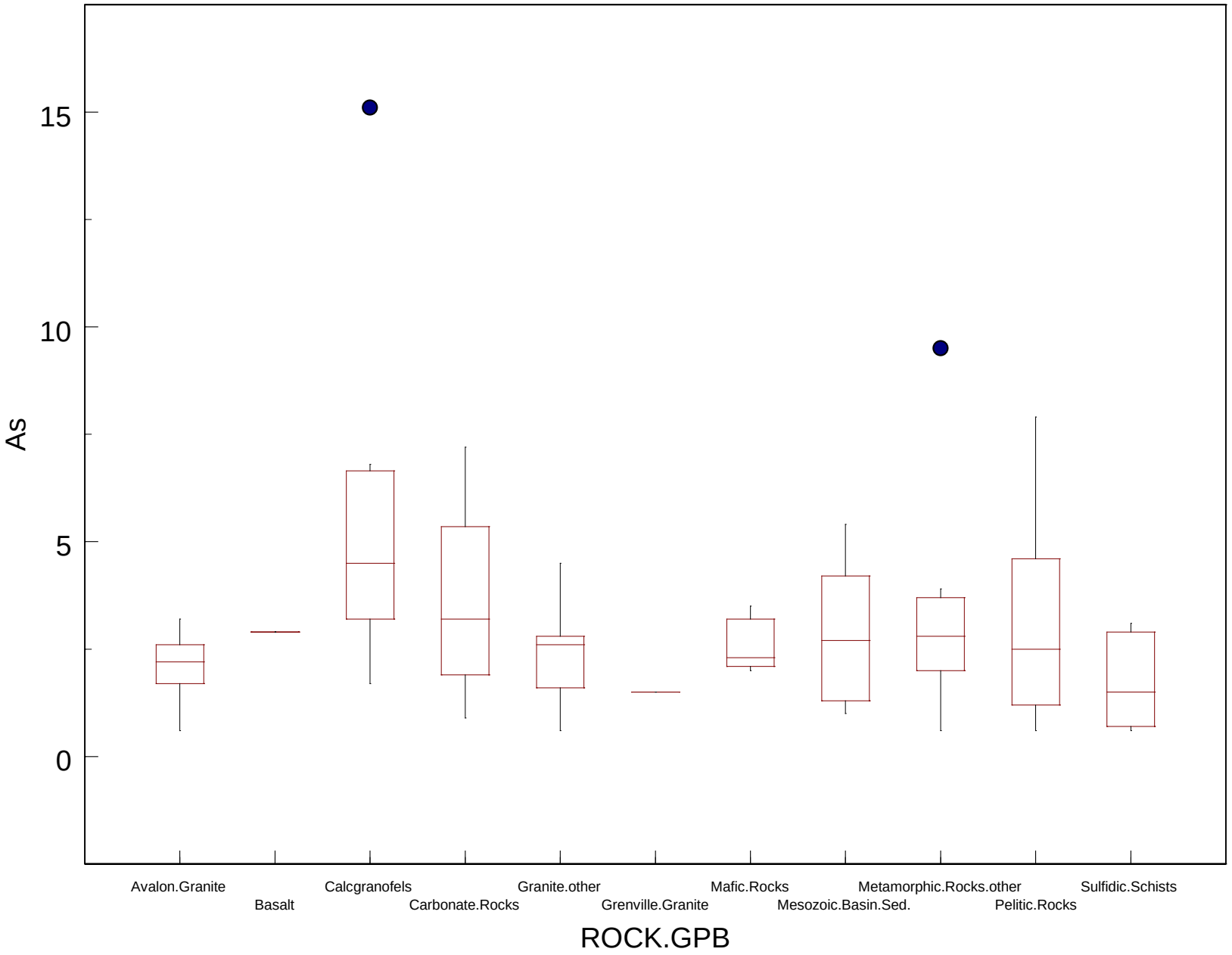
- soils overlying the NH-Maine sequence have the highest arsenic (As) concentrations (15 mg/kg)

- soils overlying granites of the Avalon belt have the highest uranium (U) concentrations (12 mg/kg and 14 mg/kg)

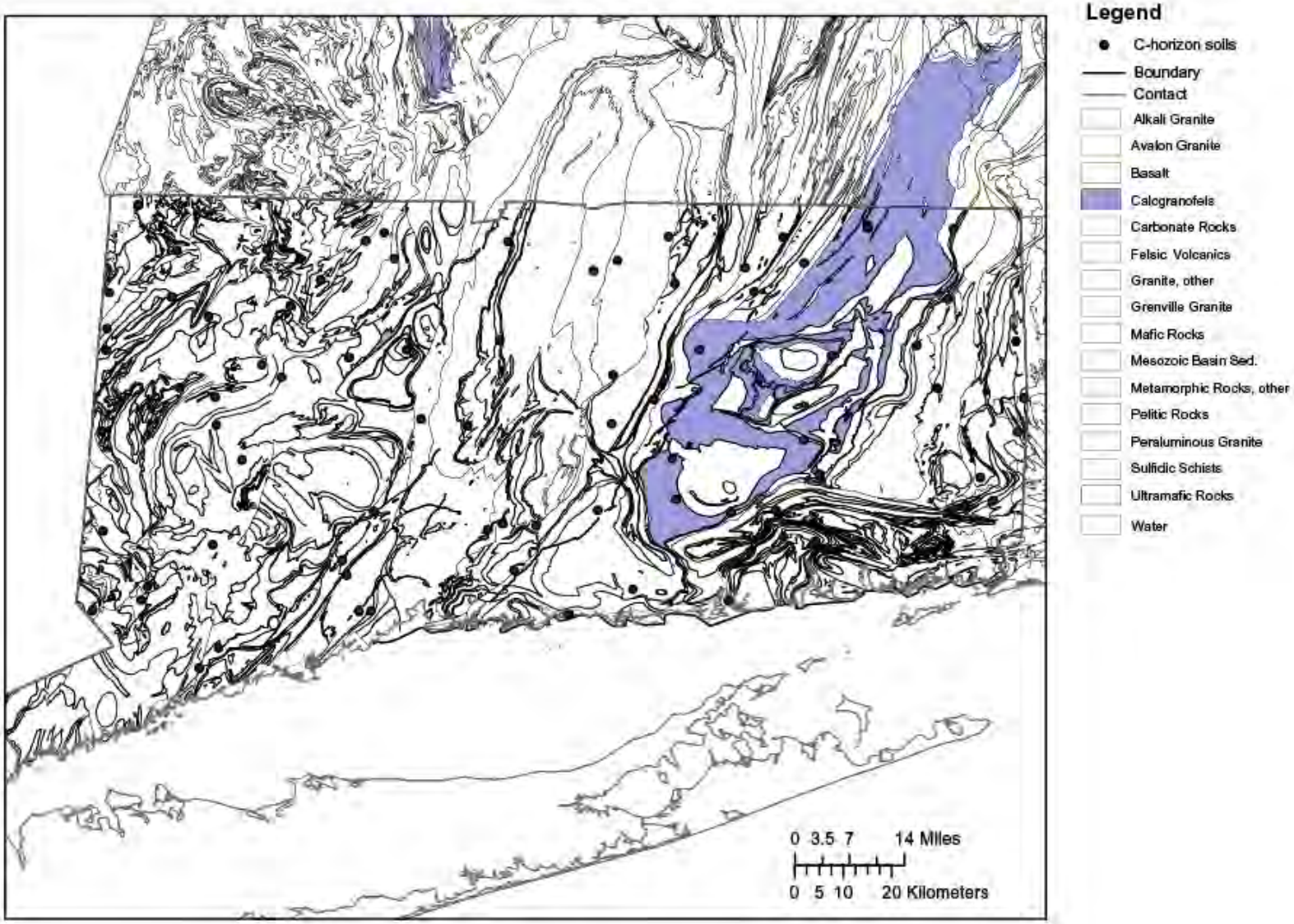
Arsenic—Geologic Province



Arsenic--GPB


15
10
5
0
As
Avalon.Granite
Basalt
Calcgranofels
Carbonate.Rocks
Granite.other
Grenville.Granite
Mafic.Rocks
Mesozoic.Basin.Sed.
Metamorphic.Rocks.other
Pelitic.Rocks
Sulfidic.Schists
ROCK.GPB

Calc-granofels



Conclusions and future work

- Concentrations of elements in C-horizon soils varied with:
  -- underlying rock types
  -- grain size– concentrations of several constituents higher in samples with more silt and clay
- Concentrations of elements in C-horizon soils compared to those at shallower depths?
  -- likely affected by land use
- Concentrations of elements in C-horizon soils compared to streams sediment sample chemistry (NAWQA and NURE)