The North American Soil Geochemical Landscapes Project

What's in a Number?

February 2008

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"Documenting and understanding natural variability is a vexing topic in almost every environmental problem: How do we recognize and understand changes in natural systems if we don't understand the range of baseline levels?"

Zoback, GSA Today, December 2001

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Soil Geochemical Landscapes Project

To inform decision-making

for

Environment and Health protection

by

enhancing certainty in risk assessment

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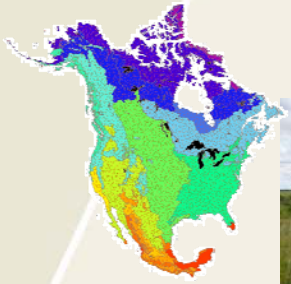
How Natural Sciences Inform



Empirical Measurement

Risk Factors

Process Knowledge

Wind, Water, Ice, Gravity
Weathering
Soil Formation

Environmental Modeling

Properties, Functions, Capacities

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Enhancing Certainty in Risk Assessment

What's in a Number?

How well the PART represents the WHOLE

How well the number informs on exposure and risk potential

The geological origins of geochemical variability

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- Graphs in the two slides that follow show a vertical geochemical profile for soil developed in Ni-rich glacial deposits in the Eastern Townships, Quebec.
- Triangles depict analyses of the <63 micron fraction of samples and circles the <2 micron fraction.
- The gradation in symbol colour is notional, distinguishing solum (dark and medium) from subsoil.
- The Ni is associated with ultramafic glacial debris originating at Thetford Mines.
- Graphs indicate an order-of-magnitude difference between surface and subsurface samples in the profile. These differences show that the interpretation of hazard potential also requires knowledge of sample depth and soil forming processes. Surface layers may not reflect the potential for hazard related to plant uptake via root systems, nor the potential for trace metal releases that may originate in land disturbances.

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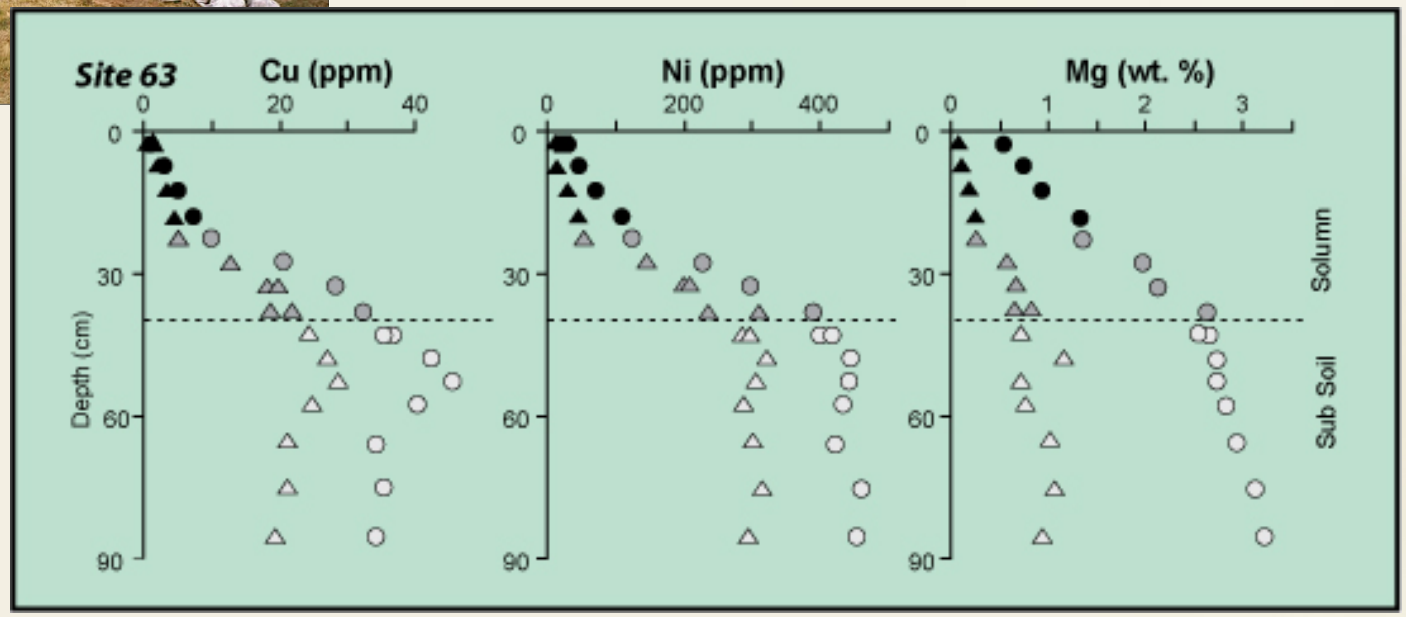
What's in a Number

Natural Variability at a Site

How well the **PART** represents the **WHOLE**



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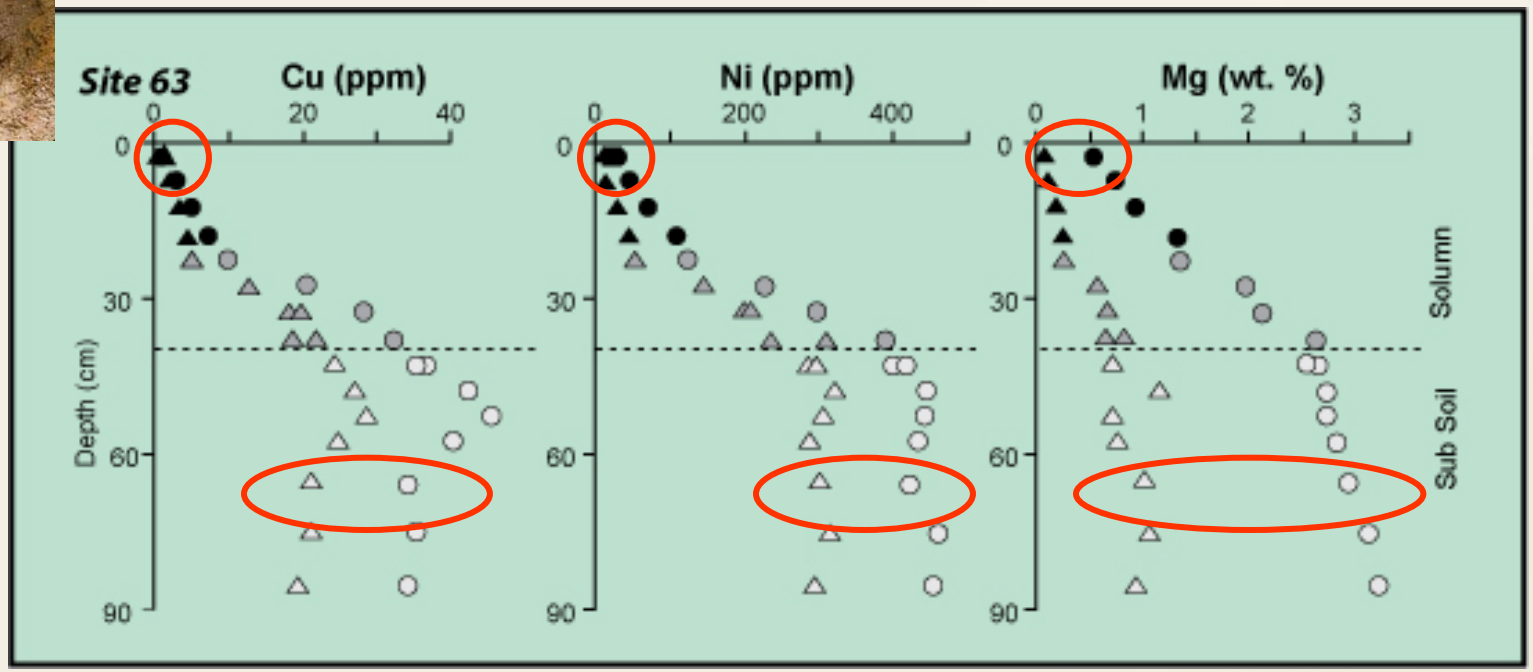
What's in a Number

How well the **PART** represents the **WHOLE**



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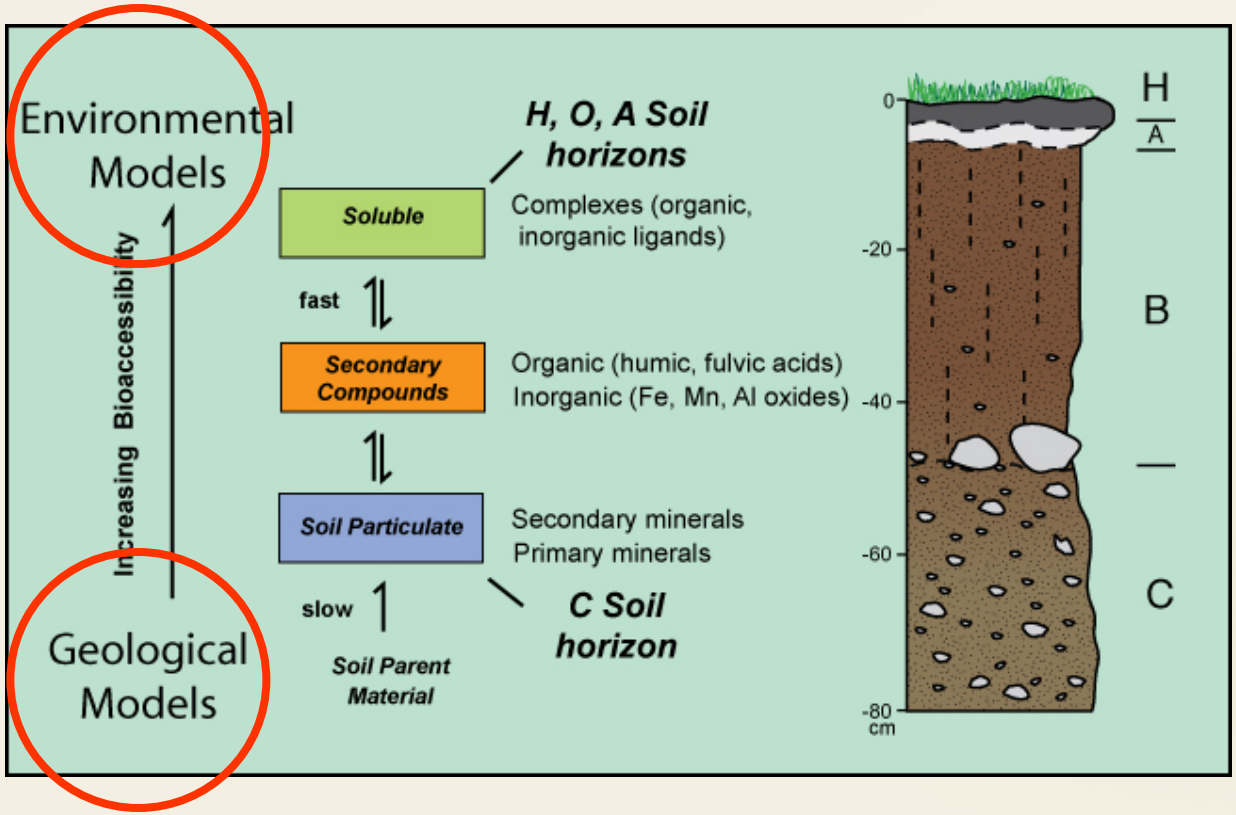
What's in a Number



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Geochemical Mapping - the Empirical Framework

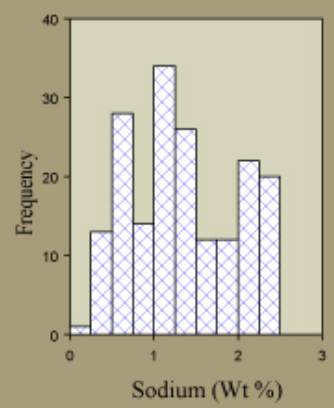
Na

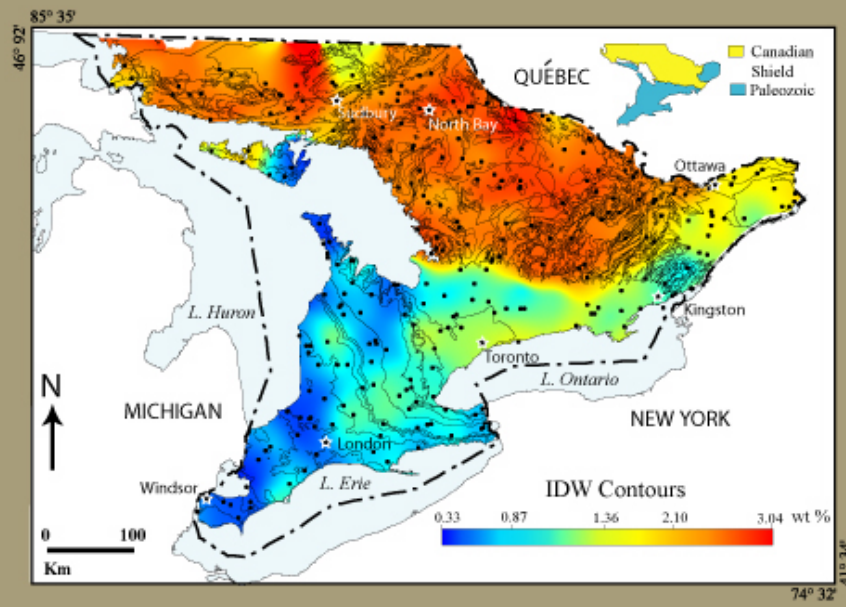
Sodium
Till Geochemistry
Wt %

Sample Preparation :	<2mm
Analytical Preparation :	None
Analytical Method :	INAA
Detection Limit (DL) :	0.1% (<DL=0.5)
Interpolation:	Inverse Distance Weighting (IDW)
	Cell Radius: 50,000m, Size: 1000m

Descriptive Statistics

Mean	1.46
Standard Deviation	0.731
Standard Error	0.052
Number	200
Minimum	0.24
Maximum	3.22





Plot based on Geological Survey of Canada unpublished data

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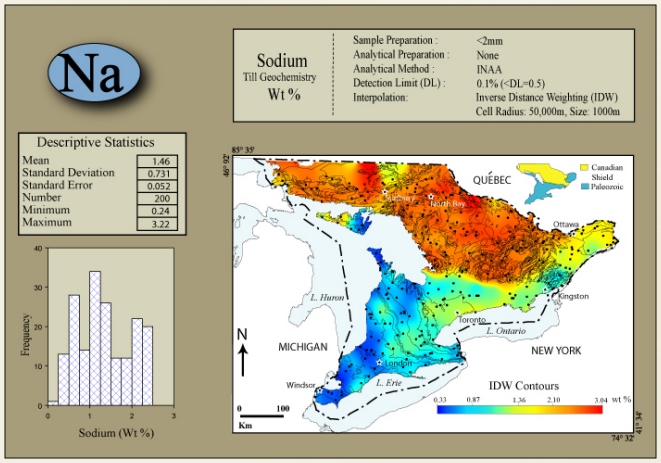
Natural Variability - Soil Parent Materials

Geological Constraints on Geochemical Variability

- ✓ **Provenance** - Geological Maps - Scale Values
- ✓ Physical **Process** Models - wind, water, ice, and gravity
- ✓ **Past** - stratigraphic models

  (e.g., compositional organization)



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Core Value for Decision-making

Geochemical Properties of Soil Parent Materials

Stable

- ✓ unchanging within timeframes of societal decision-making

Predictive

- ✓ variability may be constrained through physical geological process models

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Geochemical Properties and Risk Assessment

Independent Factors

Dependent Factors

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Independent Factors - Geological

- ✓ **Provenance**
  - ✓ **(e.g. elements, mineral residence sites, speciation, weathering transformations)**
- ✓ **Process**
  - ✓ **(e.g., mineral partitioning)**
- ✓ **Past**
  - ✓ **(e.g., compositional organization)**

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Dependent Factors - Protocol

- ✓ Sampling
  - ✓ (e.g., media, location, tools, etc.)
- ✓ Sample Preparation
  - ✓ (e.g., temperature, grain size, etc.)
- ✓ Sample Analysis
  - ✓ (e.g., analytical instrument, decomposition, etc.)

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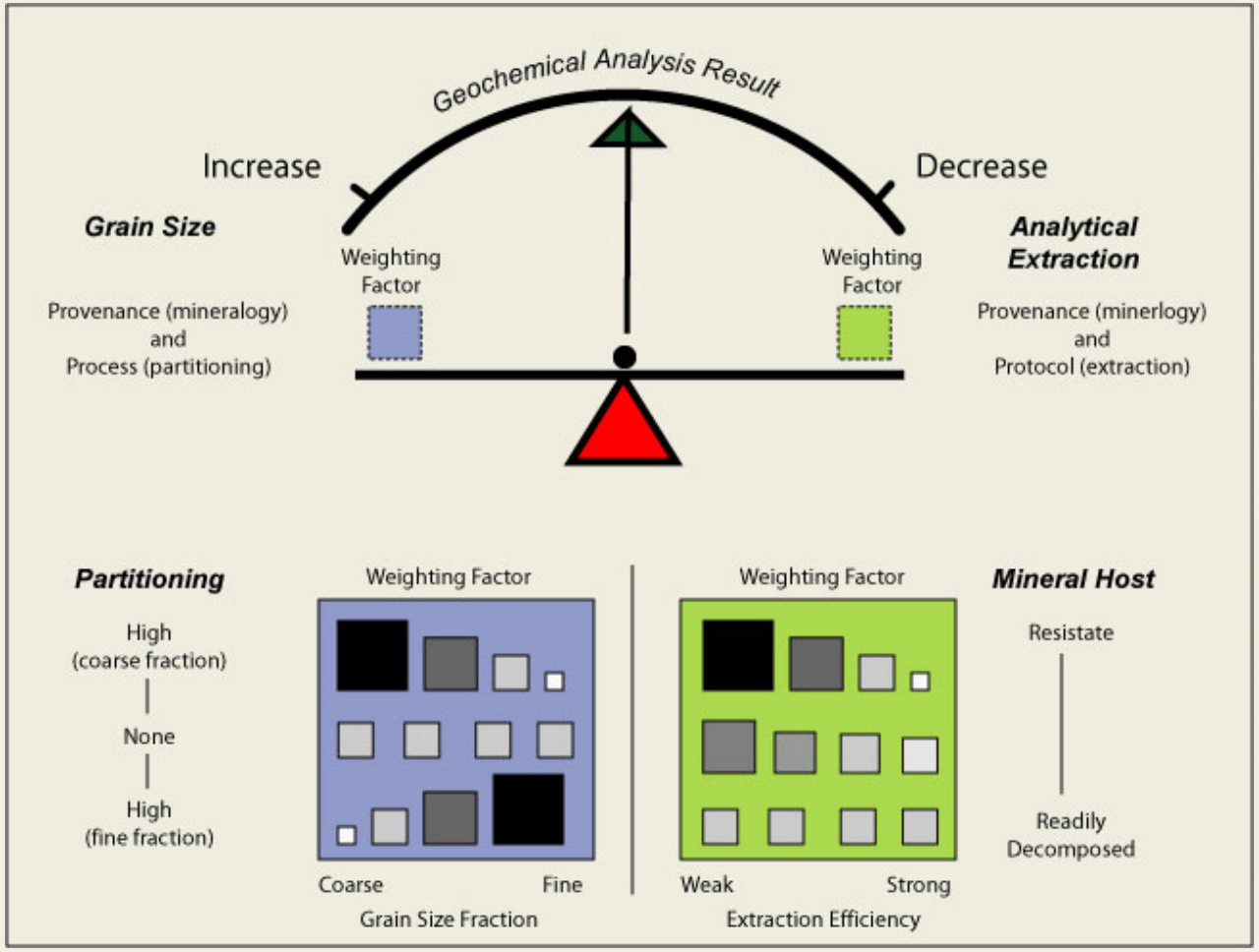

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What's in a Number

How Independent and Dependent Factors combine determines:

- ✓ Spatial variability in geochemical maps and models

  AND

- ✓ Interpretive value of geochemical data for Risk Assessment
  - ✓ (exposure pathways, bioaccessibility)

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Resolving What's in a Number

Enhancing Certainty in Risk Assessment

- ✓ Independent Factors
- ✓ Dependent Factors
- ✓ Interpretive Modelling
- ✓ Statistical Design - QA/QC - Published Protocol
- ✓ Environmental Standards (CANMET)
- ✓ BTEP

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What's in a Number

Constraining Variability

- ✓ **Independent Factors**
  - **Analysis of common rock-forming minerals**
    - ✓ **what minerals are affected by what decompositions**

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What's in a Number

Constraining Variability

- ✓ Dependent Factors
  - ✓ Grain Size (<2mm; <0.063 mm)
  - ✓ Analytical Decomposition (total, strong acid, water)

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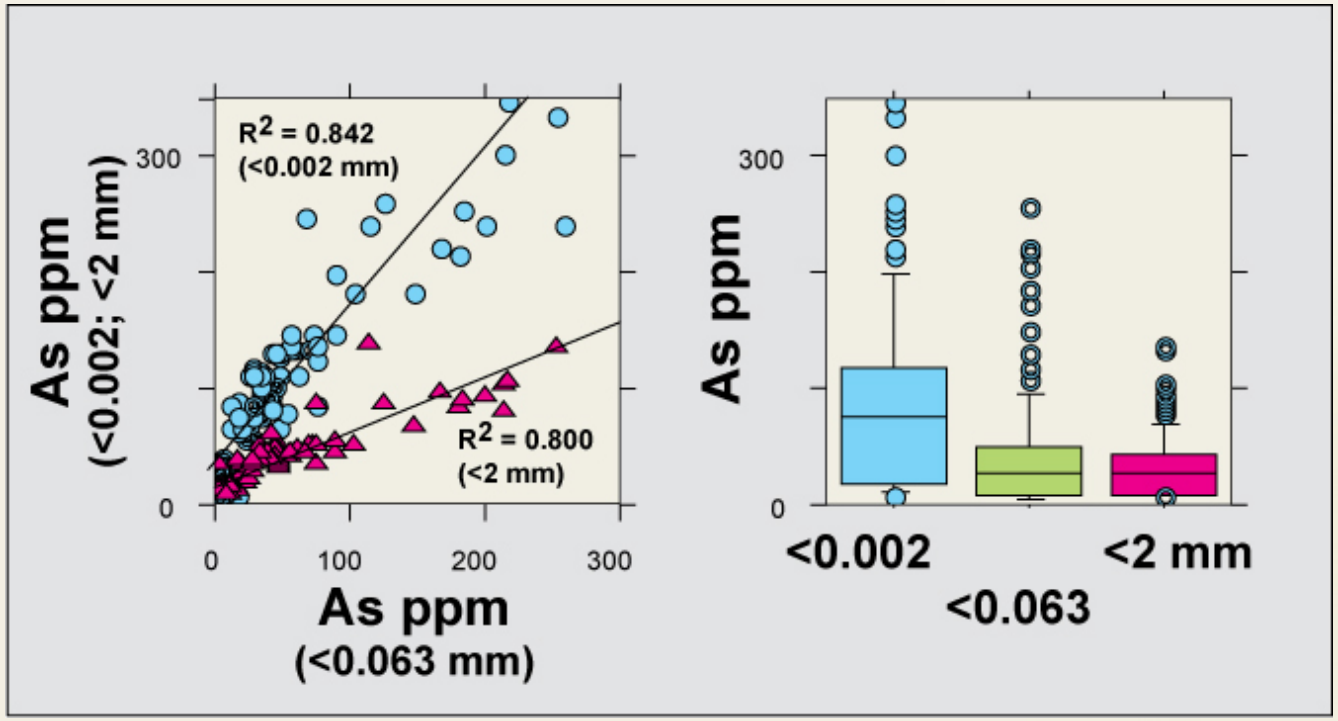
What's in a Number

Interpretive Value for Risk Assessment



Source: Klassen, R.A., 1994. Till geochemistry and ice flow data, central Newfoundland (NTS 12A/10, 15, 16; 12H/1); Geological Survey of Canada, Open File 2823, 350 pp.

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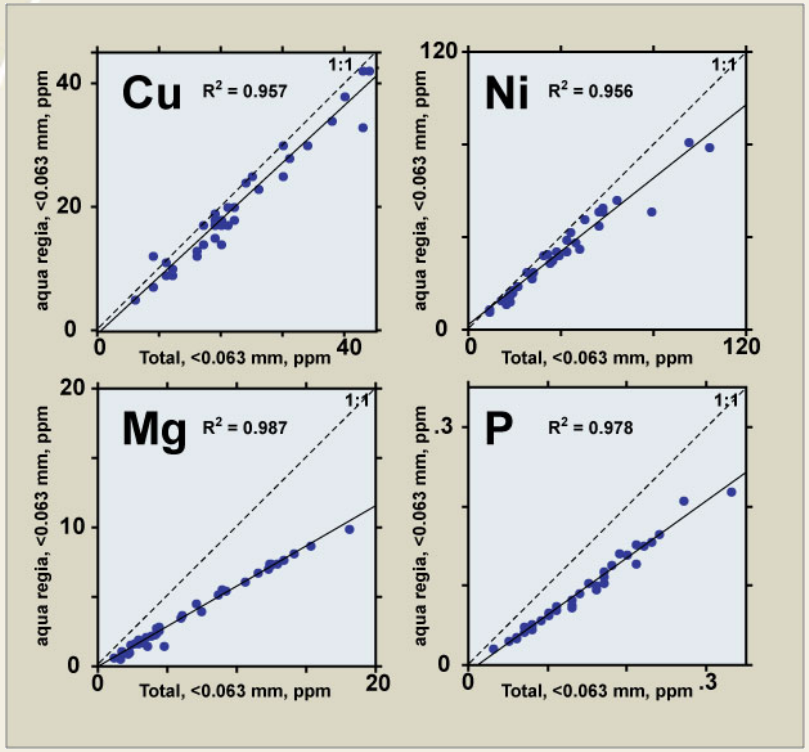

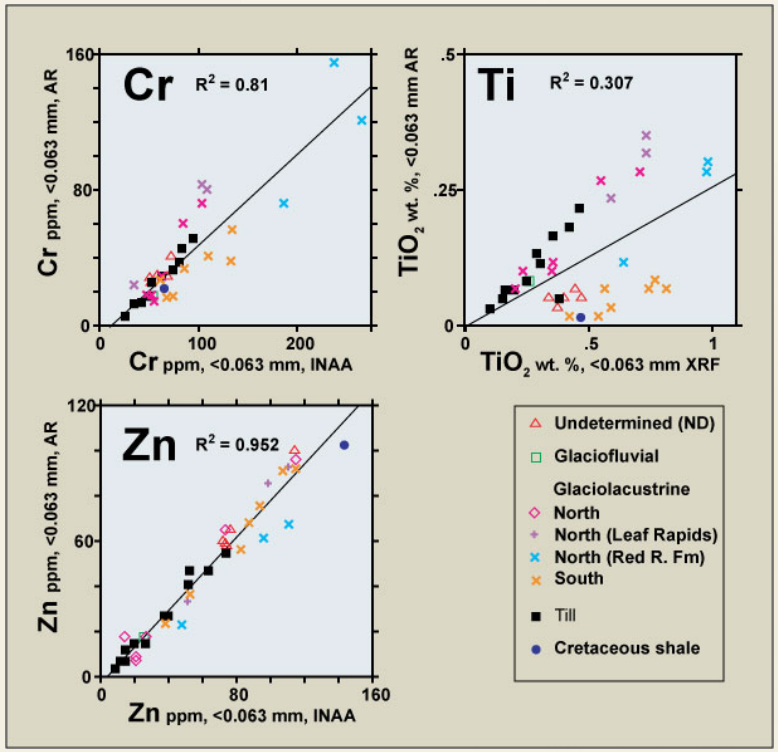

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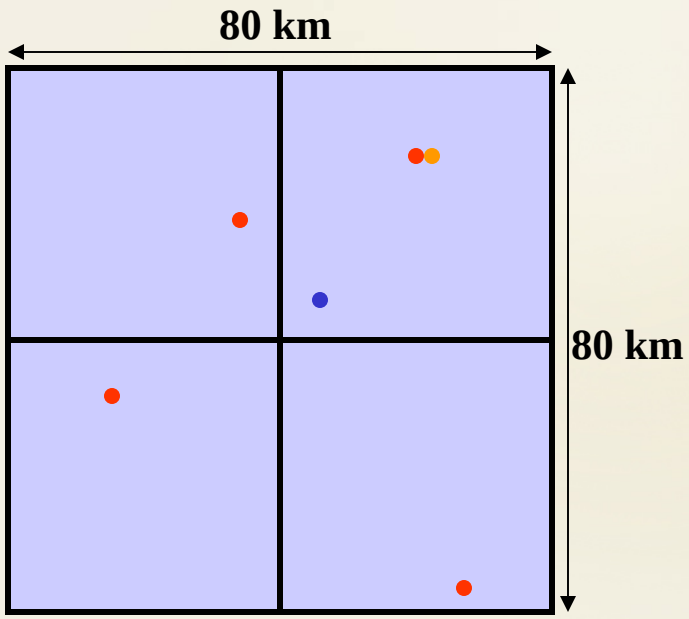
What's in a Number

Background Variation

- ✓ Nested Sampling Design - statistical characterization
  - ✓ Sample (vial) ●
  - ✓ Site (10m) ●
  - ✓ Area (40x40 km) ●
  - ✓ Inter-Area (>40x40 km)
- ✓ Documented Protocols
  - ✓ Sampling
  - ✓ Analysis
  - ✓ QA/QC



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What's in a Number

Analytical Standards

- ✓ New Suites of Environmental Standards (CANMET)
  - ✓ Defined by Mineralogy and Provenance
  - ✓ Underpin the wider interpretation and application of NASGLP data for risk assessment
    - ✓ Water and gastric leaches
    - ✓ Grain size
    - ✓ Mineralogy

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What's in a Number

New Approaches

- ✓ **BTEP (Business Transformation Enablement Program)**
  - ✓ Strategic planning, requirements analysis, implementation
  - ✓ Support for policy-making and regulation - legal requirements
  - ✓ Future value for decision-making

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Soil Geochemical Landscapes Project

Partnership Opportunities

- ✓ Constraining variability in terms of Independent and Dependent Factors
  - ✓ Ongoing research
    - ✓ Grain size, decomposition
    - ✓ Determining the origins of geochemical domains
    - ✓ Enhancing risk assessment using multidisciplinary approaches in targeted terrains
- ✓ Creation of New Environmental Standards (CANMET)
  - ✓ Letter of Support
  - ✓ Establishing geological reference materials

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Partnership Opportunities

- ✓ **Communicating Need**
  - ✓ **BTEP planning (application in policy-making and regulation)**
- ✓ **Regulatory Approaches**
  - ✓ **Defining Threshold Values in terms of dependent and independent factors**
- ✓ **Improved Environmental Modelling**
  - ✓ **E.g., Critical Load modelling, acid rain neutralization, soil fertility**