



# **GEOCHEMICAL VARIABILITY IN SURFICIAL MATERIALS BASED ON CANADA-WIDE AND NEW BRUNSWICK DATASETS**

Eric C. Grunsky

Natural Resources Canada-Geological Survey  
of Canada





# Canada-Wide Study





# Data from Geochemical Surveys

Earth Sciences Sector

- As part of a project set up to estimate background concentrations in surficial media, geochemical data were taken from till surveys undertaken across Canada and merged.
- 17 surveys were used where raw data were directly comparable – i.e. collected from till, sieved to <63 micron, and analyzed using same or similar Aqua Regia variants. Results of study were released as Geological Survey of Canada, Open File 5084 (Rencz et al., 2006). This merged data set is the basis of the analyses that follow.
- Eco-classification system used is the State of the Environment Reporting spatial framework maintained by the CANSIS group at Agriculture and Agri-Food Canada (Ecological Stratification Working Group. 1996) .
- Geological provinces from Atlas of Canada  
<http://atlas.nrcan.gc.ca/site/english/maps/environment/geology/geologicalprovinces>



Natural Resources  
Canada

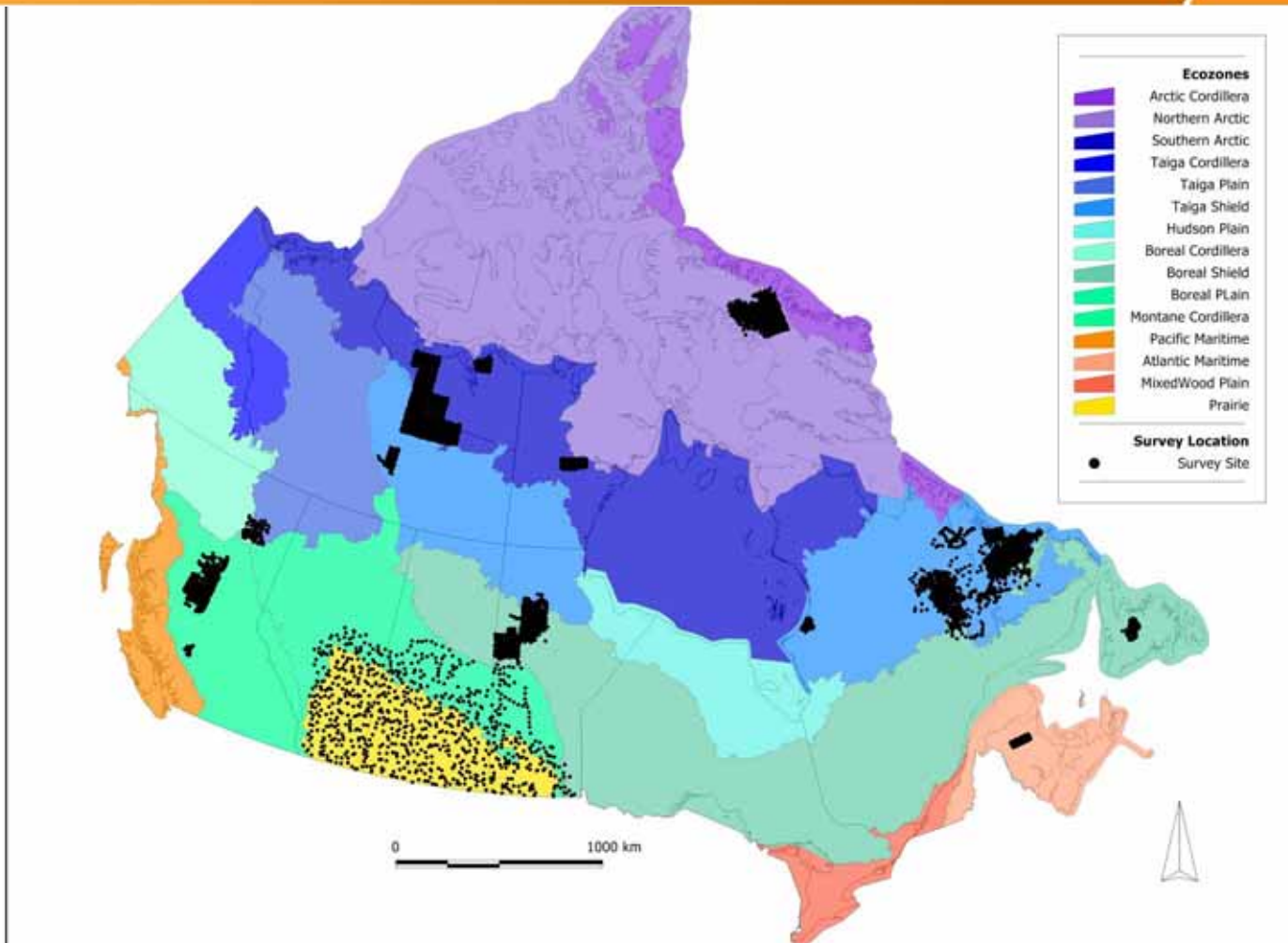
Ressources naturelles  
Canada

Canada



# Sites by Ecozone

Earth Sciences Sector



EcoZones

Lambert Conformal Conic  
Lon: 87°57'19" W  
Lat: 63°18'09" N  
Printed at: 2010-02-02



Natural Resources  
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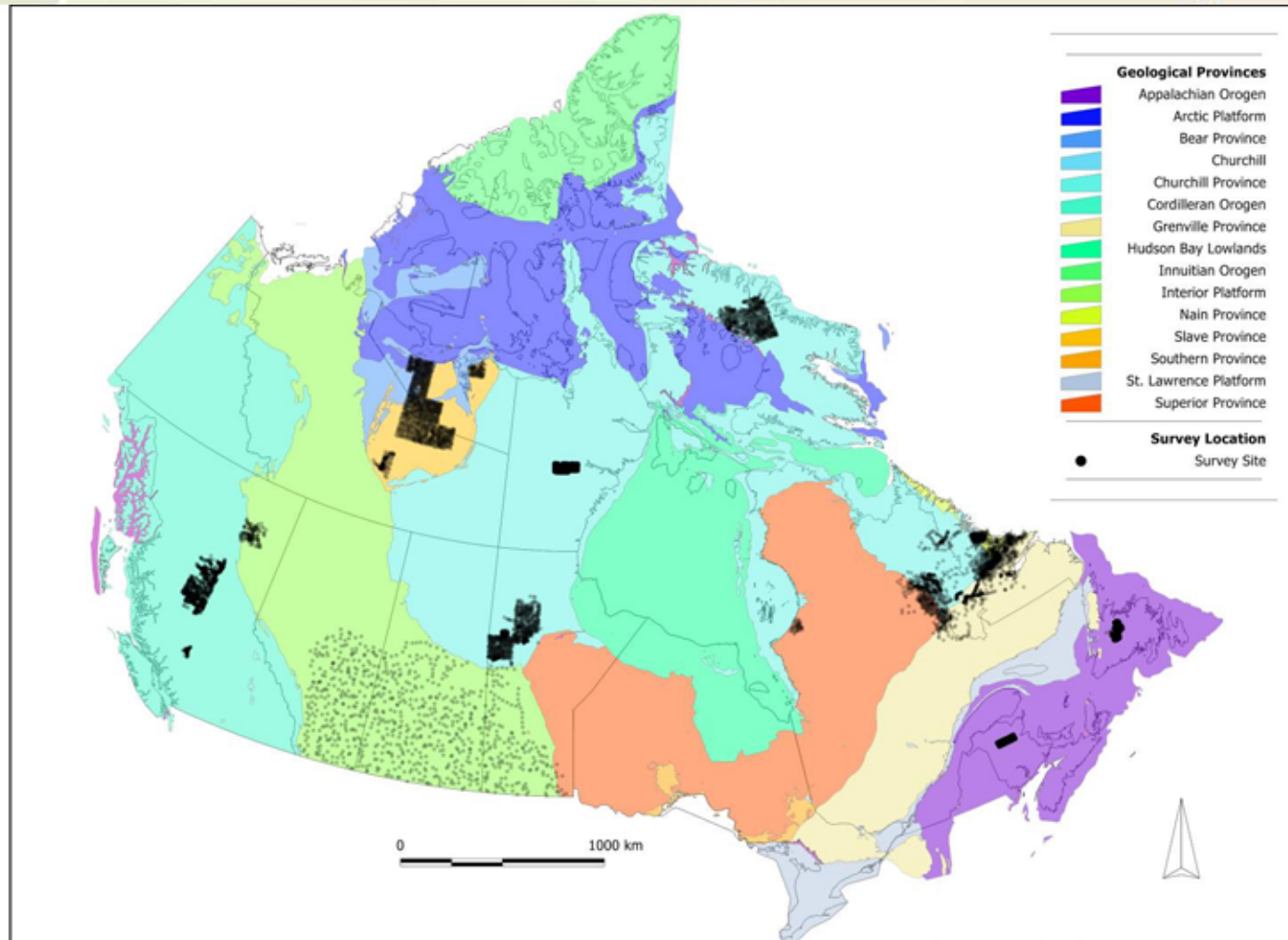
Ressources naturelles  
Canada

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# Sites by Geology

Earth Sciences Sector



Geology

Lambert Conformal Conic  
Lon: 86°46'56" W  
Lat: 63°14'20" N  
Printed at: 2010-02-02



Natural Resources  
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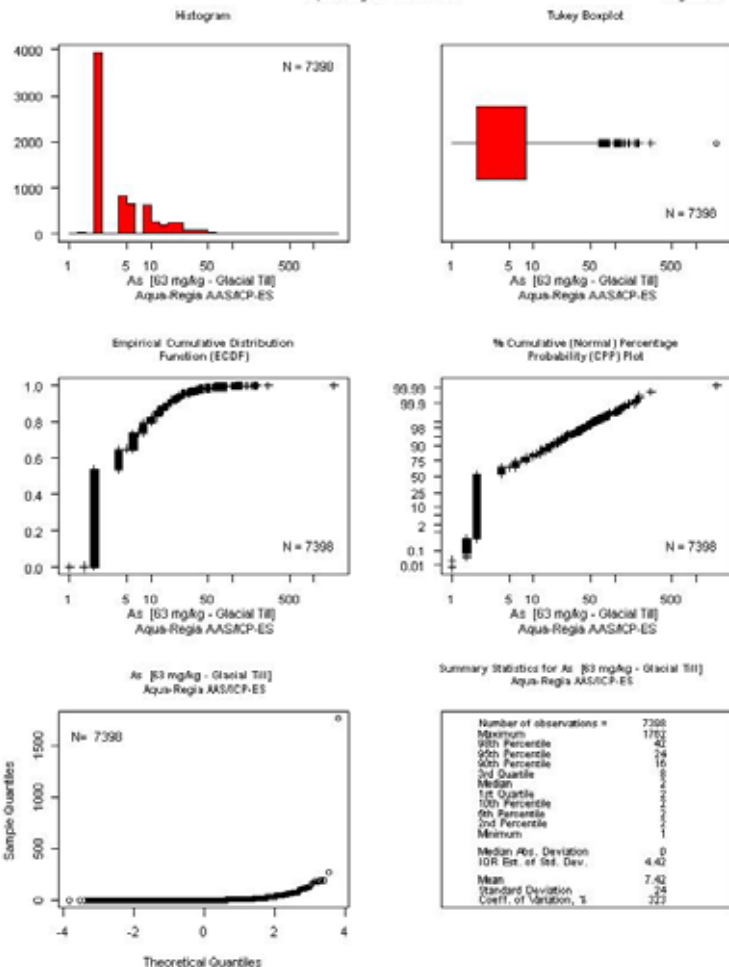
# As and Cr Across Canada

## Aqua Regia

Earth Sciences Sector

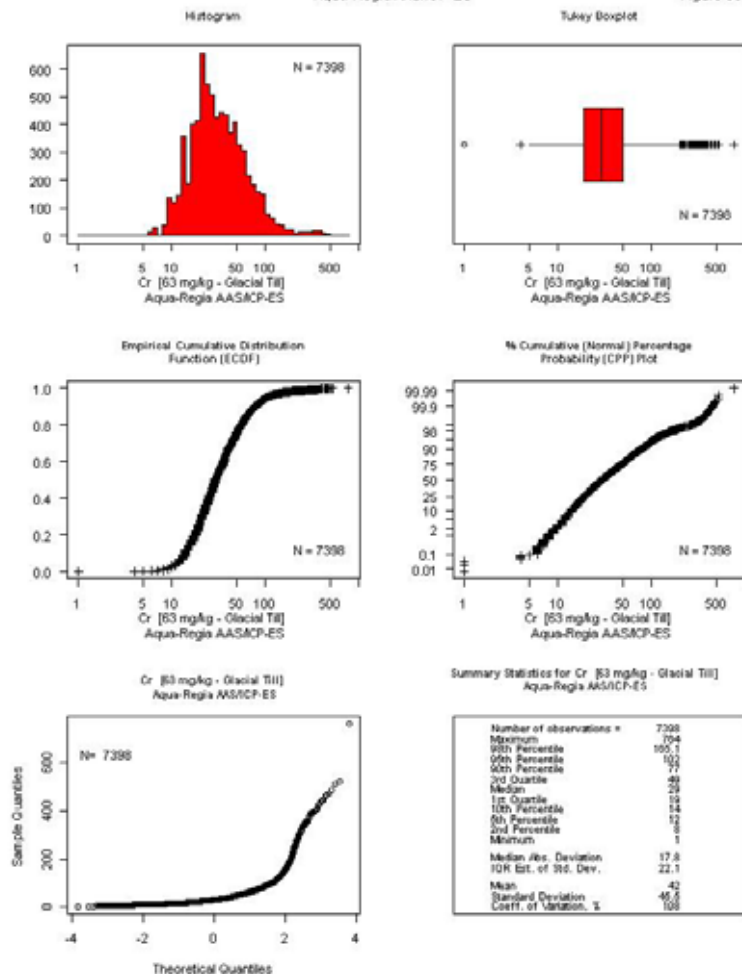
Till Surveys Across Canada  
As [63 mg/kg - Glacial Till]  
Aqua-Regia AAS/CP-ES

Figure 64



Till Surveys Across Canada  
Cr [63 mg/kg - Glacial Till]  
Aqua-Regia AAS/CP-ES

Figure 66



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada





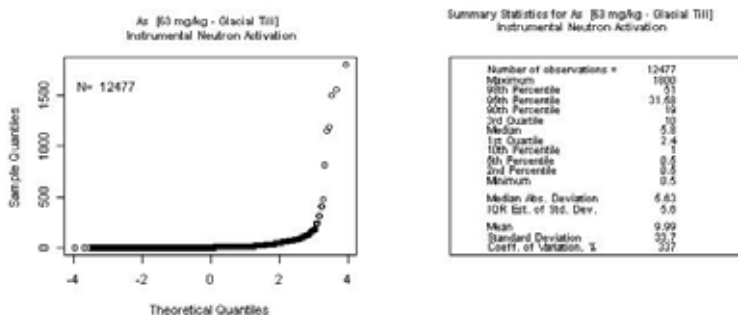
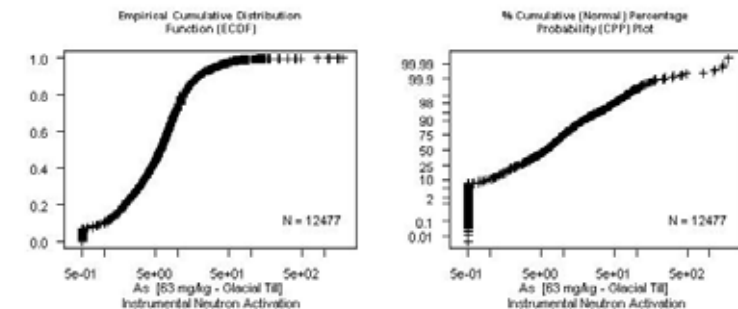
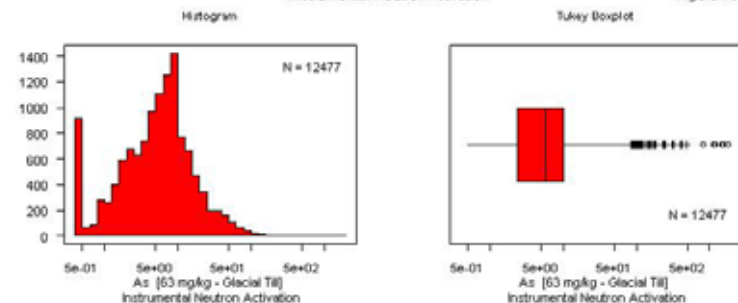
# As and Cr Across Canada

## Neutron Activation

Earth Sciences Sector

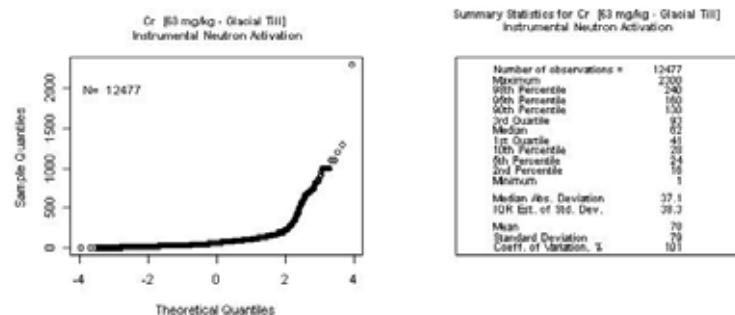
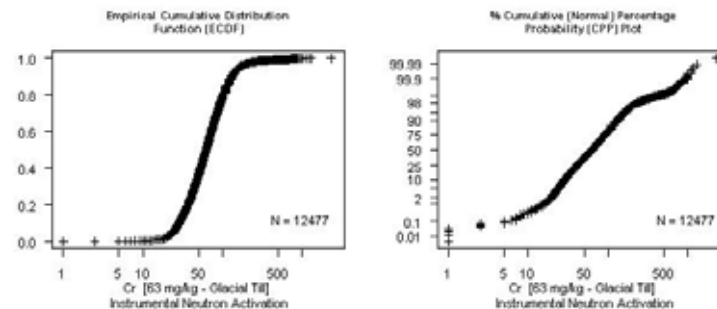
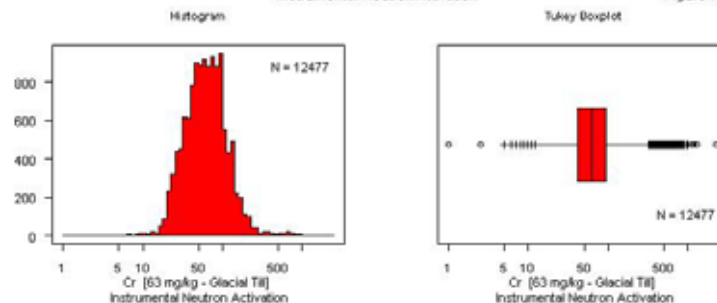
Till Surveys Across Canada  
As [63 mg/kg - Glacial Till]  
Instrumental Neutron Activation

Figure 73



Till Surveys Across Canada  
Cr [63 mg/kg - Glacial Till]  
Instrumental Neutron Activation

Figure 75



Natural Resources  
Canada

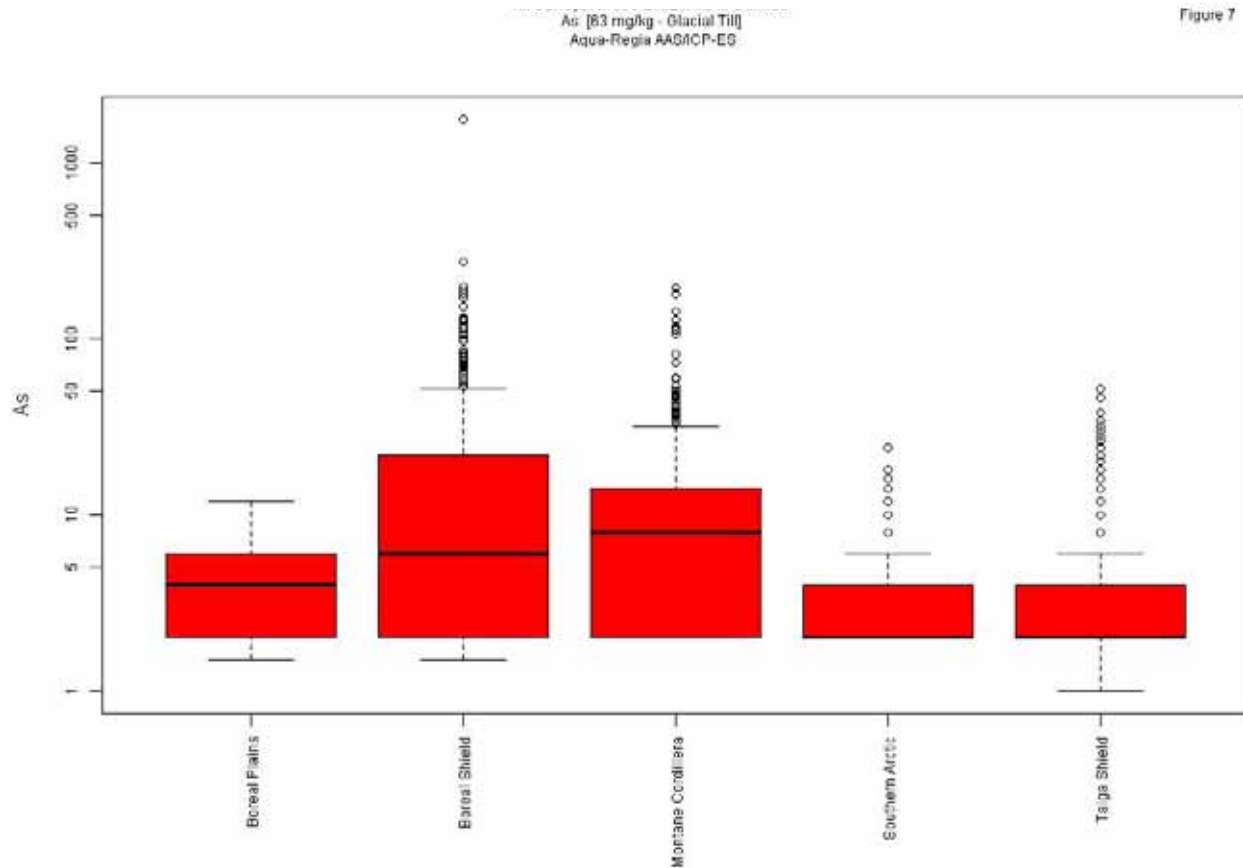
Ressources naturelles  
Canada





# As – Aqua regia – Till by Ecozone

Earth Sciences Sector



Natural Resources  
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Ressources naturelles  
Canada

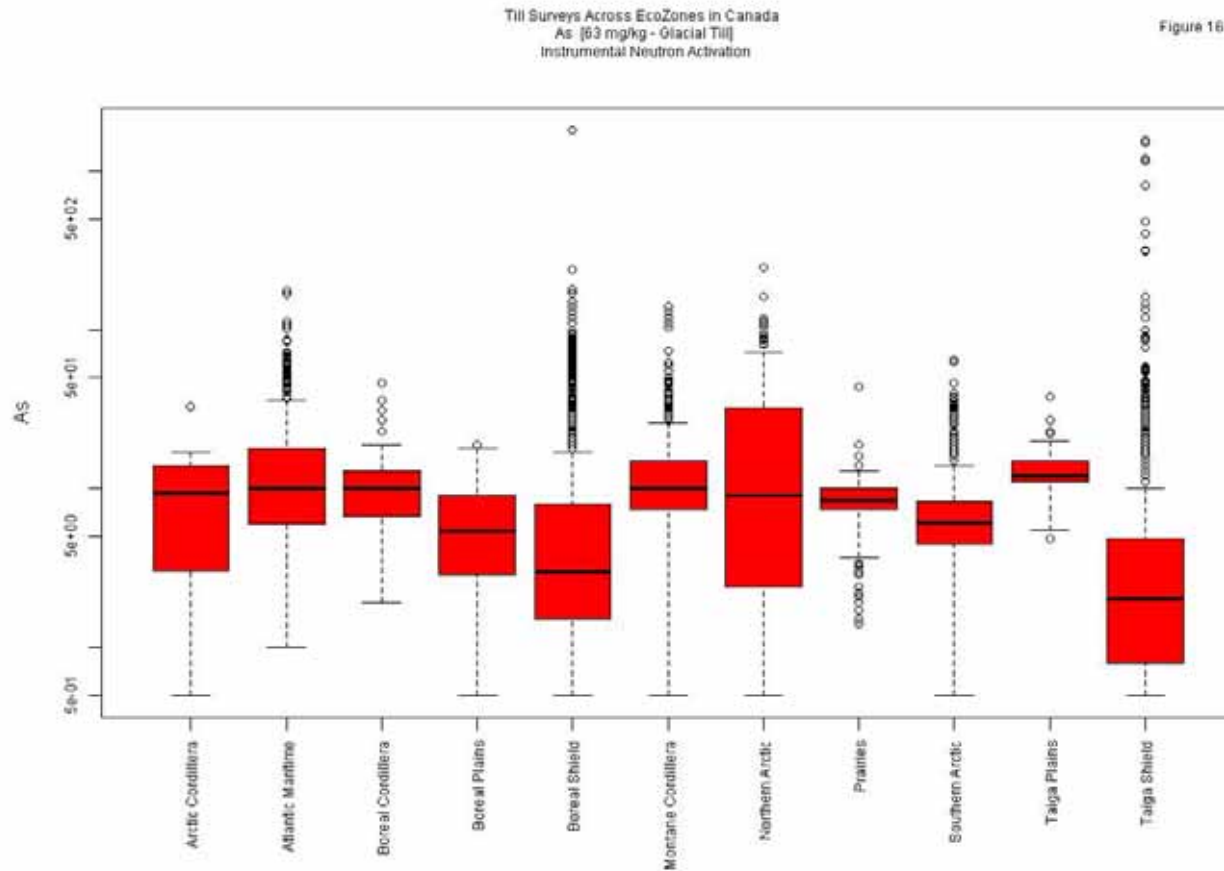
Canada





# As – Neutron Activation – Till by Ecozone

Earth Sciences Sector



Natural Resources  
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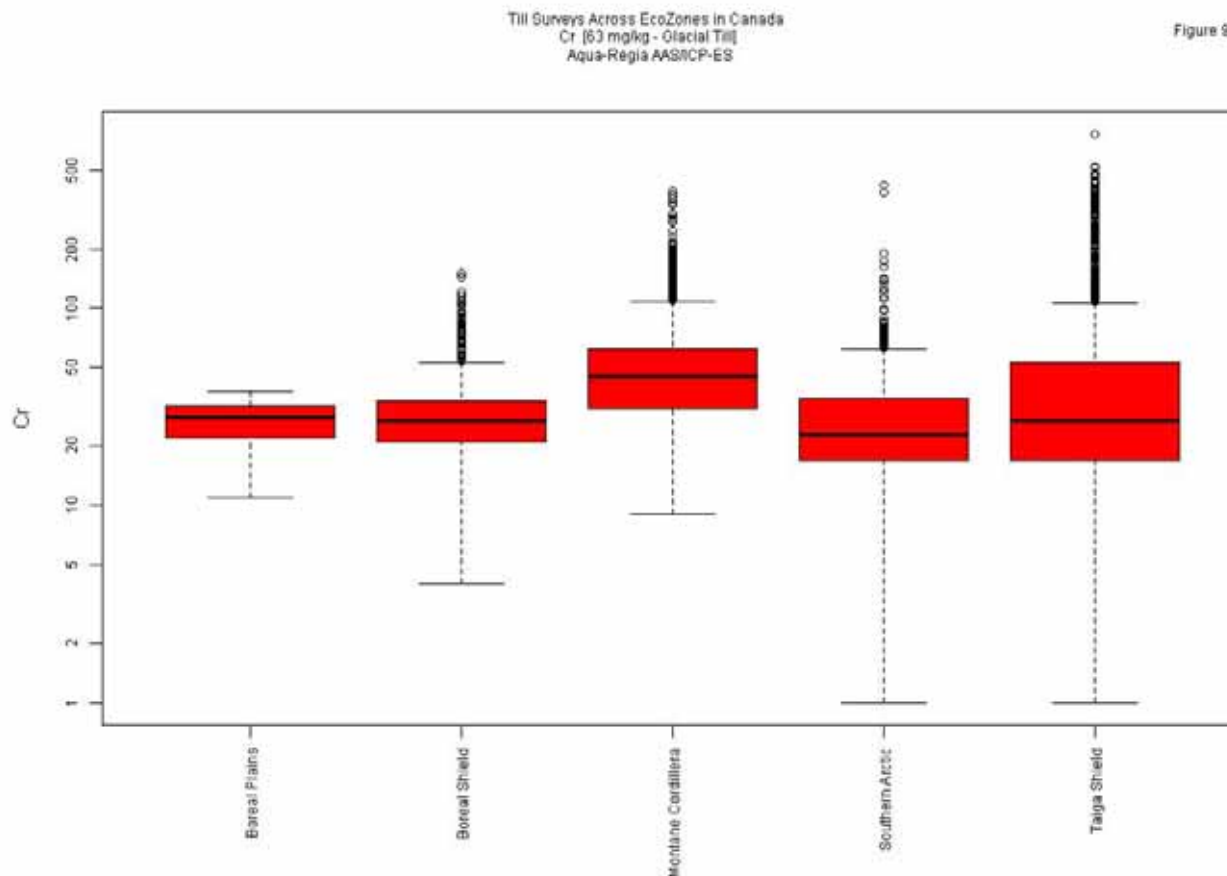
Ressources naturelles  
Canada





# Cr – Aqua regia – Till by Ecozone

Earth Sciences Sector



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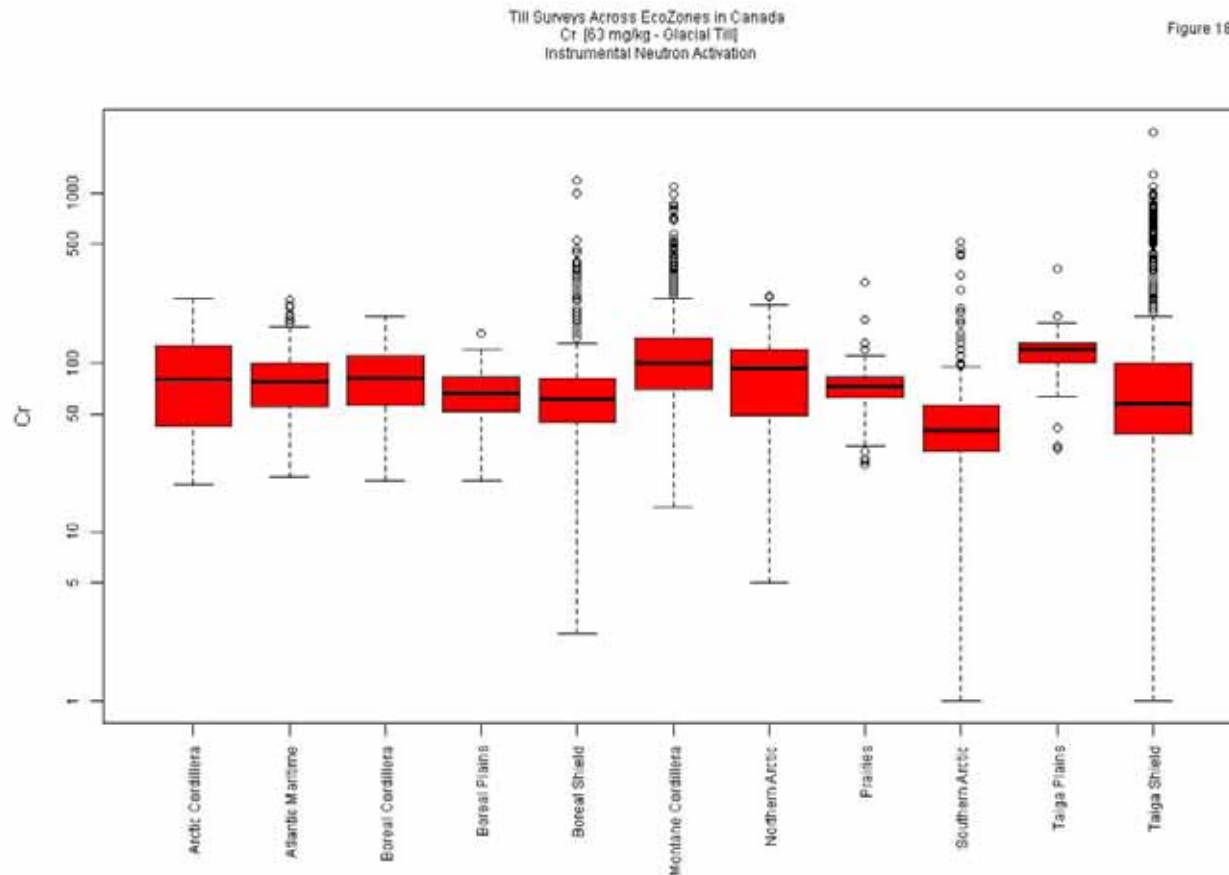
Ressources naturelles  
Canada

Canada



# Cr – Neutron Activation – Till by Ecozone

Earth Sciences Sector



Natural Resources  
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Ressources naturelles  
Canada



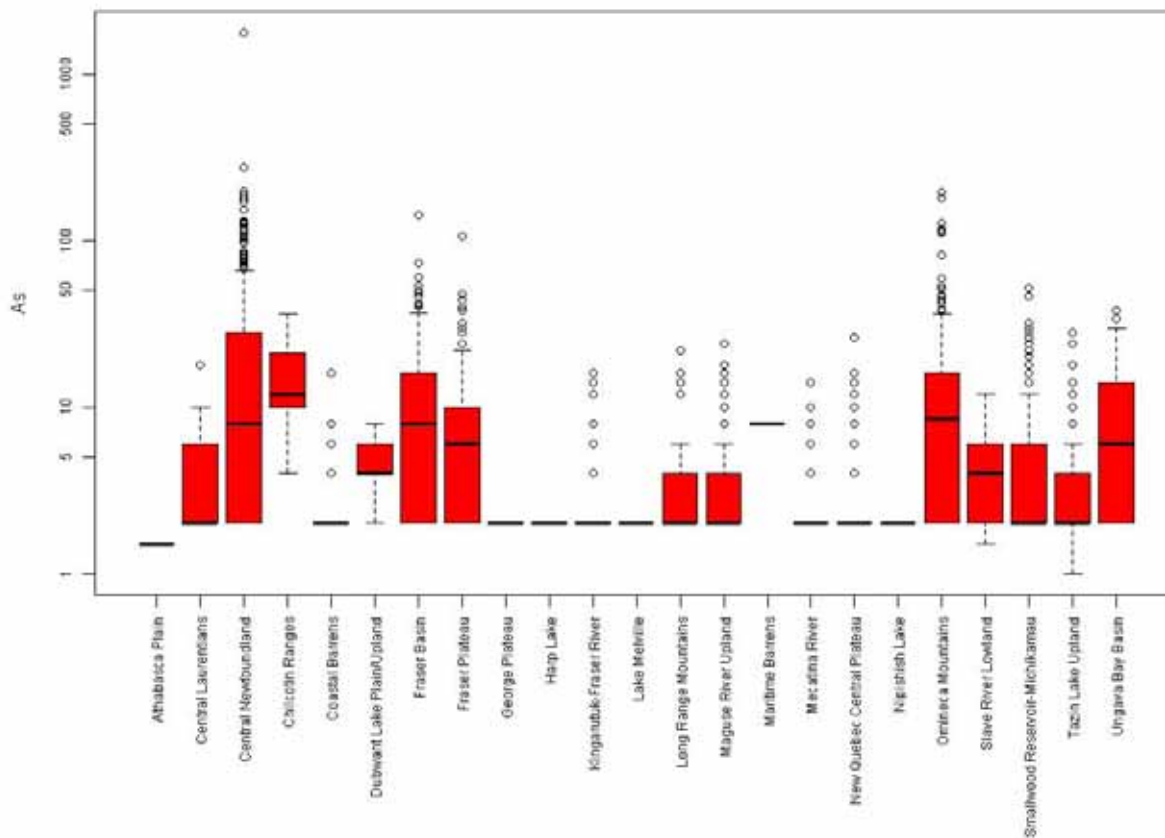


# As – Aqua Regia – Till by Ecoregion

Earth Sciences Sector

Till Surveys Across EcoRegions in Canada  
As: [63 mg/kg - Glacial Till]  
Aqua-Regia AAS/ICP-ES

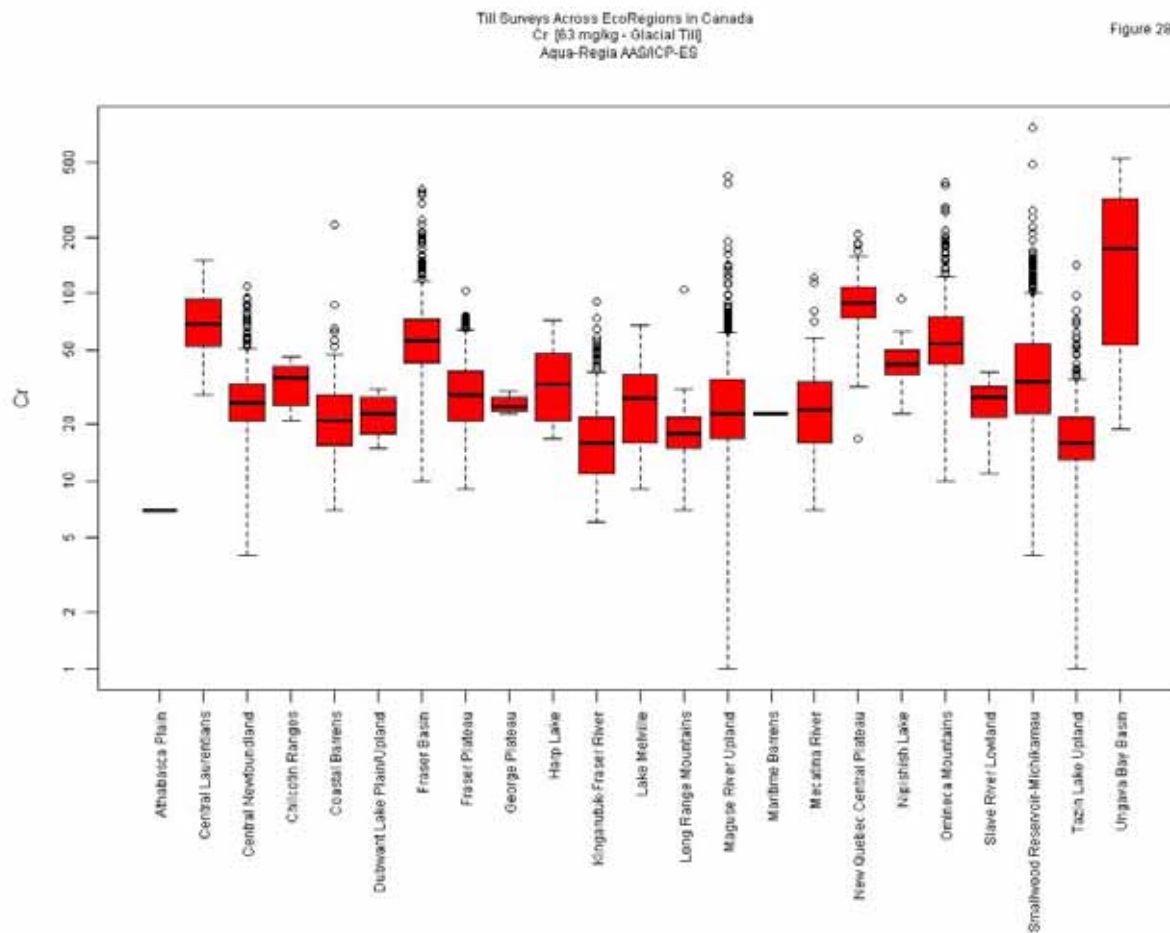
Figure 26





# Cr – Aqua Regia – Till by Ecoregion

Earth Sciences Sector



Natural Resources  
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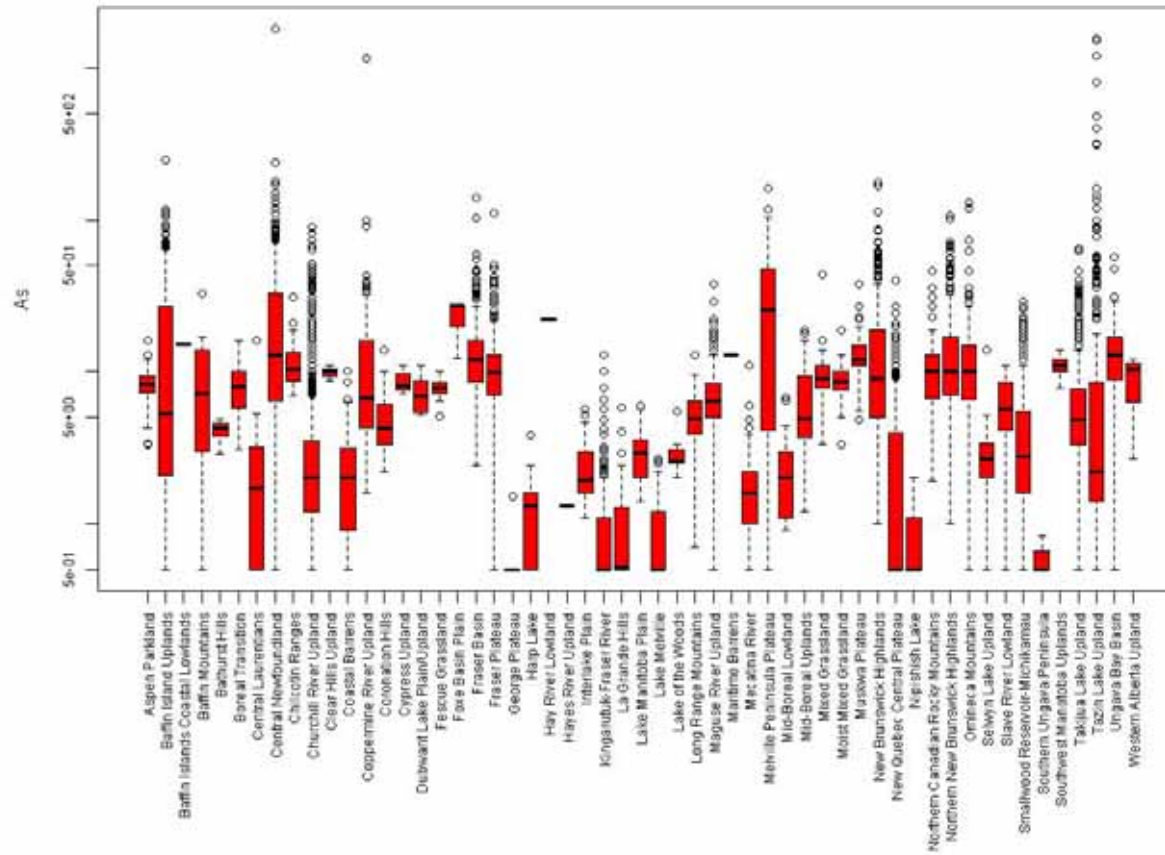


# As – Neutron Activation – Till by Ecoregion

Earth Sciences Sector

Till Surveys Across EcoRegions in Canada  
As [63 mg/kg - Glacial Till]  
Instrumental Neutron Activation

Figure 35



Natural Resources  
Canada

Ressources naturelles  
Canada

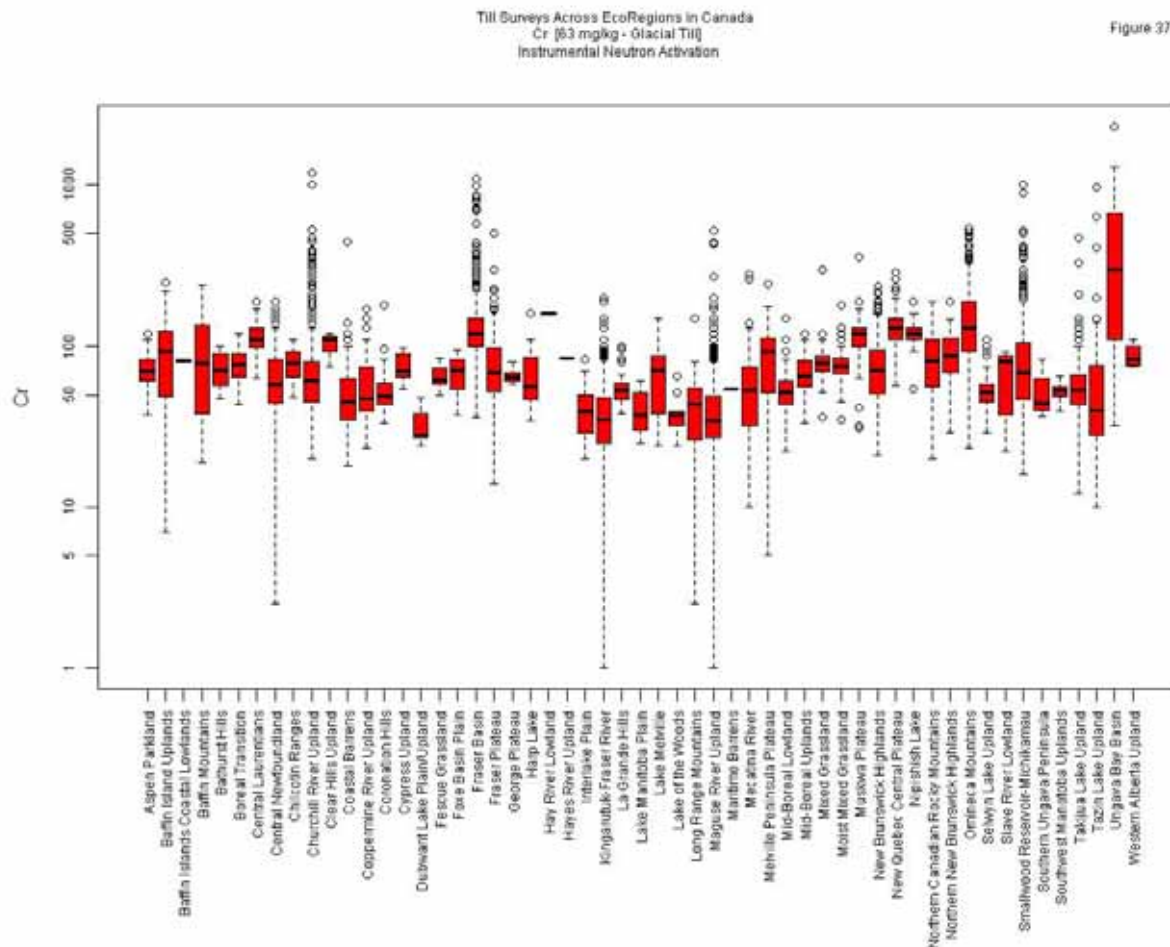






# Cr – Neutron Activation – Till by Ecoregion

Earth Sciences Sector



Natural Resources  
Canada

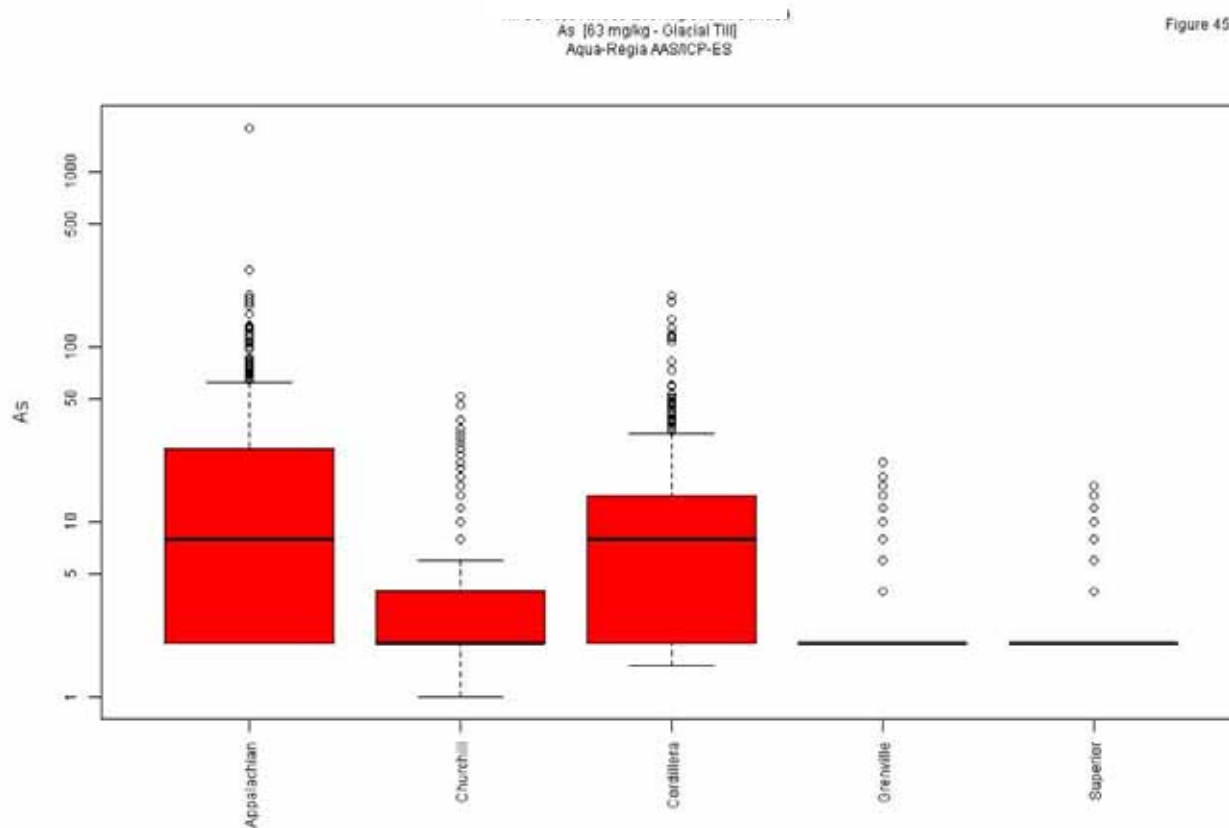
Ressources naturelles  
Canada





# As – Aqua Regia – Till by Geologic Province

Earth Sciences Sector



Natural Resources  
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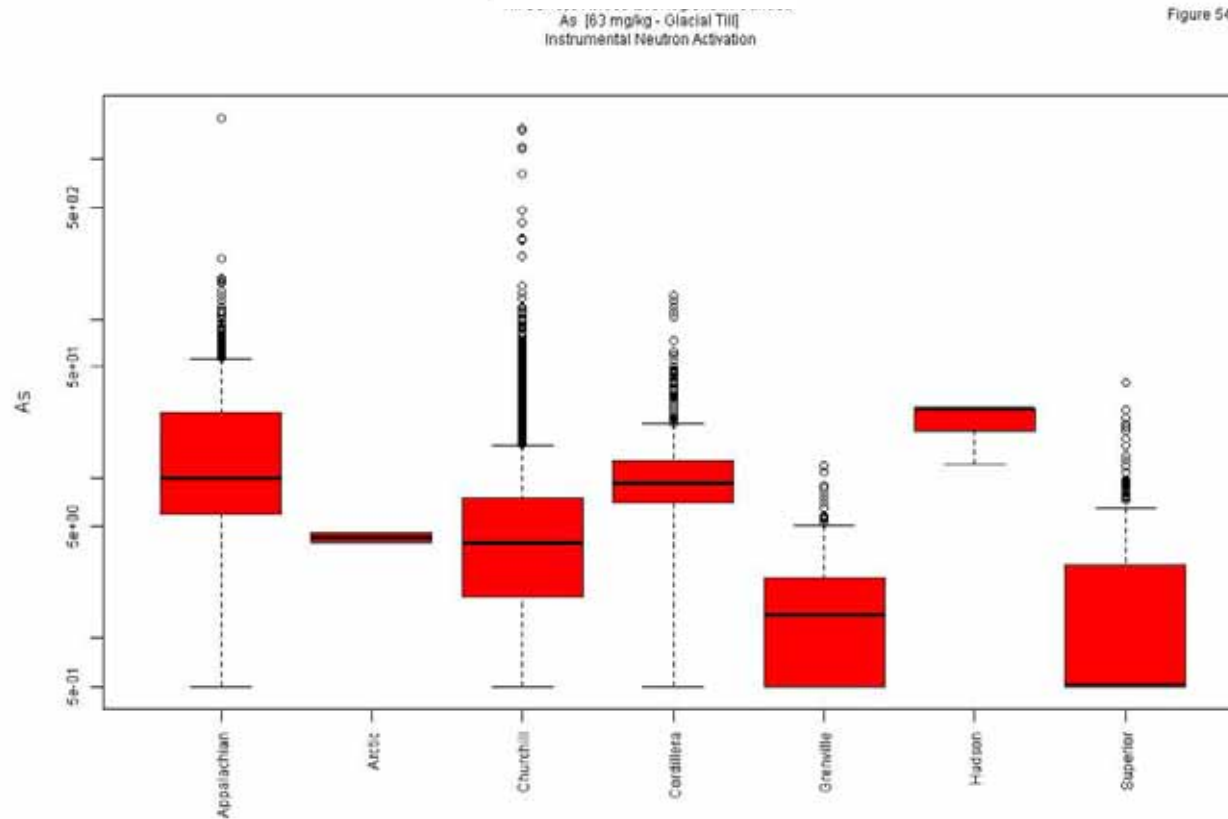
Ressources naturelles  
Canada

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# As – Neutron Activation – Till by Geologic Province

Earth Sciences Sector



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Ressources naturelles  
Canada

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# New Brunswick Study



# Till Sampling Surveys in New Brunswick

Earth Sciences Sector

- Till sampling surveys were undertaken in New Brunswick in the 1980s to the 2000s.
- Data for the <63 micron fraction obtained using an Aqua Regia or variants were used for the analyses that follow.
- The Natural Resource Canada - Geoscience Data Repository links for the surveys used are listed below.
- Eco-classification system used for the analyses that follow is the State of the Environment Reporting spatial framework maintained by the CANSIS group at Agriculture and Agri-Food Canada (Ecological Stratification Working Group. 1996).



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Canada

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# Till Sampling Surveys in New Brunswick

Earth Sciences Sector

Site Count	Title and online link
218	Till sampling survey, NTS 21O/2, north central New Brunswick, 1990-91. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=050004">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=050004</a>
145	Till sampling survey, NTS 21O/1, north central New Brunswick, 1990-1991. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=050005">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=050005</a>
124	Till sampling survey, NTS 21P/4, northern New Brunswick, 1993. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130027">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130027</a>
264	Till and soil sampling survey, NTS 21O/7 (Nepisiguit Lakes), north central New Brunswick, 1989. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130002">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130002</a>
265	Till sampling survey, NTS 21O/3, northwestern New Brunswick, 1989. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130003">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130003</a>
292	Till sampling survey, NTS 21G/12 (Forest City), 13 (Fosterville), southwest New Brunswick, 1990-1995. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130004">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130004</a>
265	Till sampling survey, Canterbury area, NTS 21G/14 southwest New Brunswick, 1990-1991. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130005">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130005</a>
278	Till sampling survey, NTS 21O/15, 22B/1, 2, northern New Brunswick, 1987-1988. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130007">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130007</a>
193	Till sampling survey, NTS 21H/11 (Waterford), southern New Brunswick, 1993-1994. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130008">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130008</a>
171	Till sampling survey, NTS 21O/15 (Atholville), 21O/16 (Charlo), north central New Brunswick, 1998-1999. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130009">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130009</a>



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# Till Sampling Surveys in New Brunswick

Earth Sciences Sector

499	Till sampling survey, NTS 21G/6, 7, southwestern New Brunswick, 2001-2002. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130010">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130010</a>
48	Till sampling survey, NTS 21H/6 (Salmon River), 21H/10 (Alma), southeastern New Brunswick, early 1990s. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130011">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130011</a>
299	Till sampling survey, NTS 21J/10 (Hayesville), central New Brunswick, 2004. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130012">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130012</a>
1129	Till sampling Survey, NTS 21O/11, 12, 13, 14, northwestern New Brunswick, 1999-2004. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130013">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130013</a>
51	Till sampling survey, NTS 21H/15 (Hillsborough), 21I/3 (Salisbury), 21I/4 (Chipman), Fundy Model Forest area, New Brunswick. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130014">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130014</a>
312	Till sampling survey, McAdam area, NTS 21G/11, southwest New Brunswick, 1991-1994. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130015">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130015</a>
248	Till sampling survey, NTS 21O/10, northern New Brunswick, 1986. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130016">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130016</a>
86	Till sampling survey, NTS 21G/3, southwest New Brunswick, 2002. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130017">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130017</a>
119	Till sampling survey, NTS 21G/10, southwest New Brunswick, 2002. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130018">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130018</a>
300	Till sampling survey, NTS 21H/12 (Sussex), 21G/9 (Hampstead, E½), southern New Brunswick, 1995-1996. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130019">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130019</a>



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# Till Sampling Surveys in New Brunswick

Earth Sciences Sector

265	Till sampling survey, NTS 21O/9, northern New Brunswick, 1985. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130020">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130020</a>
41	Till sampling survey, Canterbury, NTS 21G/14, southwest New Brunswick, 1995. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130023">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130023</a>
135	Till sampling survey, NTS 21H/10, 11, 15, southeast New Brunswick, 1988. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130024">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130024</a>
81	Till sampling survey, NTS 21H/6, 11, southeast New Brunswick, 1989. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130025">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130025</a>
189	Till sampling survey, NTS 21P/5, northern New Brunswick, 1996. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130026">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130026</a>
110	Till sampling survey, NTS 21G/2 (St. George), southwest New Brunswick, 2003. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130028">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130028</a>
336	Till sampling, NTS 21J/3, (Millville), southwest New Brunswick, 1995-1998. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130029">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130029</a>
114	Till sampling survey, NTS 21J/4 (Woodstock), southwest New Brunswick, 1999. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130030">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130030</a>
270	Till sampling, NTS 21H/14 (Petitcodiac), southeastern New Brunswick, 1993 and 1997. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130034">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130034</a>
270	Till sampling, NTS 21H/13 (Codys), southern New Brunswick. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130039">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130039</a>
306	Till and soil sampling survey, NTS 21O/8 (California Lake), north central New Brunswick, 1990-1991. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130042">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130042</a>



# Till Sampling Surveys in New Brunswick

Earth Sciences Sector

341	Till sampling, NTS 21J/6 (Coldstream), 21J/7 (Napadogan), west central New Brunswick, 1998, 2000-2002. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130043">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130043</a>
264	Till sampling survey, NTS 21P/12 (Bathurst), 21P/13 (Pointe Verte), northern New Brunswick, 2004-2005. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130044">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130044</a>
292	Till sampling survey, NTS 21O/6 (Sisson Branch Reservoir), northern New Brunswick, 2005. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130045">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=130045</a>
40	Overburden drilling and till geochemistry survey, 3 areas in northern and western New Brunswick, 1986-1987. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210035">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210035</a>
281	Till samples from a trenching survey, NTS 21J/10, central New Brunswick, 1986 and 1987. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210036">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210036</a>
978	Till sampling survey, northern Miramichi Zone, NTS 21O, P, New Brunswick, 1985. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210037">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210037</a>
1516	Till sampling survey, central Miramichi Zone, NTS 21O,P, J, New Brunswick, 1985-1987. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210038">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210038</a>
705	Till sampling survey, southern Miramichi Zone, NTS 21J, G, New Brunswick, 1985. <a href="http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210039">http://gdr.nrcan.gc.ca/geochem/metadata_svy_e.php?key=210039</a>
Total - 11840	



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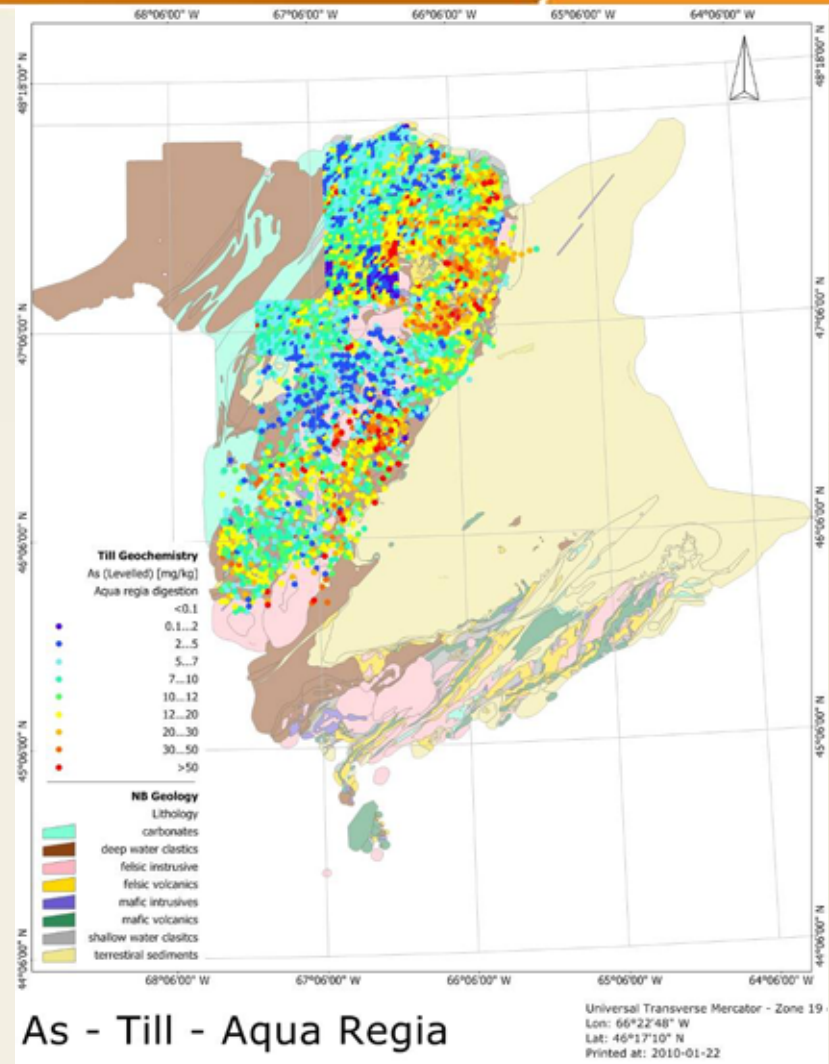
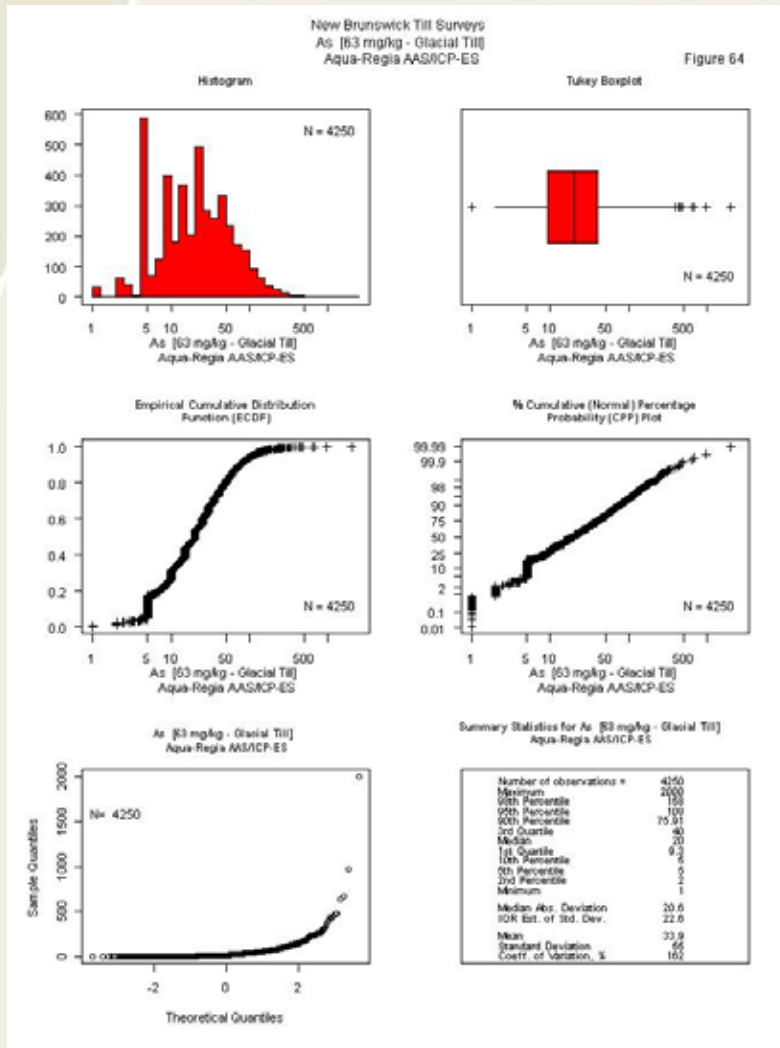
Ressources naturelles  
Canada

Canada



# As – Till – Aqua Regia New Brunswick

Earth Sciences Sector



Natural Resources  
Canada

Ressources naturelles  
Canada

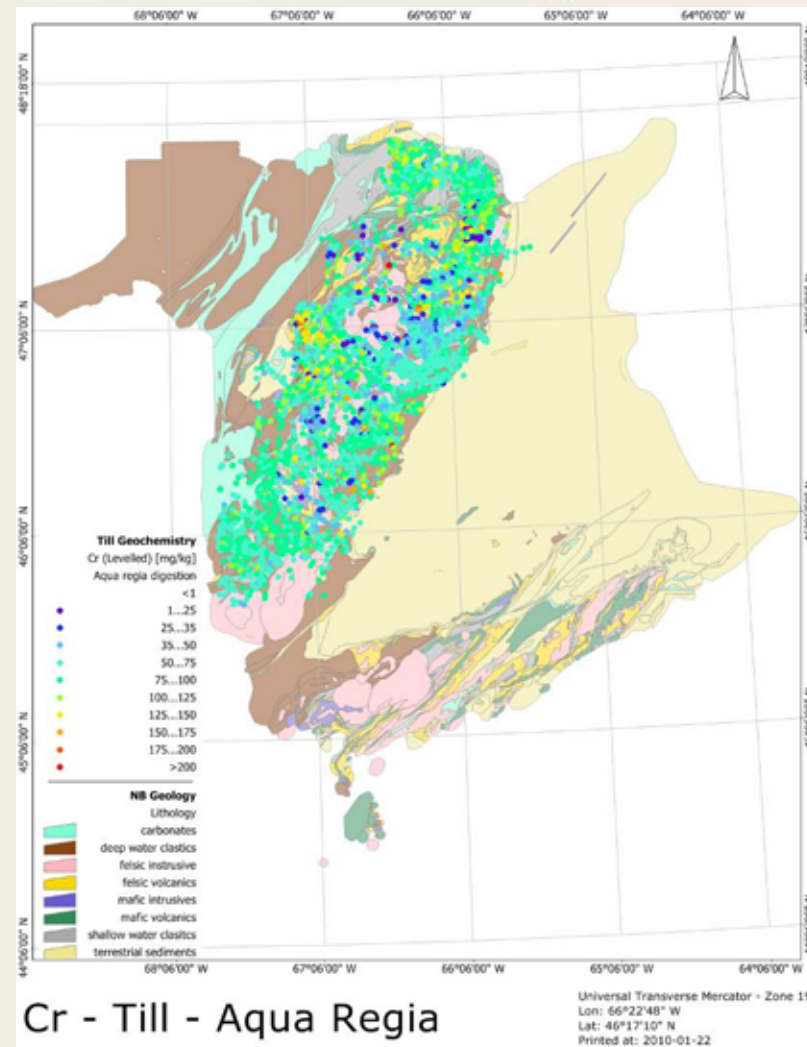
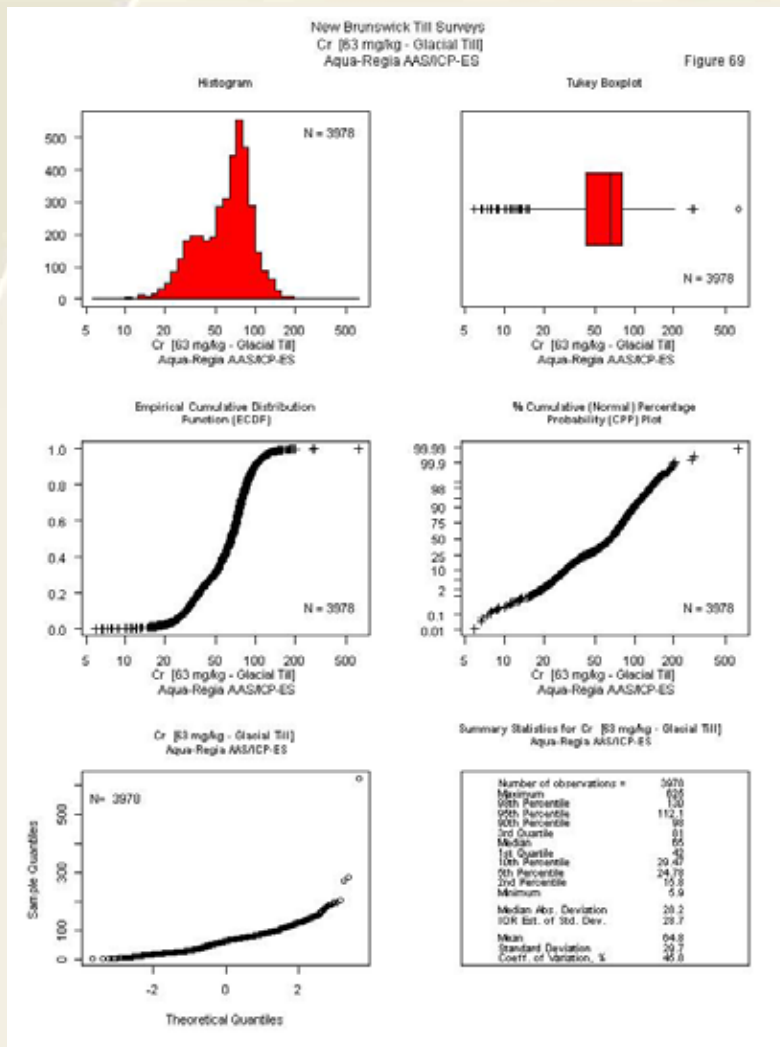






# Cr – Till – Aqua Regia New Brunswick

Earth Sciences Sector



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

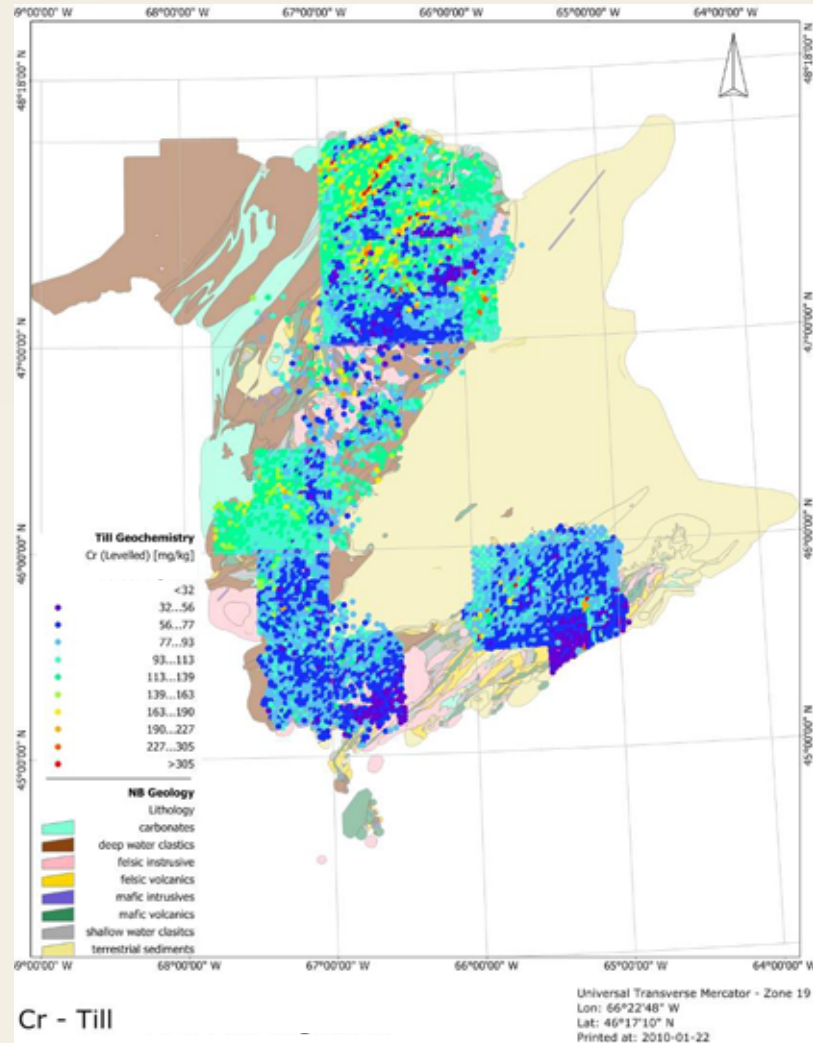
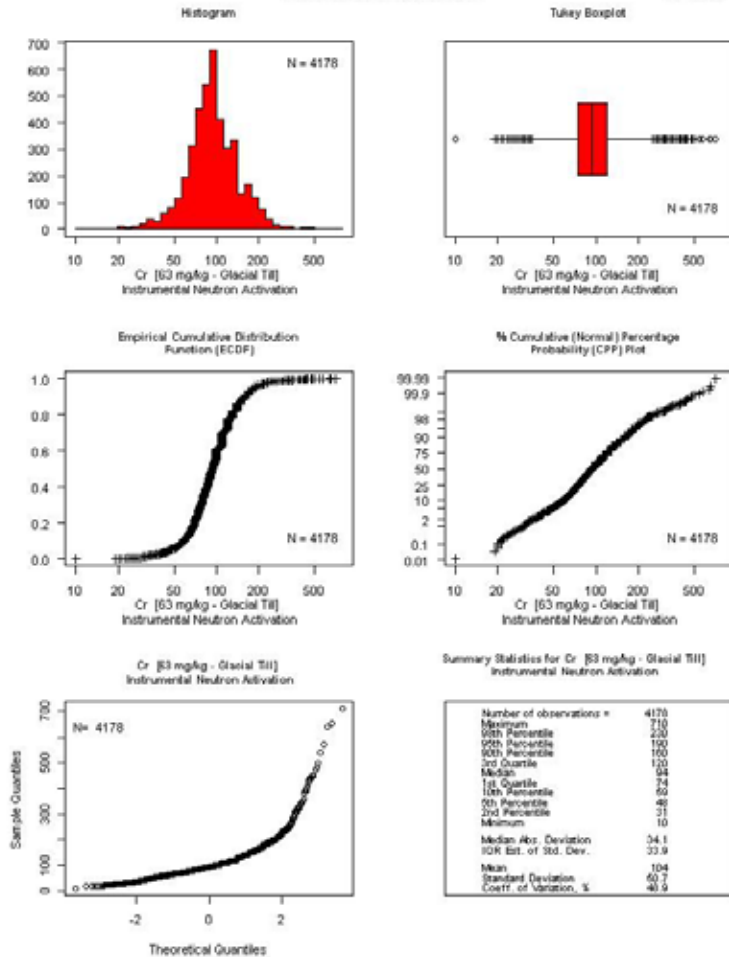


# Cr – Till – Neutron Activation New Brunswick

Earth Sciences Sector

New Brunswick Till Surveys  
Cr [63 mg/kg - Glacial Till]  
Instrumental Neutron Activation

Figure 04



Natural Resources  
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Ressources naturelles  
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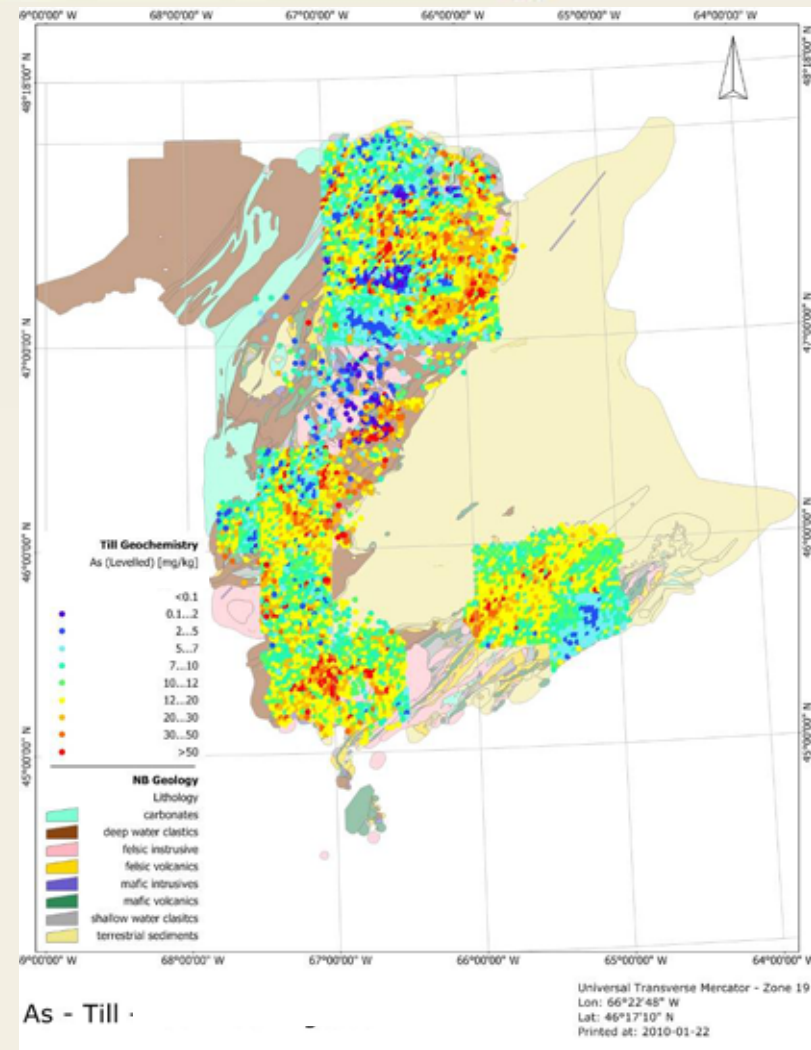
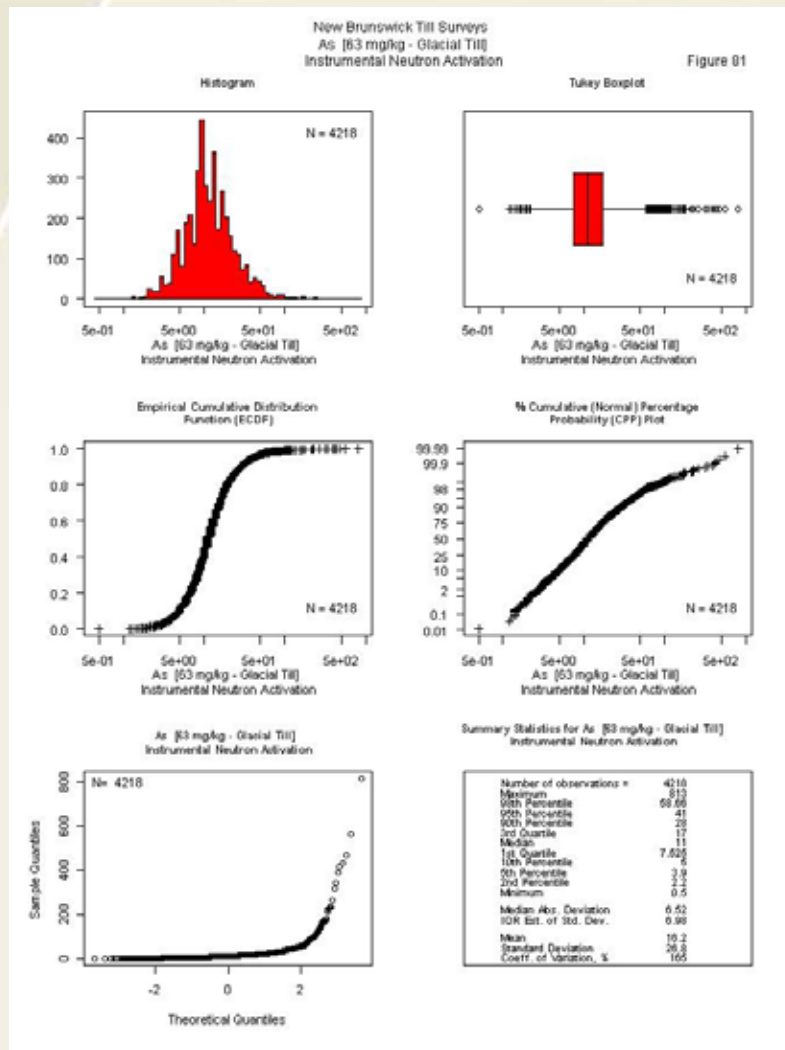
Canada





# As – Till – Neutron Activation New Brunswick

Earth Sciences Sector



< 63 micron



Natural Resources  
Canada

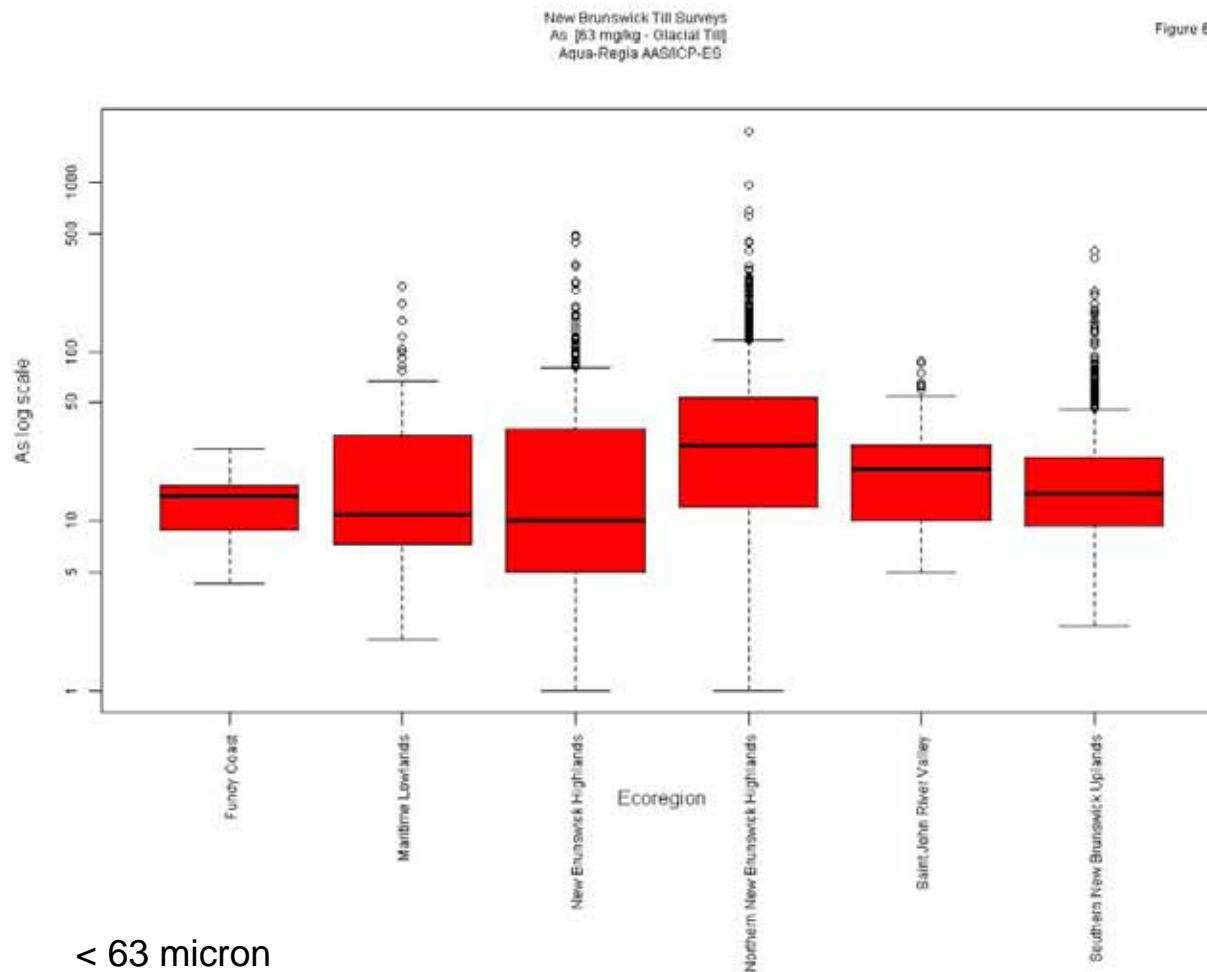
Ressources naturelles  
Canada

Canada



# As – Aqua regia – Till by Ecoregion

Earth Sciences Sector



Natural Resources  
Canada

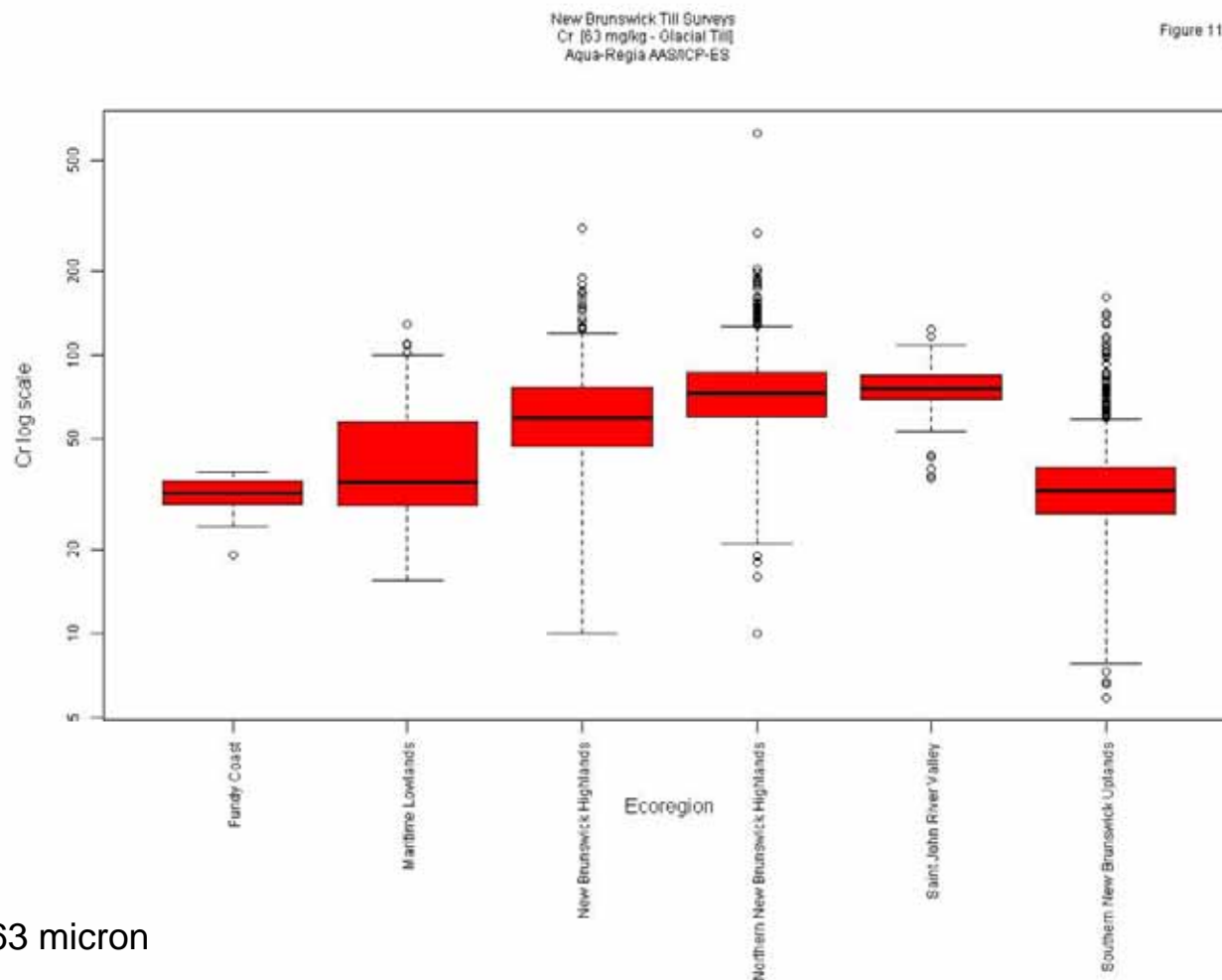
Ressources naturelles  
Canada

Canada



# Cr – Aqua regia – Till by Ecoregion

Earth Sciences Sector



< 63 micron



Natural Resources  
Canada

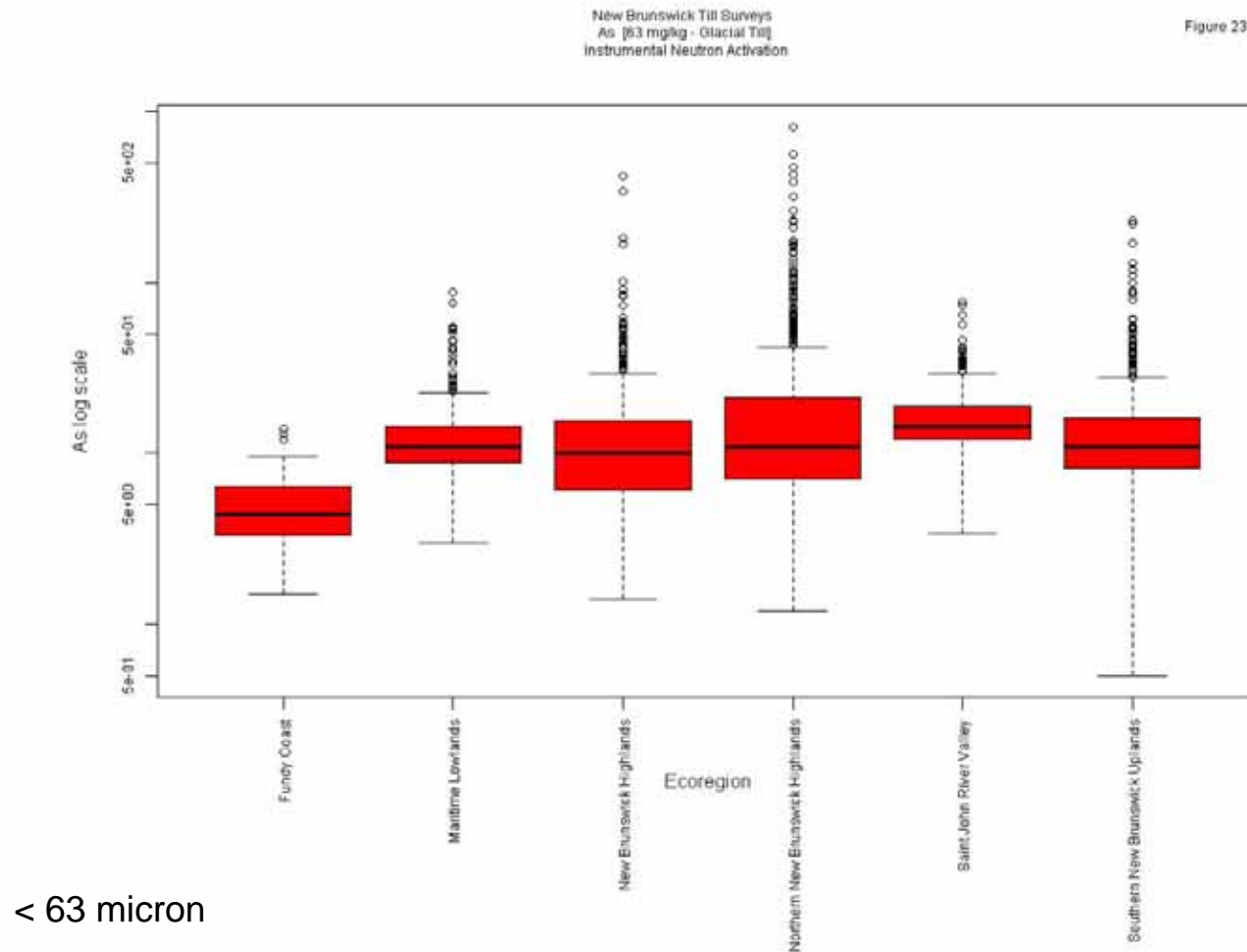
Ressources naturelles  
Canada

Canada



# As – Neutron Activation – Till by Ecoregion

Earth Sciences Sector



Natural Resources  
Canada

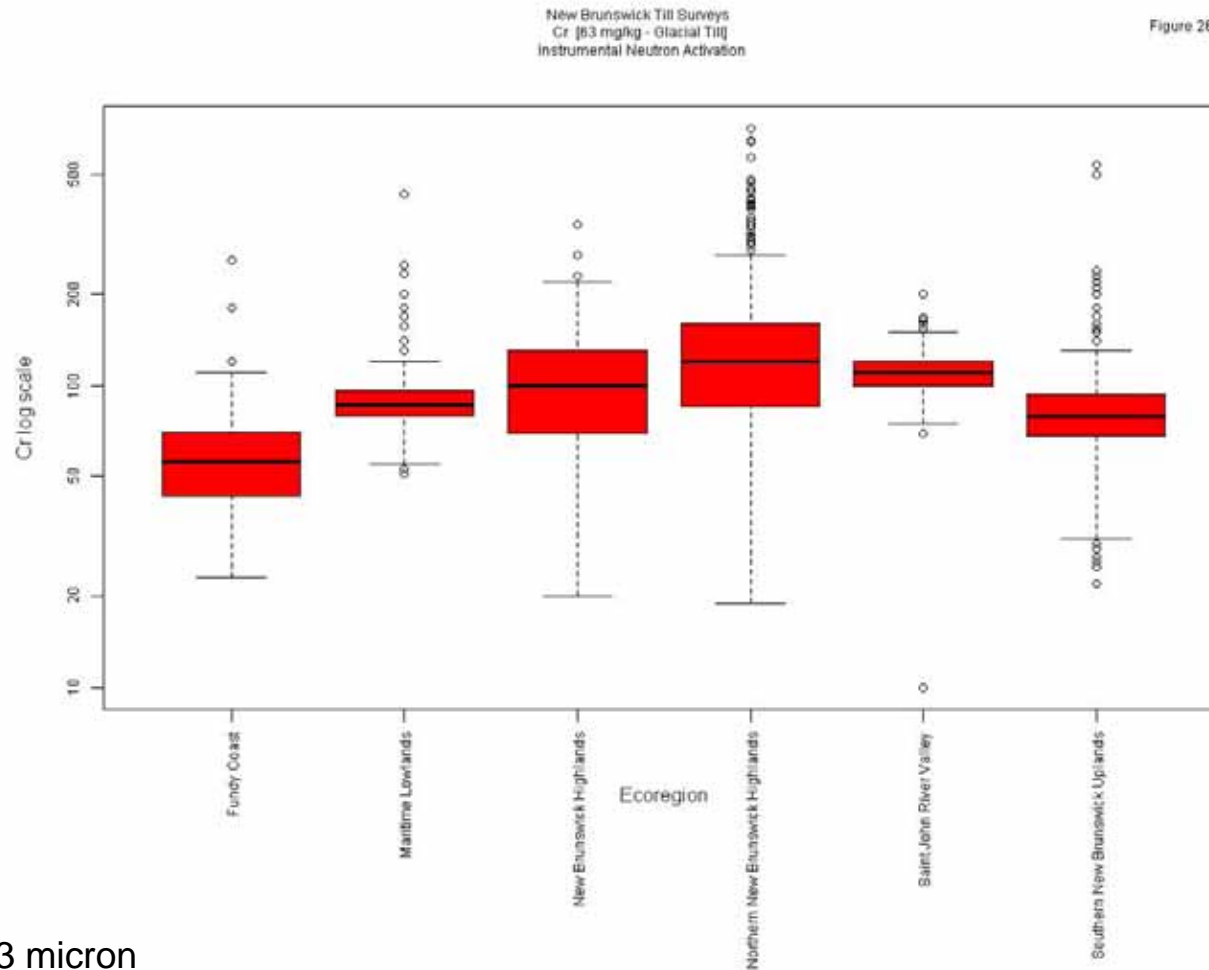
Ressources naturelles  
Canada

Canada



# Cr – Neutron Activation – Till by Ecoregion

Earth Sciences Sector



Natural Resources  
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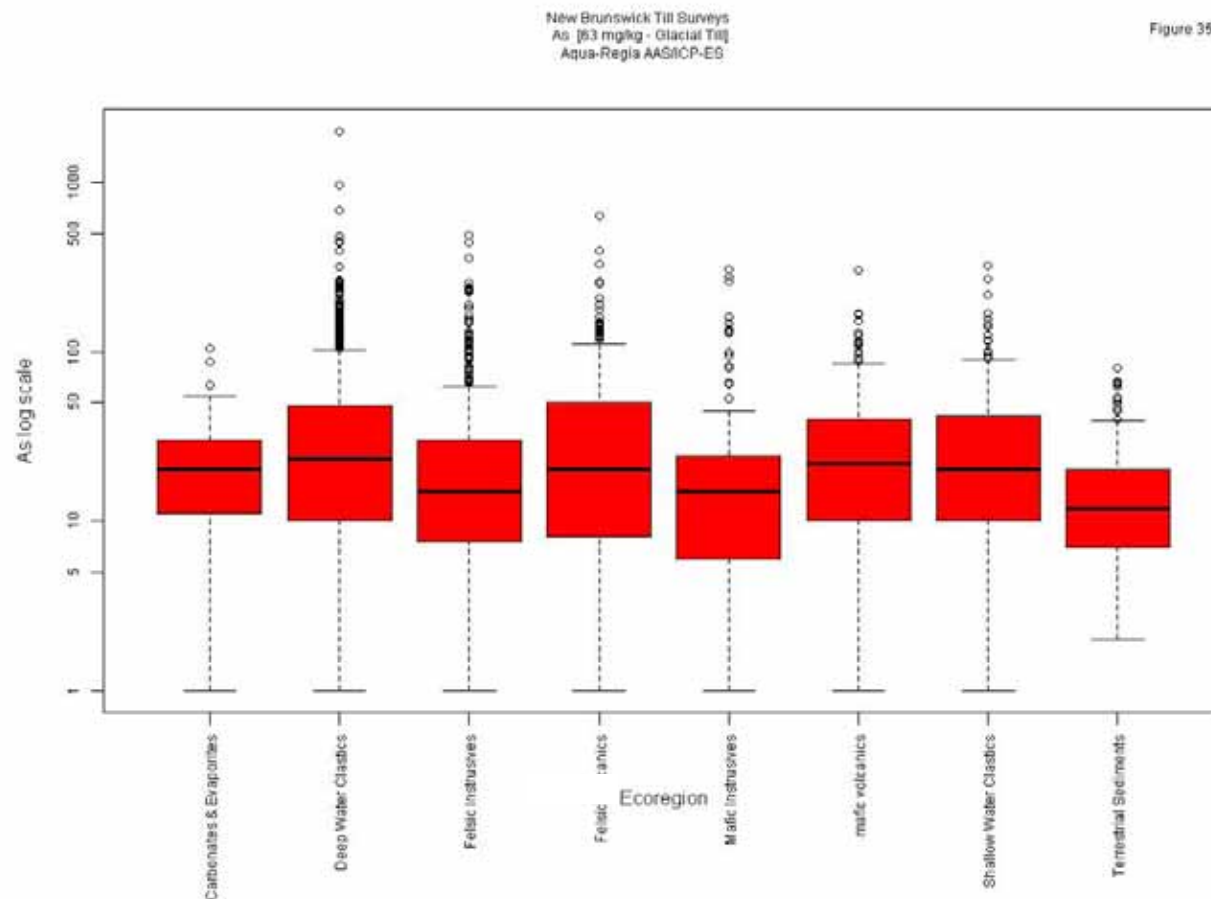
Ressources naturelles  
Canada

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# As – Aqua Regia – Till by Bedrock Lithology

Earth Sciences Sector



< 63 micron



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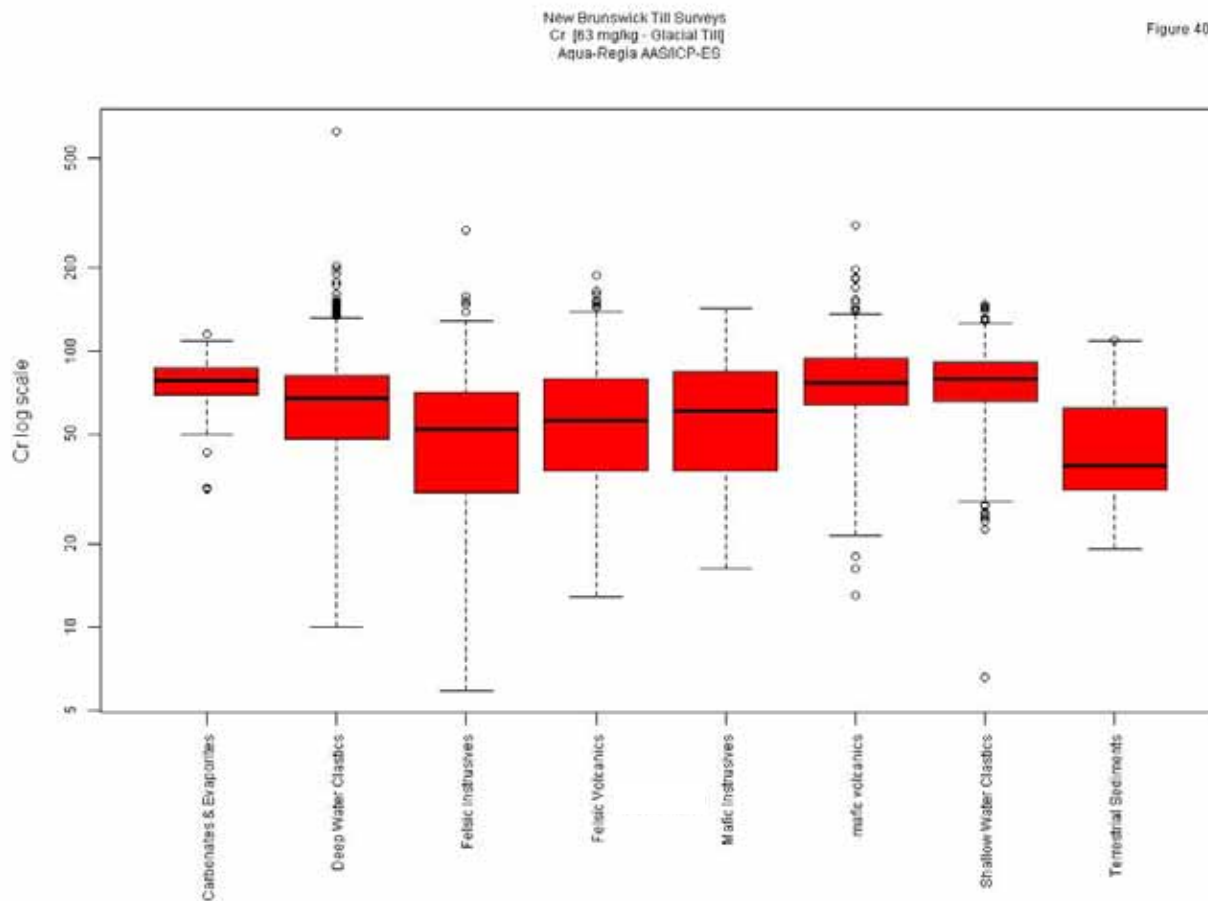
Canada





# Cr – Aqua regia – Till by Bedrock Lithology

Earth Sciences Sector



< 63 micron



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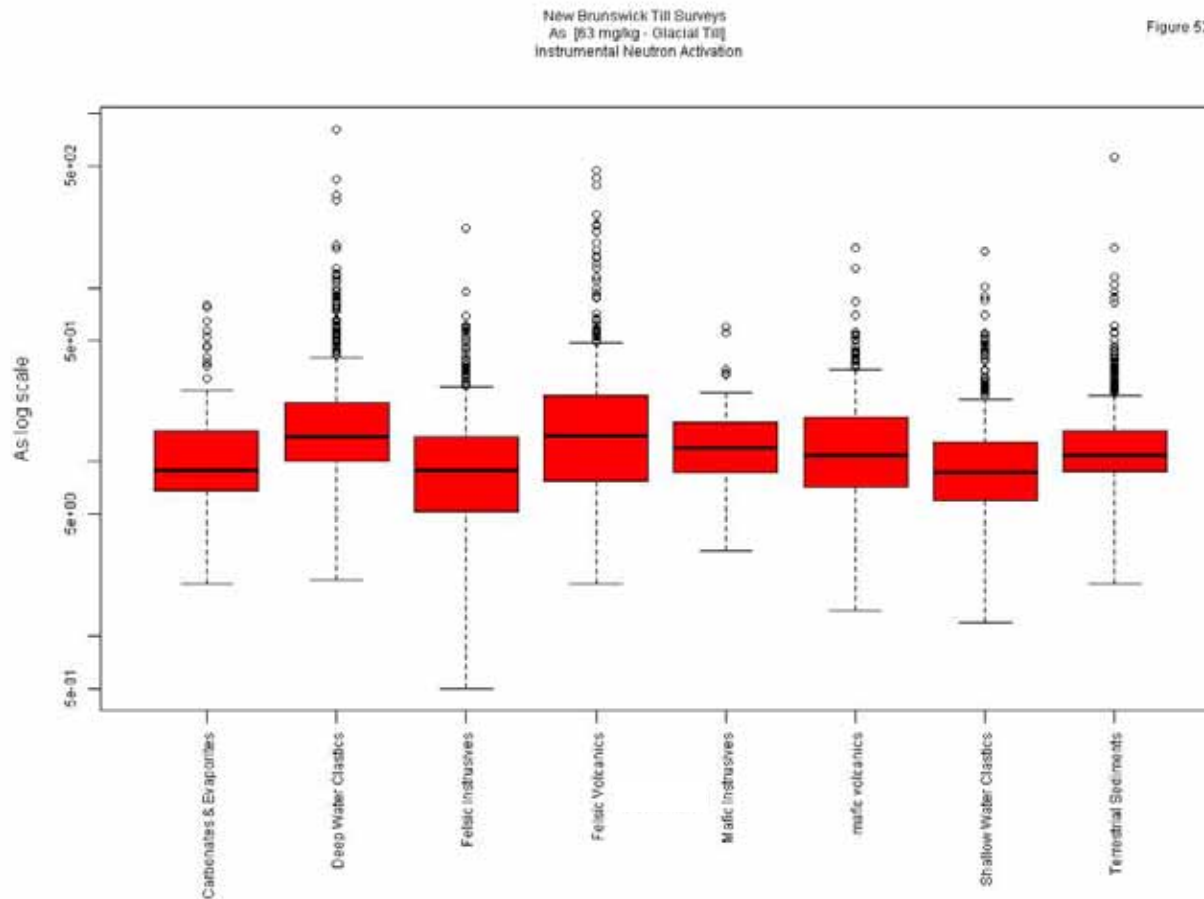
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# As – Neutron Activation – Till by Bedrock Lithology

Earth Sciences Sector



< 63 micron



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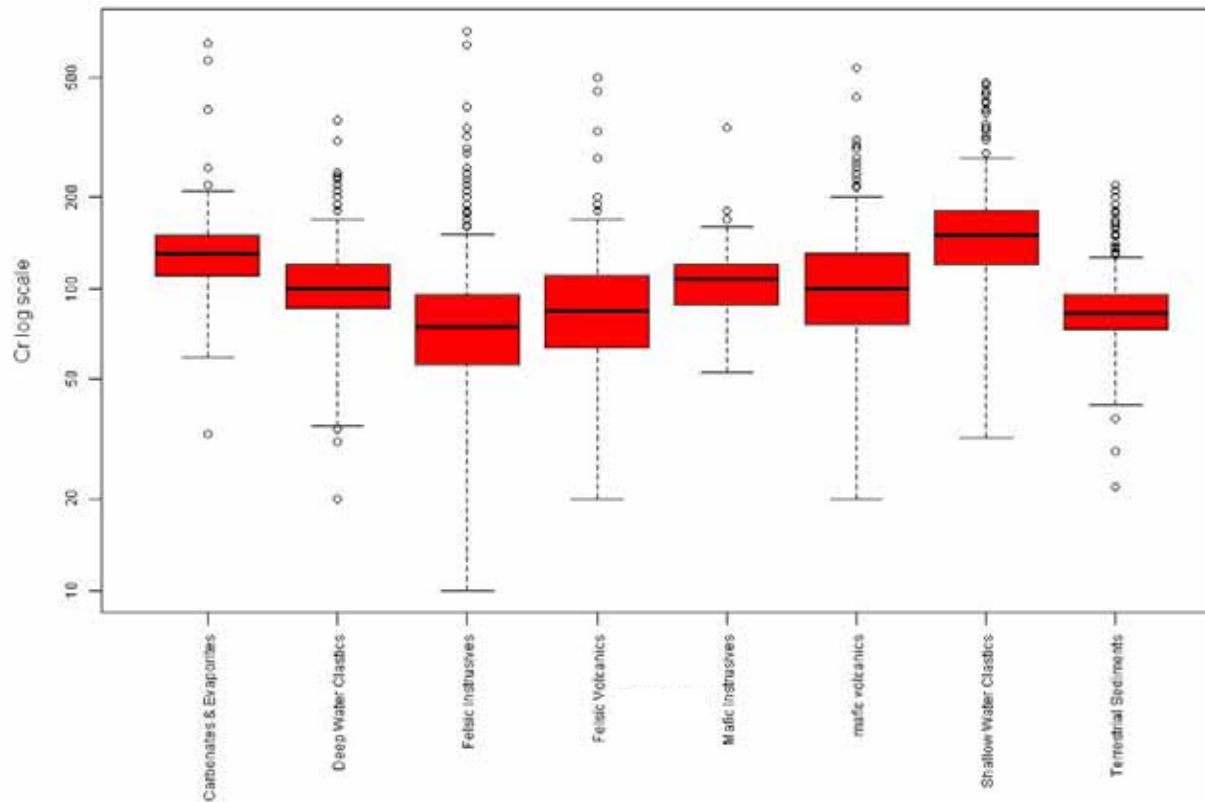


# Cr – Neutron Activation – Till by Bedrock Lithology

Earth Sciences Sector

New Brunswick Till Surveys  
Cr [63 mg/kg - Glacial Till]  
Instrumental Neutron Activation

Figure 55



< 63 micron



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# Recommendations

Earth Sciences Sector

Choose a sample density that will suit the purpose of the project.

Determine the influence of bedrock, soil, ecoregion and culture by using graphical tools for the display of element variability (box plots).



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# Other Considerations When Using Legacy Data





# Interpretation of Geochemical Survey Data

Earth Sciences Sector

- Geochemical data derived from government geochemical surveys are difficult to assemble and integrate due to the use of different spatial resolution, size fractions, and methods of digestion and analytical instrumentation.
- The assembly of these data is a challenge but the results provide opportunities for discovering a wider range of geochemical processes using advanced methods of statistical analysis.
- Many of the topics related to integrating geochemical data sets are covered in Grunsky (2010).



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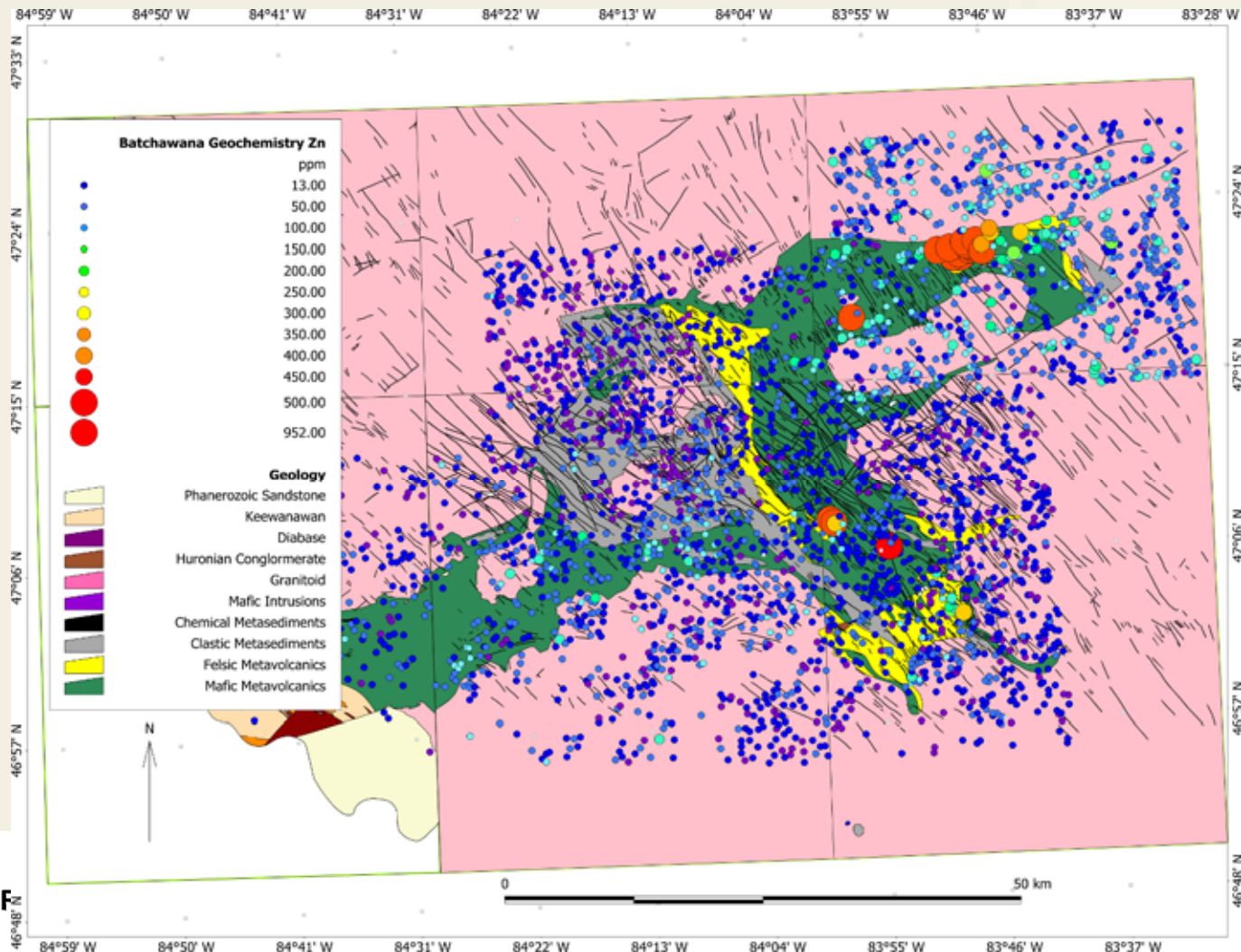
# Interpretation of Geochemical Survey Data

Earth Sciences Sector

Example – Lake sediment data from the Batchawana area (Grunsky, 2010)

Zn

3047 lake  
sediment  
samples  
collected  
between  
1989-1995



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# Sources of Batchawana Data

Earth Sciences Sector

- FORTESCUE, J.A.C. and VIDA, E.A., 1989, Geochemical Survey of the Trout Lake Area; Ontario Geological Survey, Map 80803.
- FORTESCUE, J.A.C. and VIDA, E.A., 1990, Geochemical Survey, Hanes Lake Area; Ontario Geological Survey, Map 80806.
- FORTESCUE, J.A.C. and VIDA, E.A., 1991a, Geochemical Survey, Montreal River Area; Ontario Geological Survey, Map 80808.
- FORTESCUE, J.A.C. and VIDA, E.A., 1991b, Geochemical Survey, Pancake Lake Area; Ontario Geological Survey, Map 80807.
- HAMILTON, S., 1995, Lake Sediment Geochemistry of the Cow River Area, Ontario Geological Survey, Open File Report 5917.



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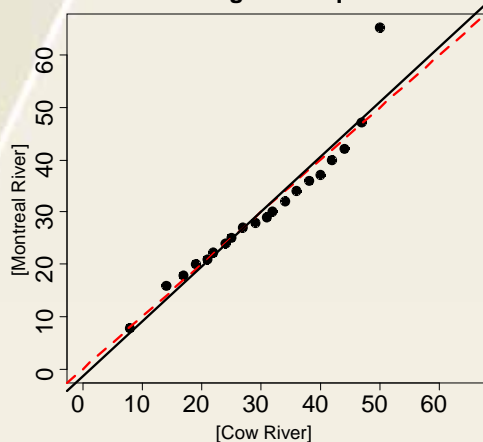
# Parametric Levelling Scenarios

## Example - Cr - Lake Sediment Surveys

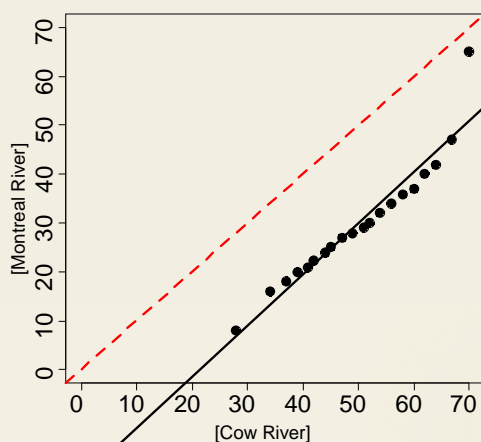
Earth Sciences Sector

Cr (mg/kg) in Lake Sediments

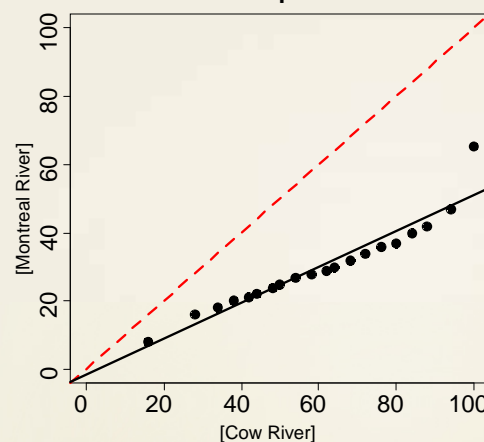
Levelling Not Required



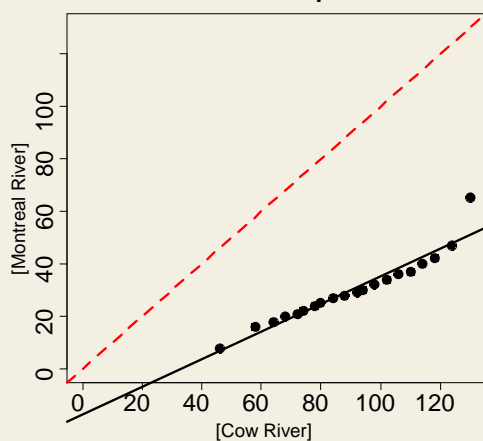
Shift



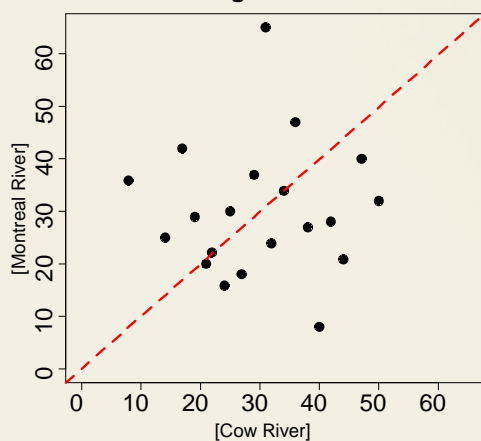
Multiplier



Shift + Multiplier



Levelling Not Possible



Quantile Interval=0.05



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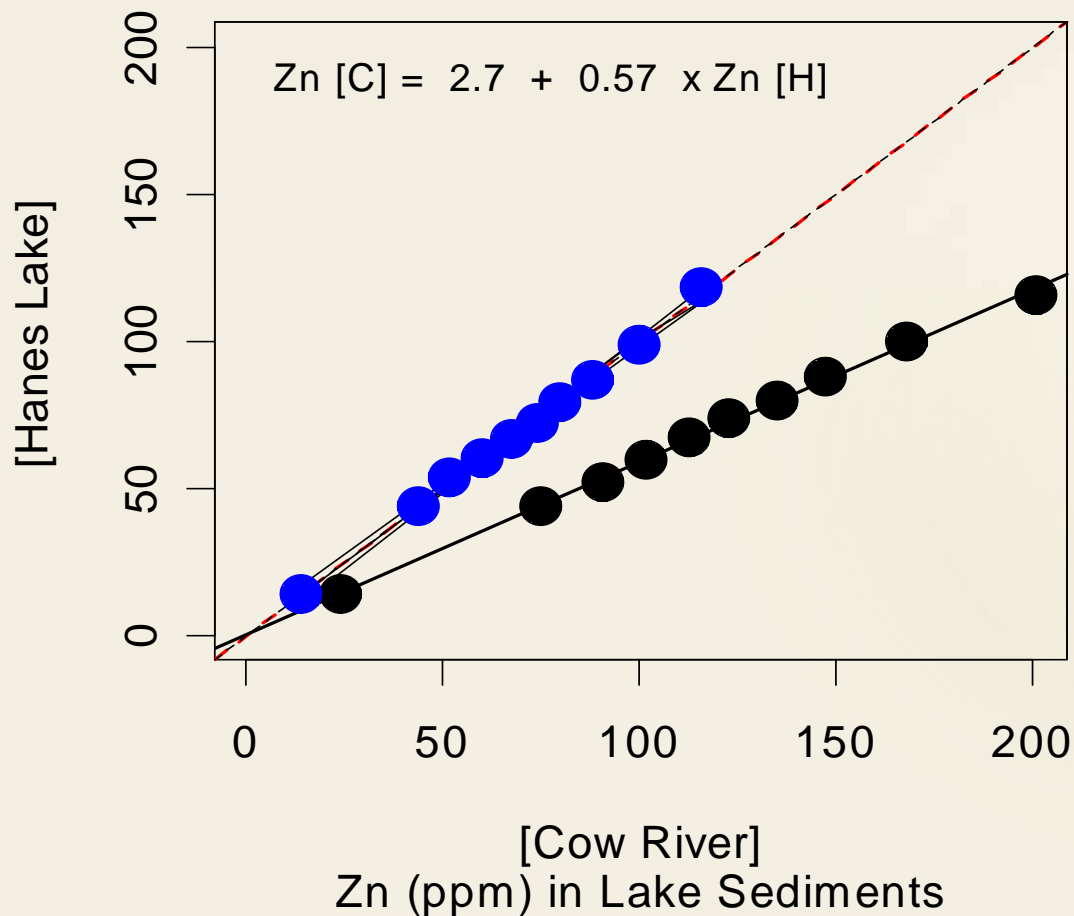
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# Example of Zn levelling

Earth Sciences Sector

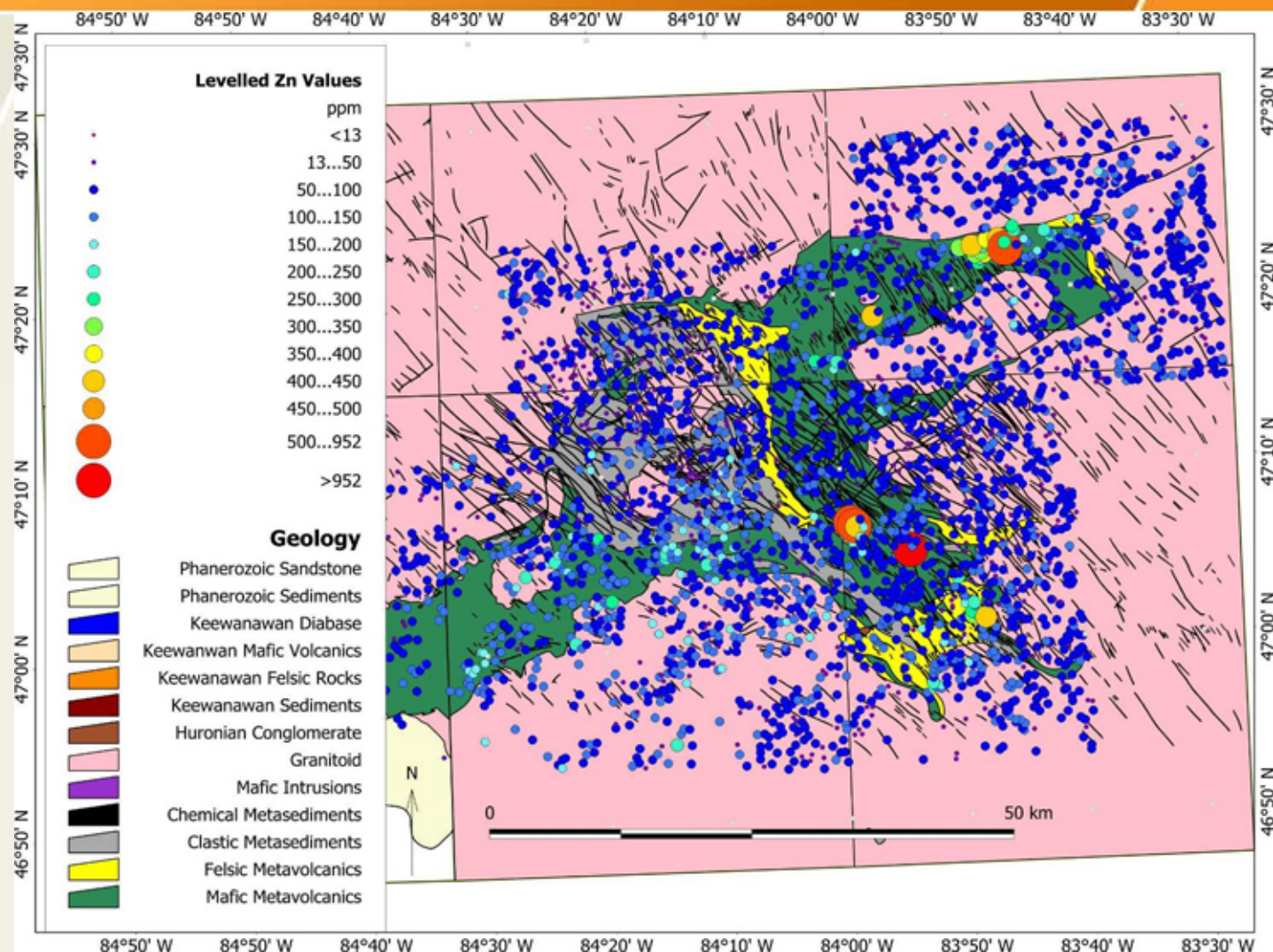
## Shift + Multiplier





# Zn in Lake Sediments after Levelling

Earth Sciences Sector



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# References

Earth Sciences Sector

Ecological Stratification Working Group. 1996. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of Environment Directorate, Ottawa/Hull. 125pp. And Map at scale 1:7.5 million. <http://www.ec.gc.ca/soer-ree/English/Framework/framework.cfm>.

Grunsky, E.C., 2010. The interpretation of geochemical surveys; Geochemistry: Exploration, Environment Analysis, v. 10, p. 27-74.

Rencz, A N; Garrett, R G; Adcock, S W; Bonham-Carter, G F. 2006 . Geochemical background in soil and till;; Geological Survey of Canada Open File 5084, 64 pages.



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