Non-Contaminant Chemistry of Natural Waters

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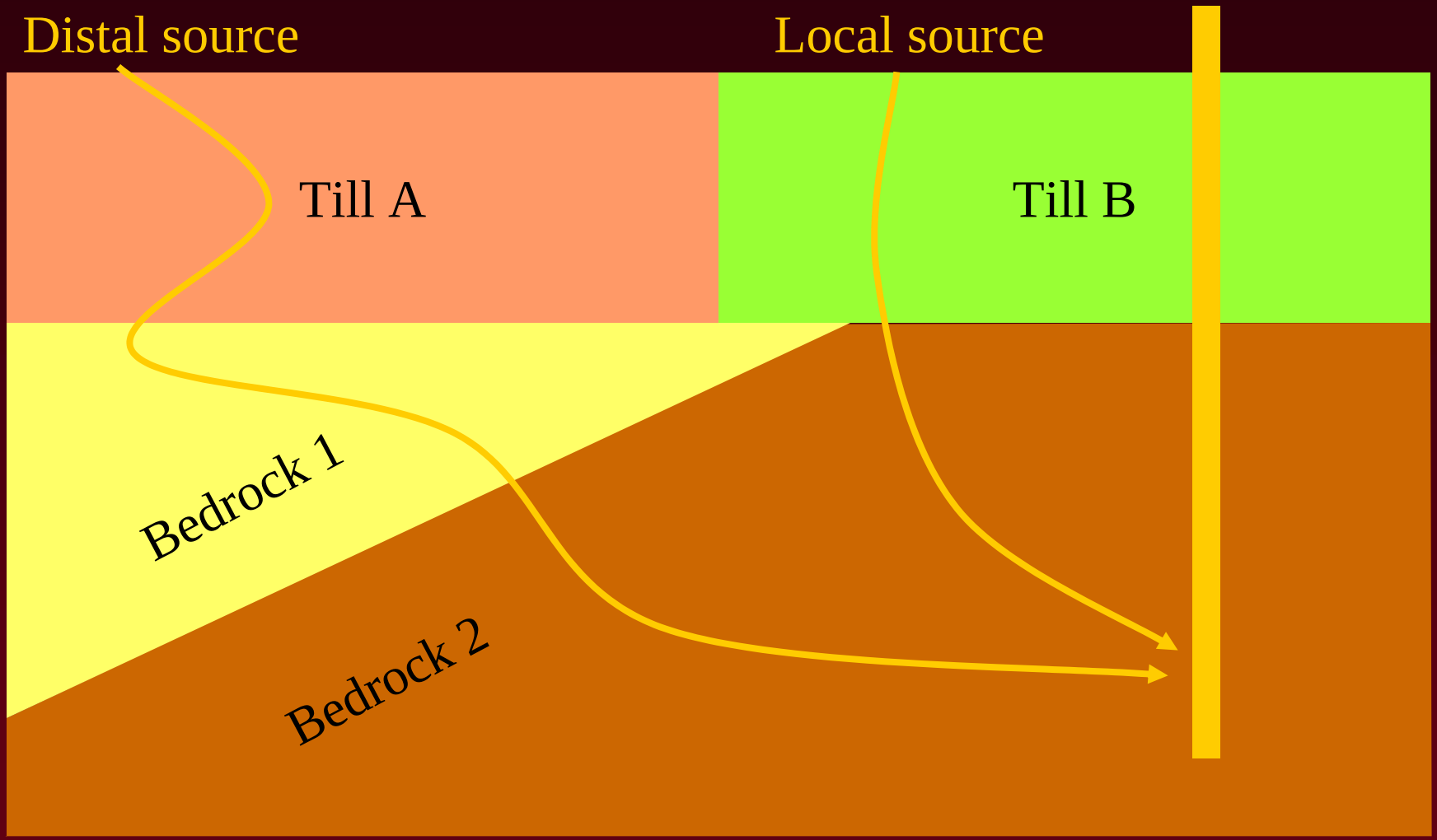
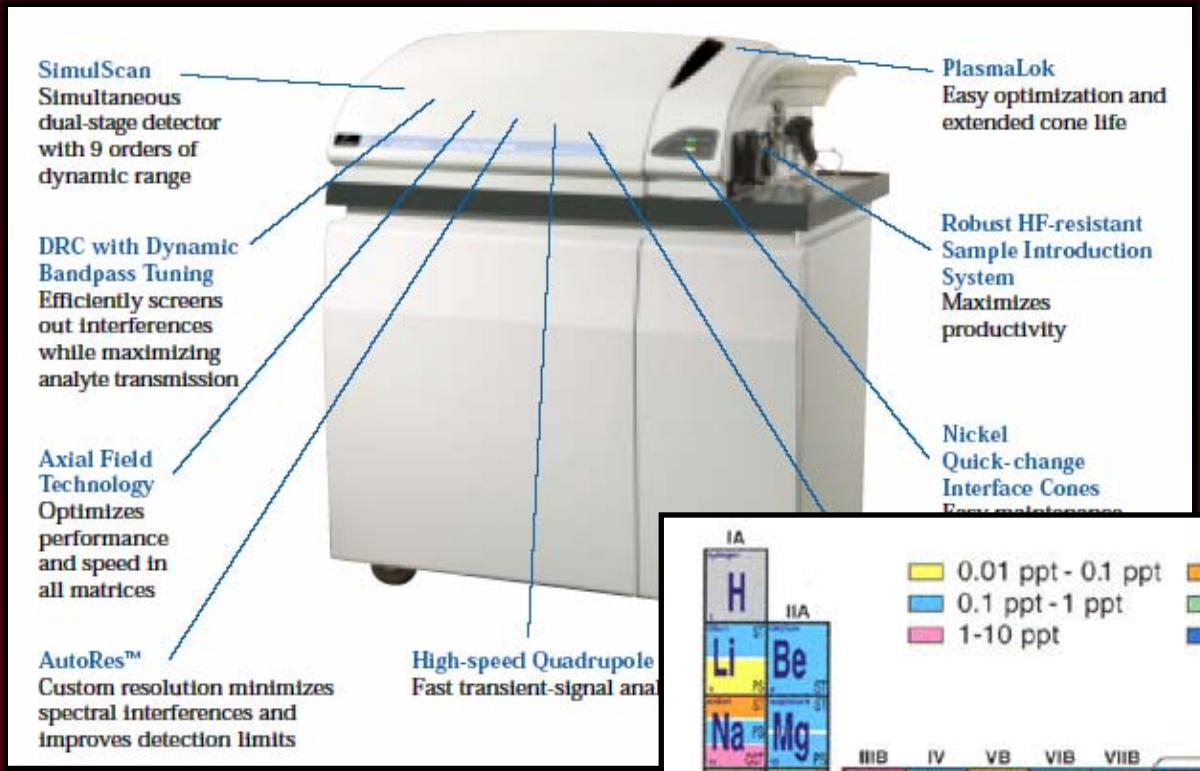
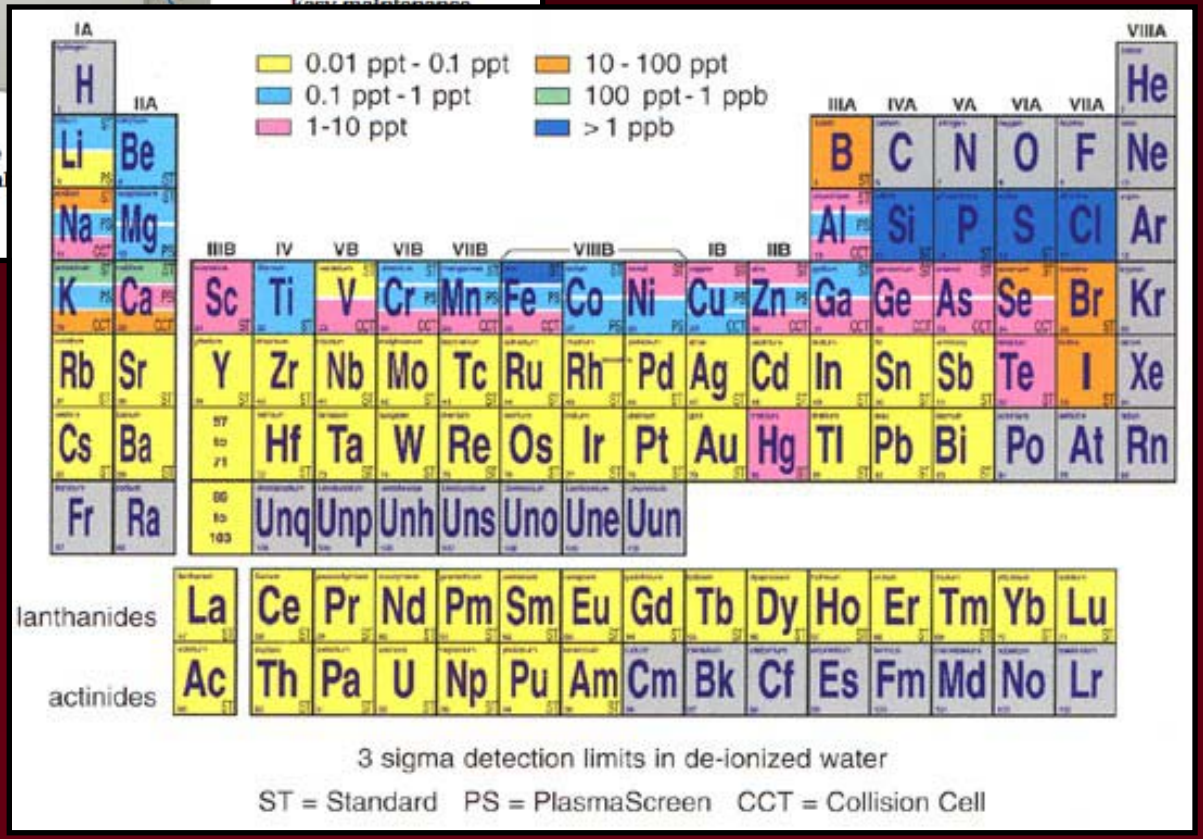


Residence Time = path length x flow velocity

Pieter Brueghel the Elder (1525-1569) *An Alchemist at work*, mid 16th cent.

ICP/MS





Multi-elemental analysis

Ion Chromatography

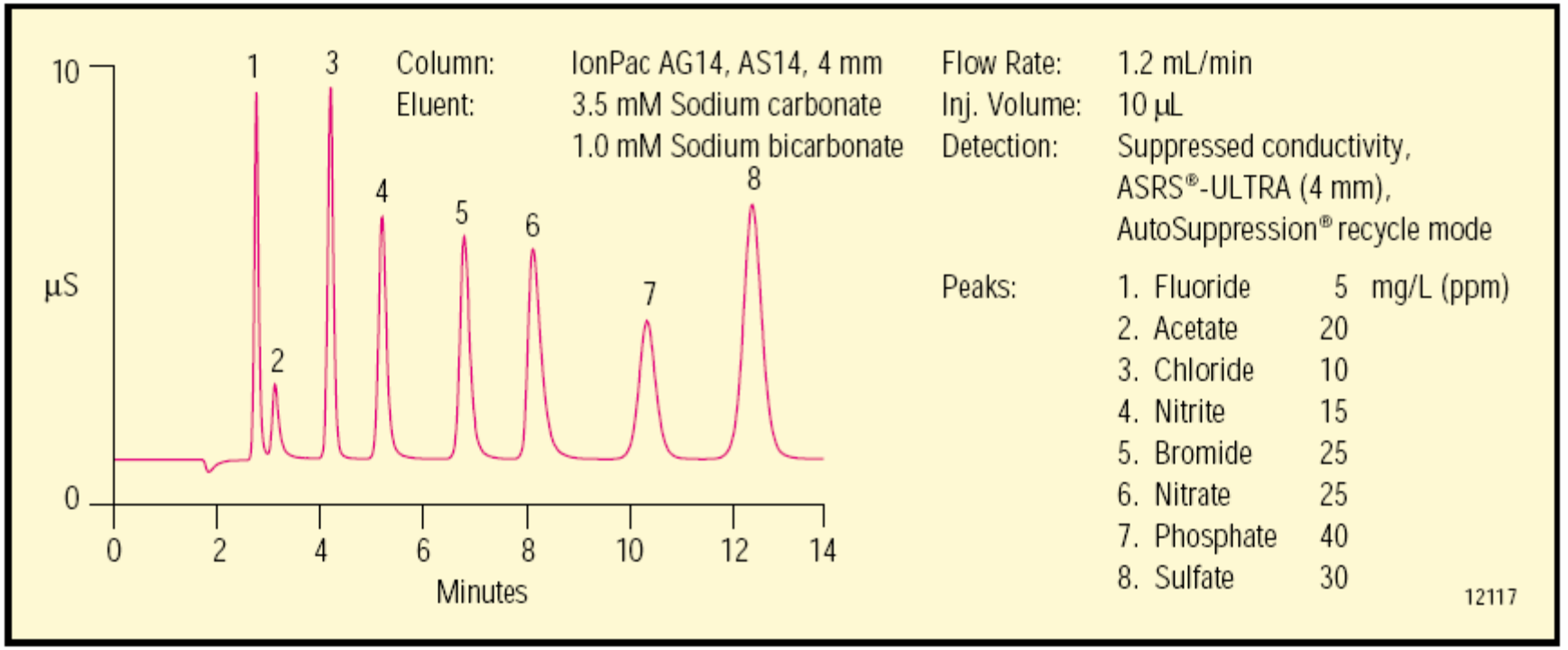


Figure 2. Isocratic separation of inorganic anions on an IonPac AS14 column in less than 13 minutes.

Spectrum of elements / species

Multiple component standards

Low detection limits

Naturally occurring and abundant

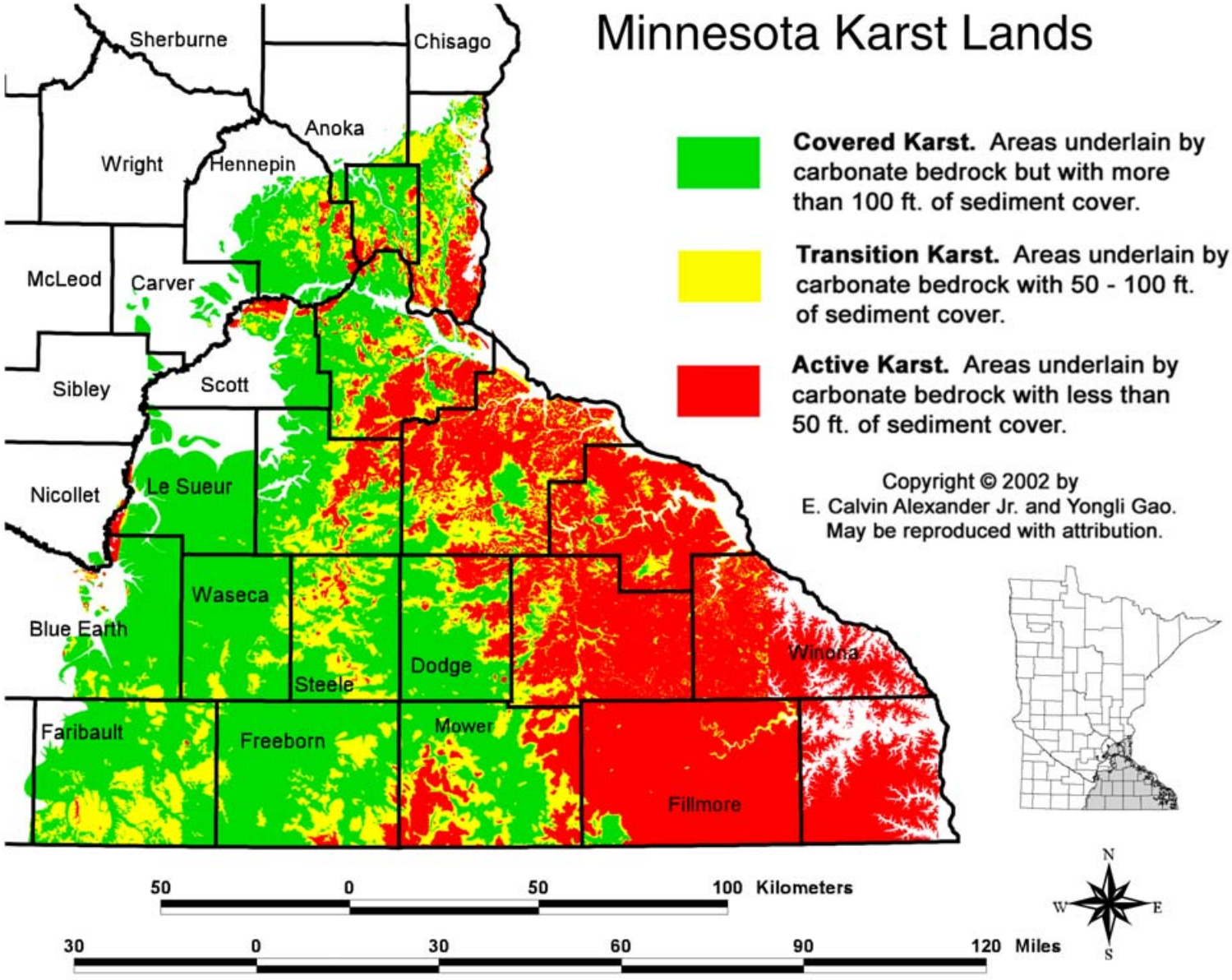
ppm / ppb / ppt

Major Elements

Calcium
Magnesium
Bicarbonate

concentrations set early in flowpath
controlled by pH and pCO_2
slow evolution thereafter

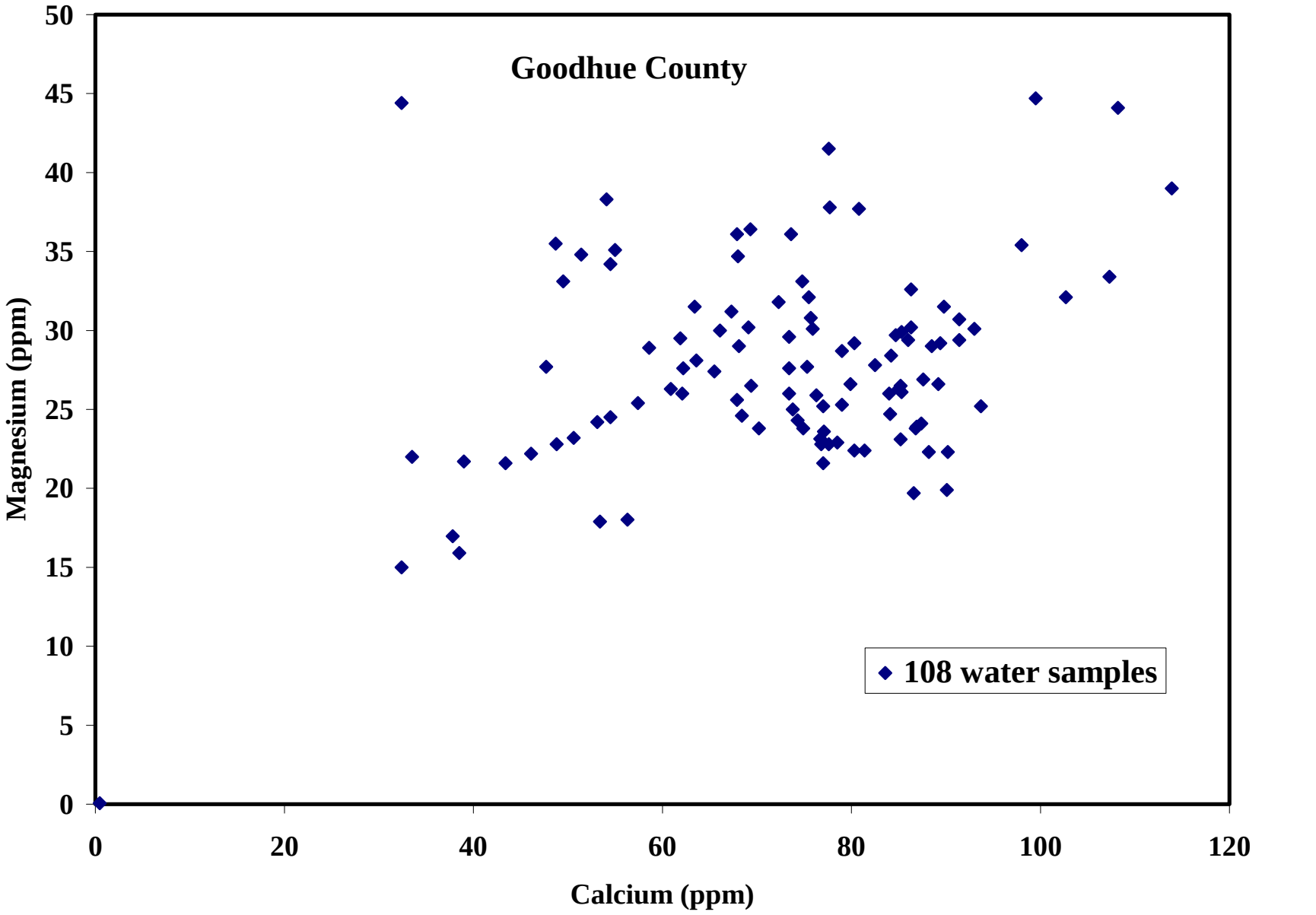
Minnesota Karst Lands



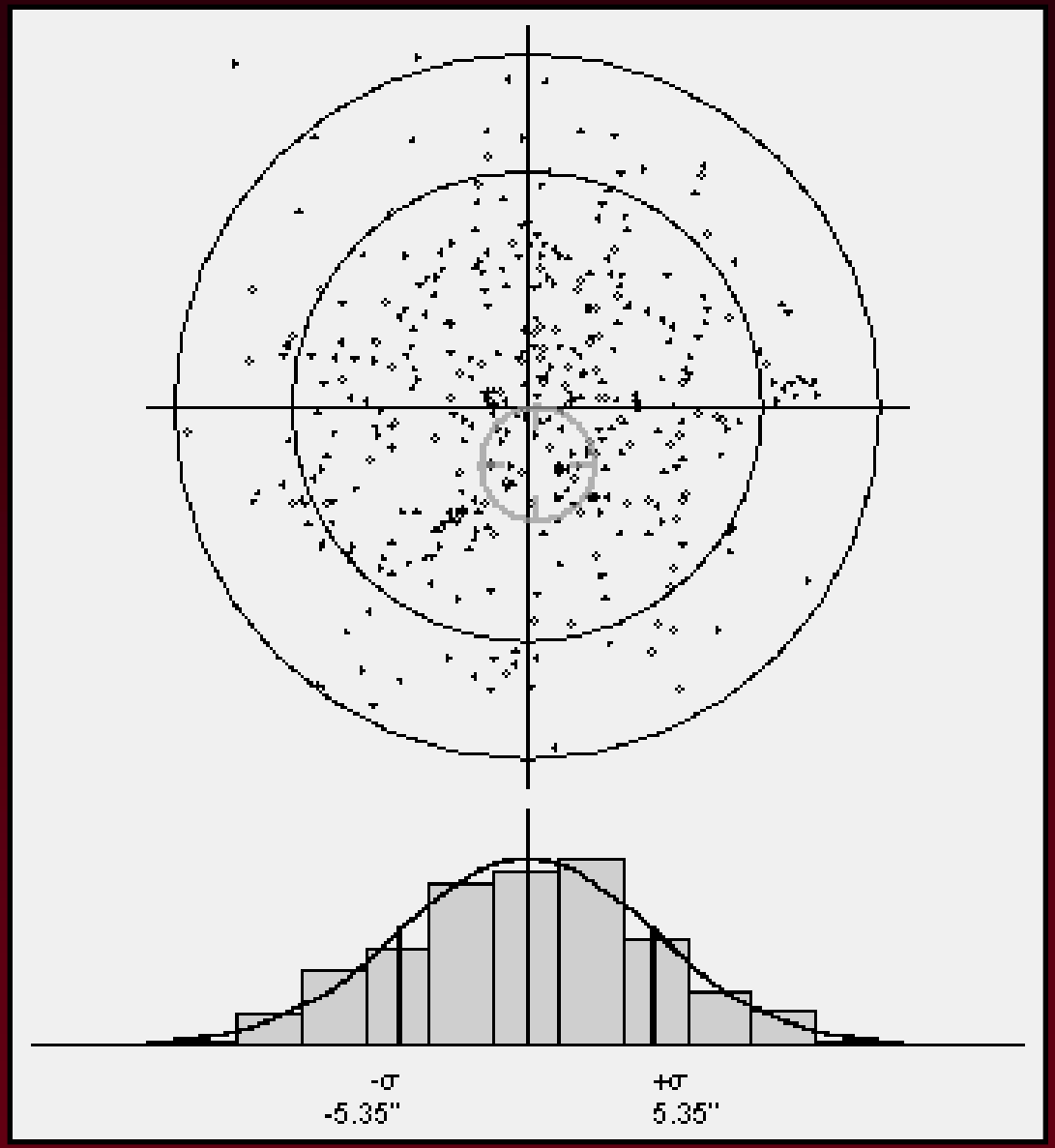
Covered Karst. Areas underlain by carbonate bedrock but with more than 100 ft. of sediment cover.

Transition Karst. Areas underlain by carbonate bedrock with 50 - 100 ft. of sediment cover.

Active Karst. Areas underlain by carbonate bedrock with less than 50 ft. of sediment cover.

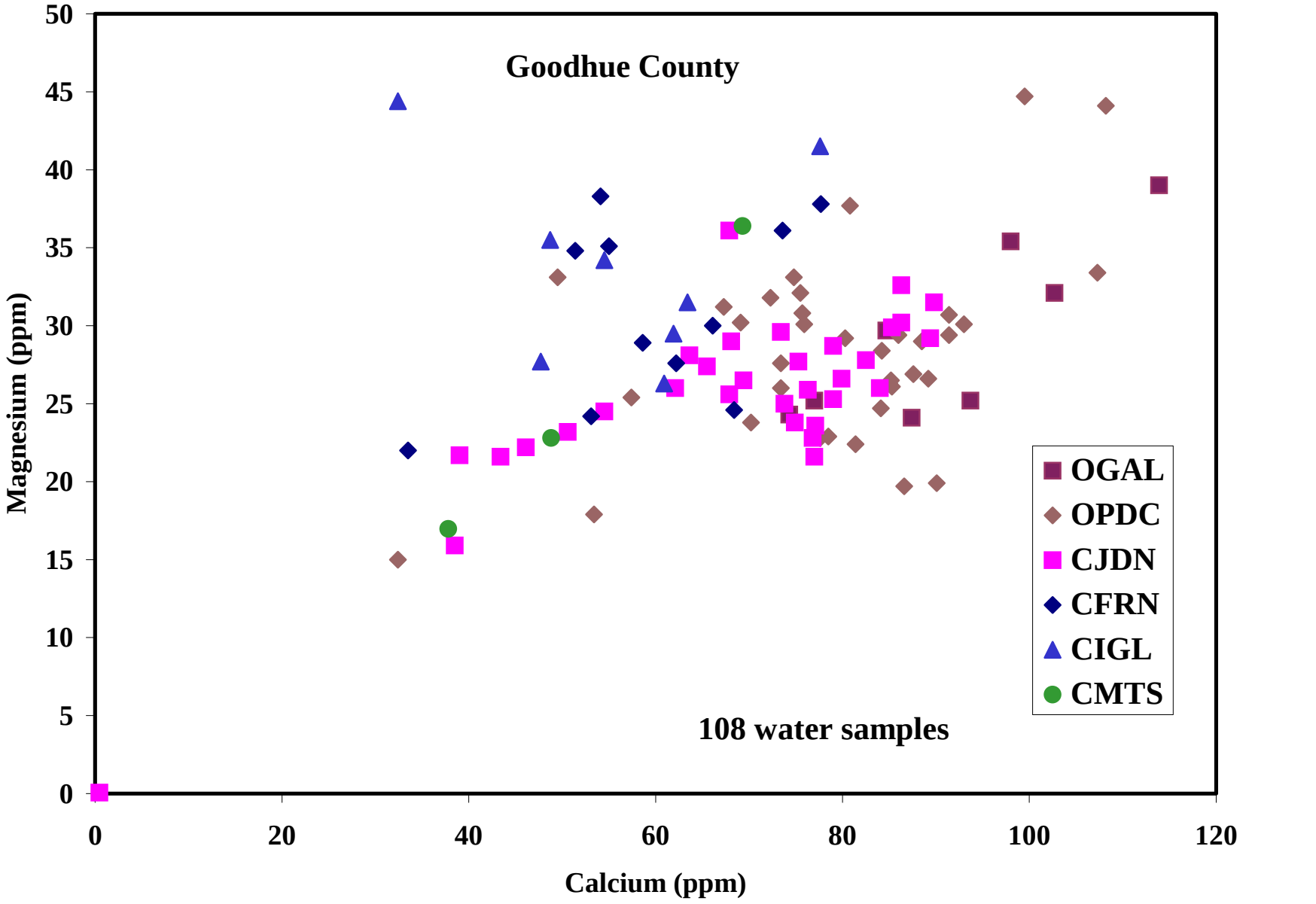


DNR County Geologic Atlas Program

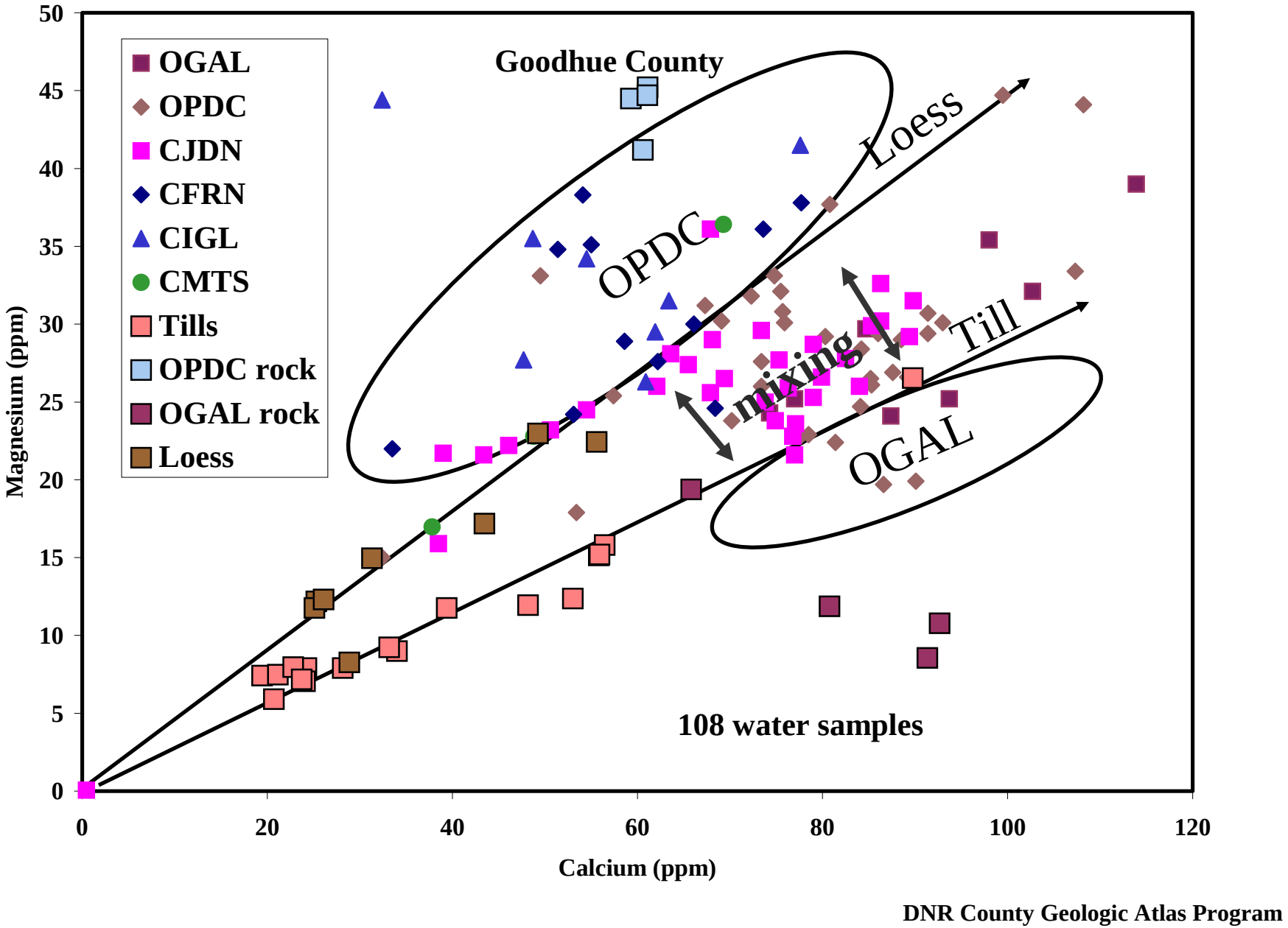


Shotgun Pattern

www.shotgun-insight.com



DNR County Geologic Atlas Program



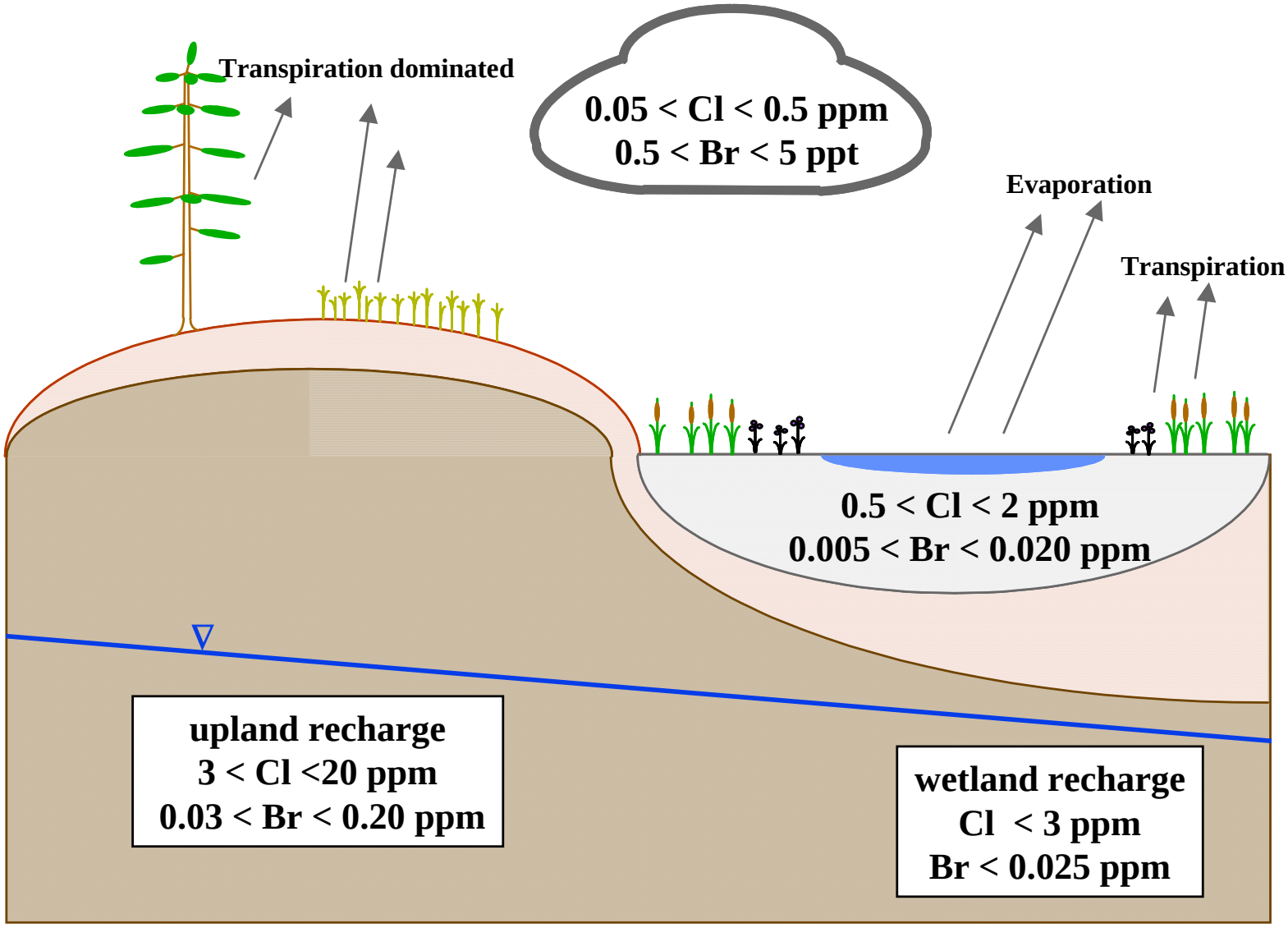
DNR County Geologic Atlas Program

Natural and/or Human

Sodium
Chloride
Sulfate

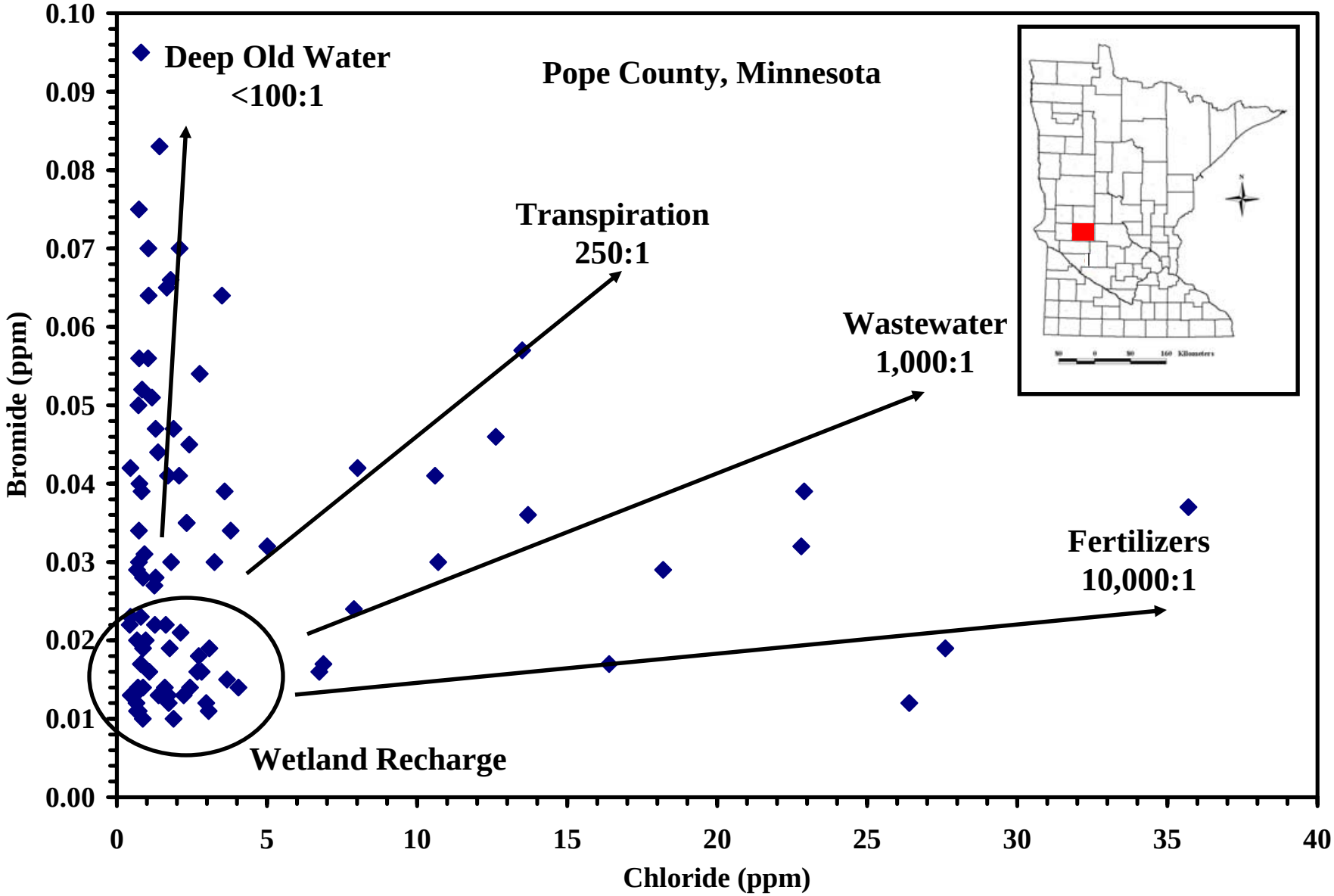
Strontium
Barium
Bromide
Nitrate
Fluoride

Chloride and Bromide in MinnesotaWaters



Chloride/Bromide ratios

Seawater	300:1
Minnesota Rain	200-250:1
Manure	500-1,000:1
Wastewater	1,000-2,000:1
KCl fertilizer	10,000:1
Road/Softener Salt	>20,000:1



DNR County Geologic Atlas Program

Cation Exchange

Water Softener

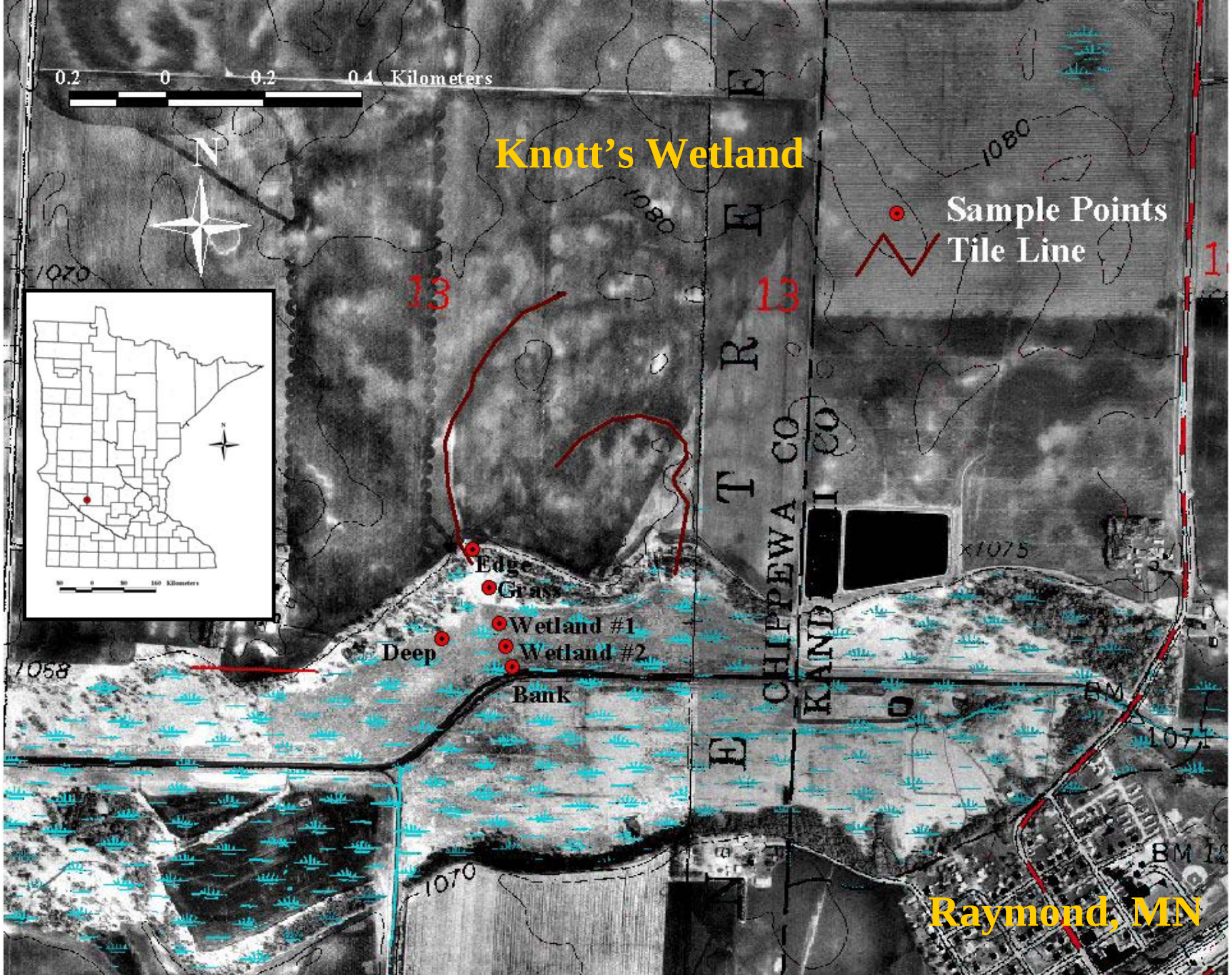
Na^{+} => Ca^{++} and Mg^{++}

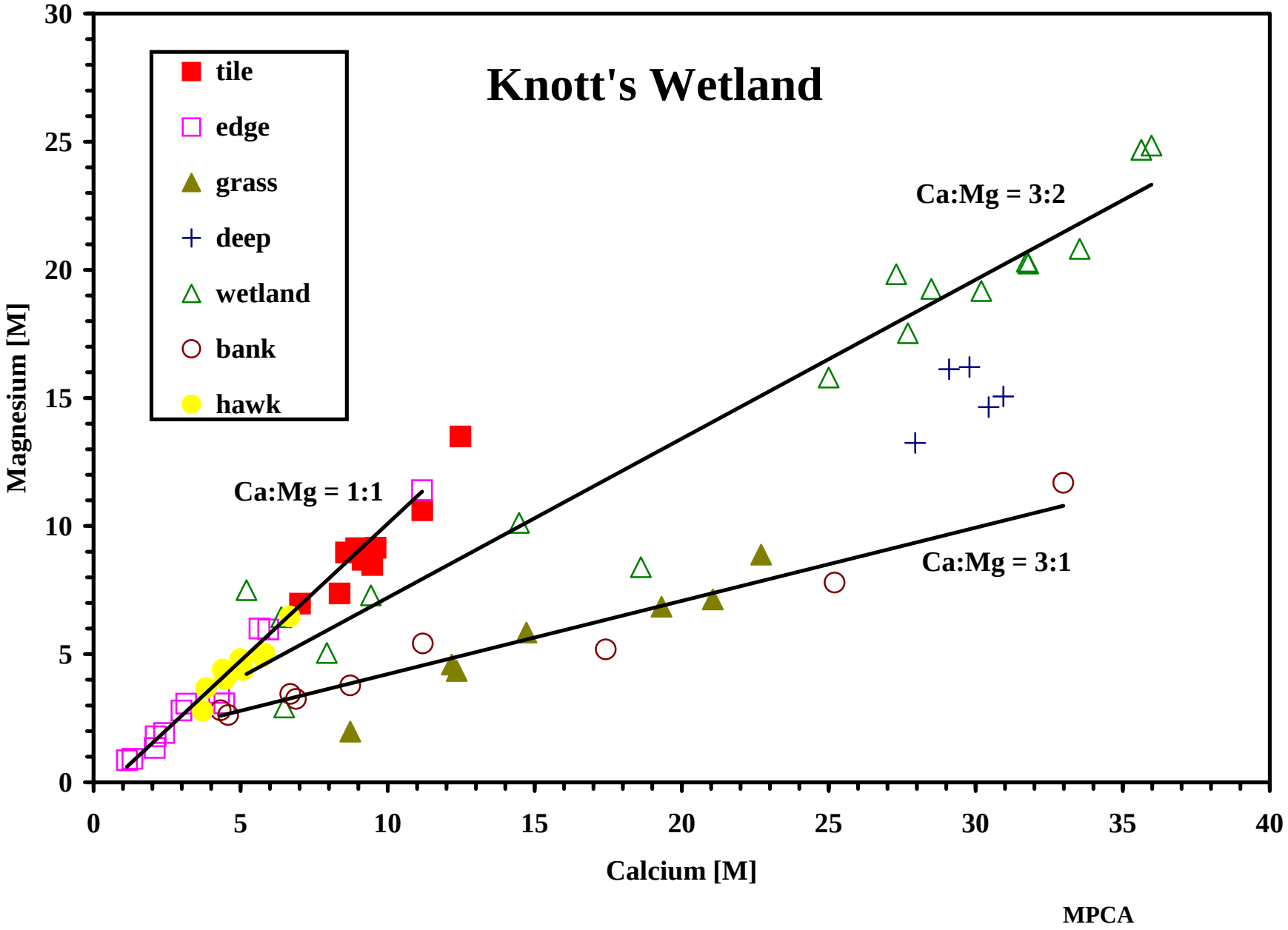
accumulates Sr^{++}

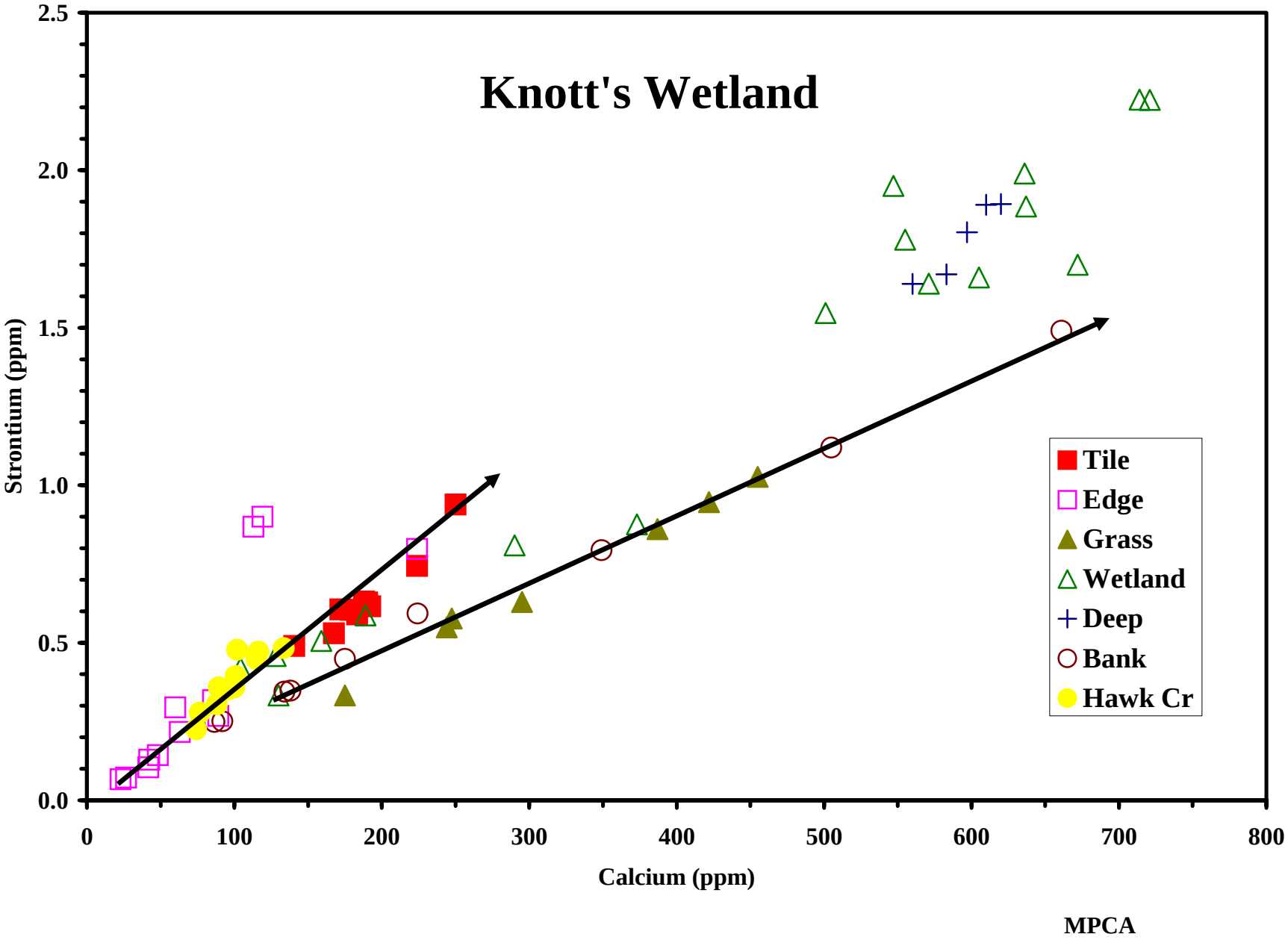
Anhydrous Ammonia

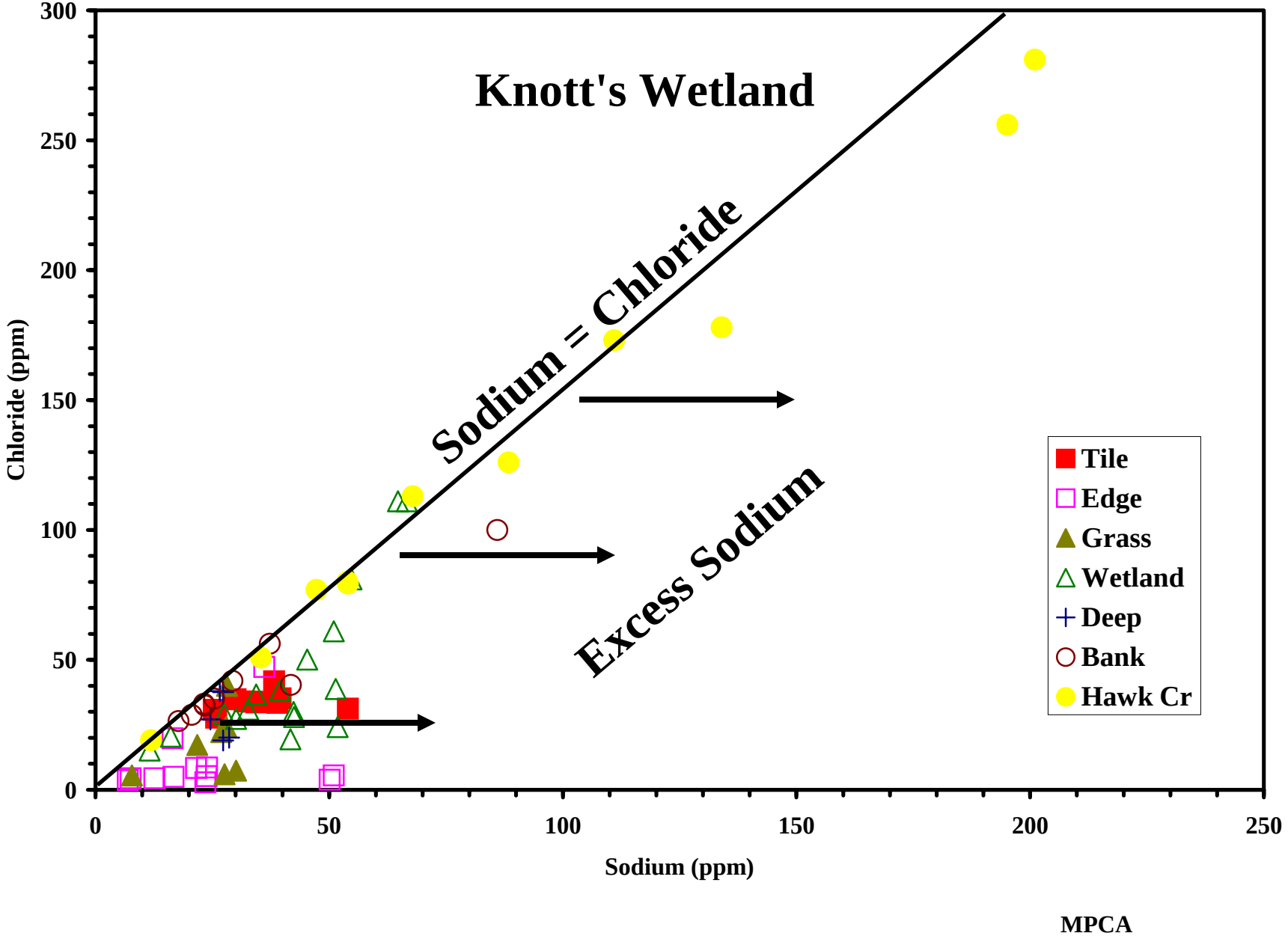
NH_4^{+} => Na^{+}, Ca^{++}, Mg^{+}, Sr^{++}, etc.

replaces almost all cations


0.2 0 0.2 0.4 Kilometers
N
Knott's Wetland
Sample Points
Tile Line
13
13
1080
1070
1075
1058
Edge
Grass
Wetland #1
Wetland #2
Deep
Bank
CHIPPEWA CO
KANDIYOHI CO
T
R
E
E
BM
1071
Raymond, MN


Knott's Wetland
tile
edge
grass
deep
wetland
bank
hawk
Ca:Mg = 3:2
Ca:Mg = 1:1
Ca:Mg = 3:1
Magnesium [M]
Calcium [M]
0
5
10
15
20
25
30
35
40
MPCA


Knott's Wetland
Strontium (ppm)
Calcium (ppm)
2.5
2.0
1.5
1.0
0.5
0.0
0
100
200
300
400
500
600
700
800
Tile
Edge
Grass
Wetland
Deep
Bank
Hawk Cr
MPCA


Knott's Wetland
Sodium = Chloride
Excess Sodium
Chloride (ppm)
Sodium (ppm)
0
50
100
150
200
250
300
Tile
Edge
Grass
Wetland
Deep
Bank
Hawk Cr
MPCA

How do you know what to plot?

Local Geology

dominant rock types in recharge areas

Land Use

dominant human activities

Analytes of Interest

conservative or adsorbed/exchanged

oxidized or reduced

Rules of Thumb

Lots of Data Points

- cation / anion chemistry should be included with all studies

Suites of Ions

- take advantage of analysis packages
- work with analyst to improve

Detection Limits

- able to quantify ions in majority of sample analyses

Conclusions

Don’t try to plot everything against everything
have a plan – apply geochemistry

Have sufficient detection limits
you can’t plot less thans

Have enough data points

Use the chemistry to elucidate all the fancy isotopic and contaminant analysis