Databases in Medical Geology

An important geoscientific tool for medical geology

Soils

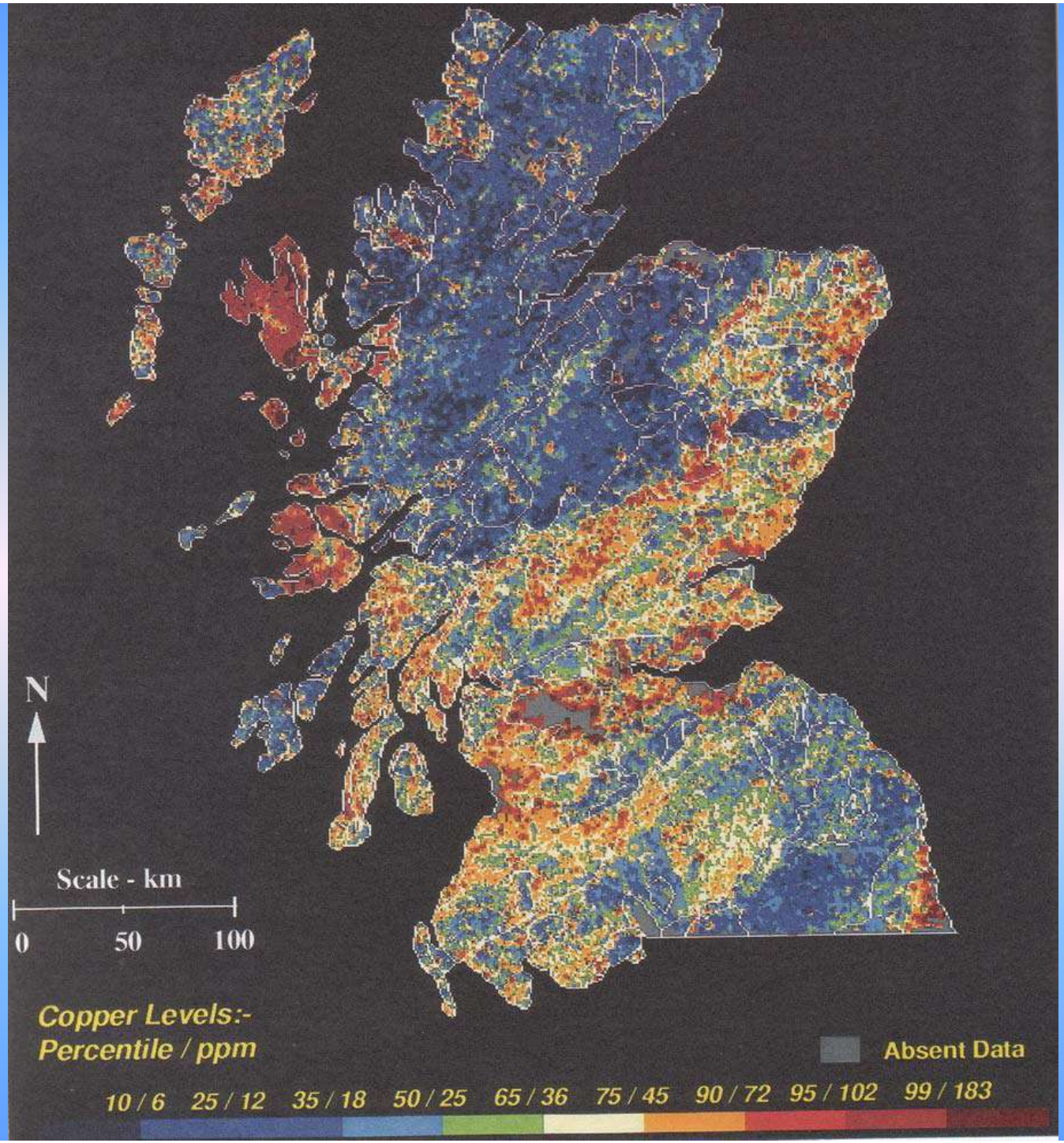
Water

Sediments

Vegetation

Mosses

Bedrock


N
Scale - km
0
50
100
Copper Levels:-
Percentile / ppm
Absent Data
10 / 6
25 / 12
35 / 18
50 / 25
65 / 36
75 / 45
90 / 72
95 / 102
99 / 183

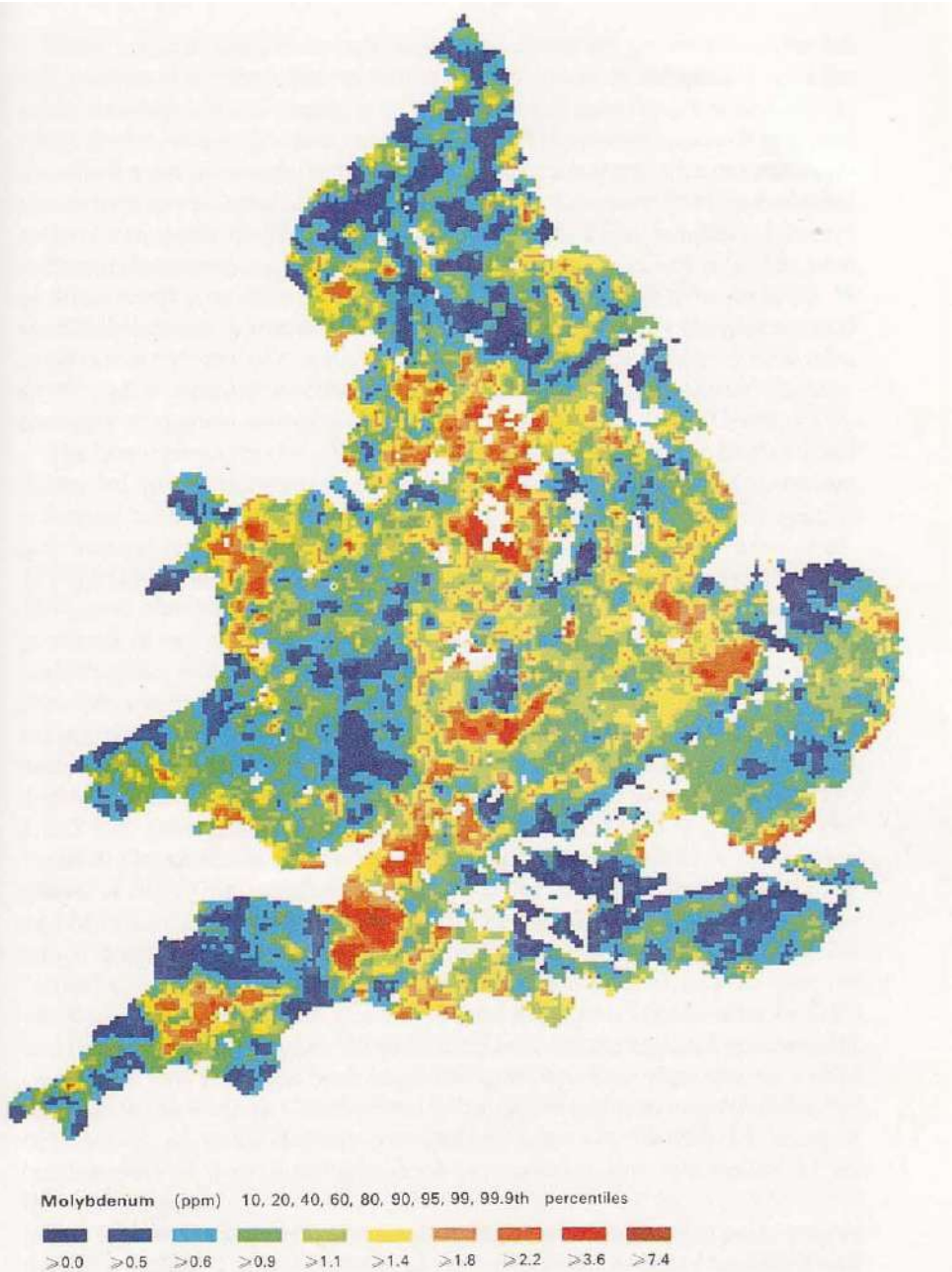
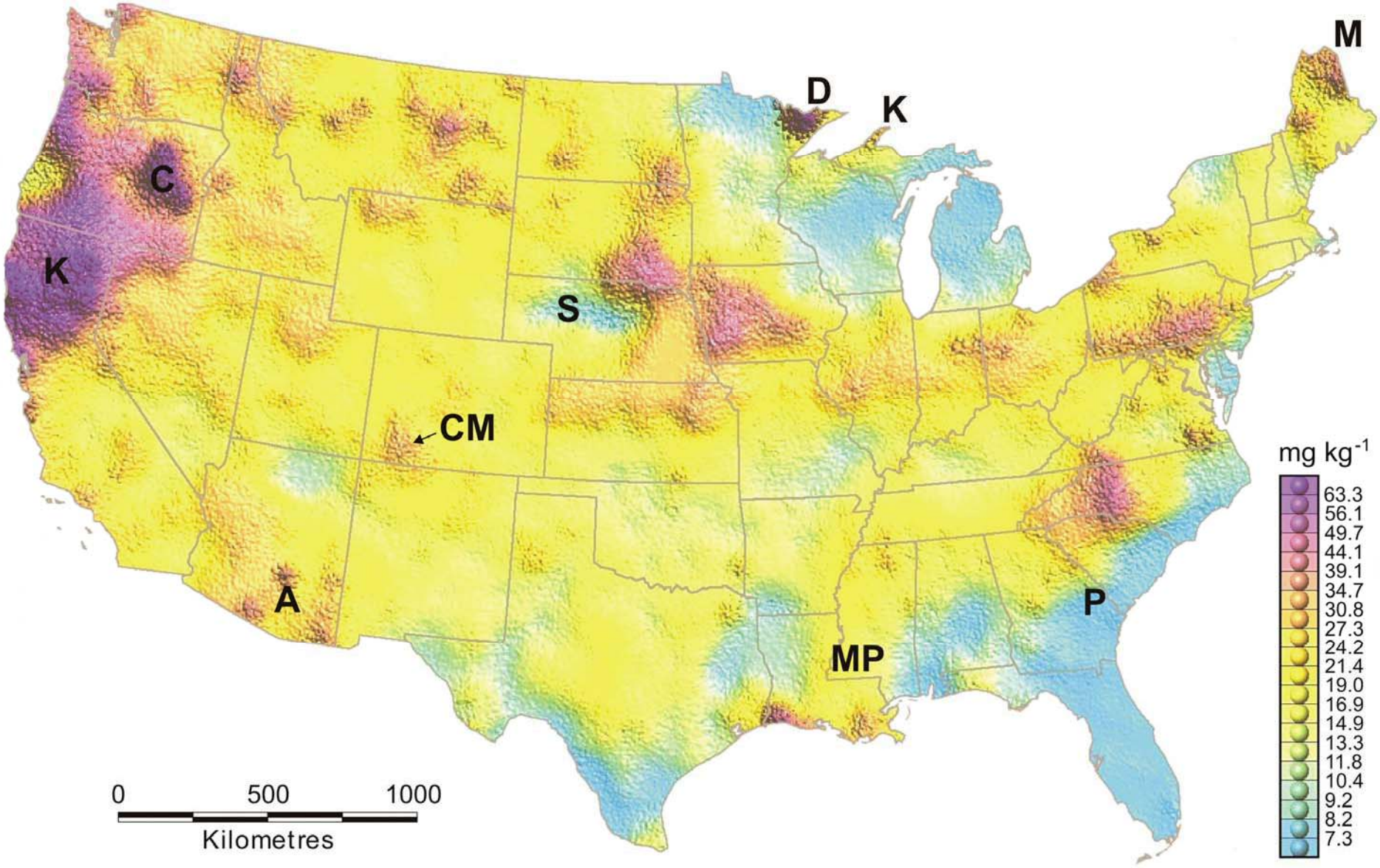


Plate 2.2 Map showing the distribution of Mo(ppm) in stream sediments in England and Wales (reproduced from Webb *et al.* (1978) by permission of Oxford University Press).



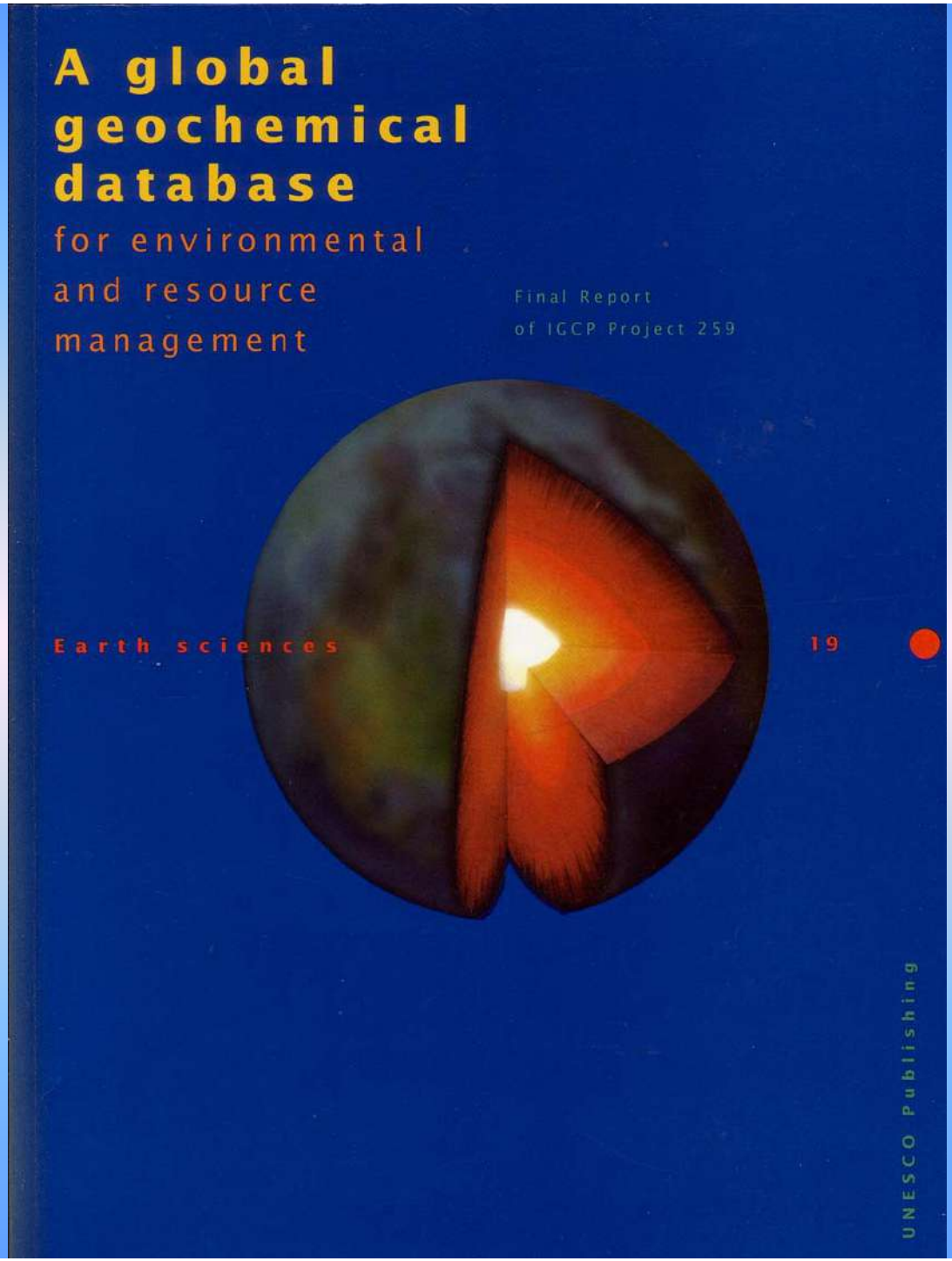
Copper content (mg kg^{-1}) of soils in the conterminous United States

Chernobyl accident 1986

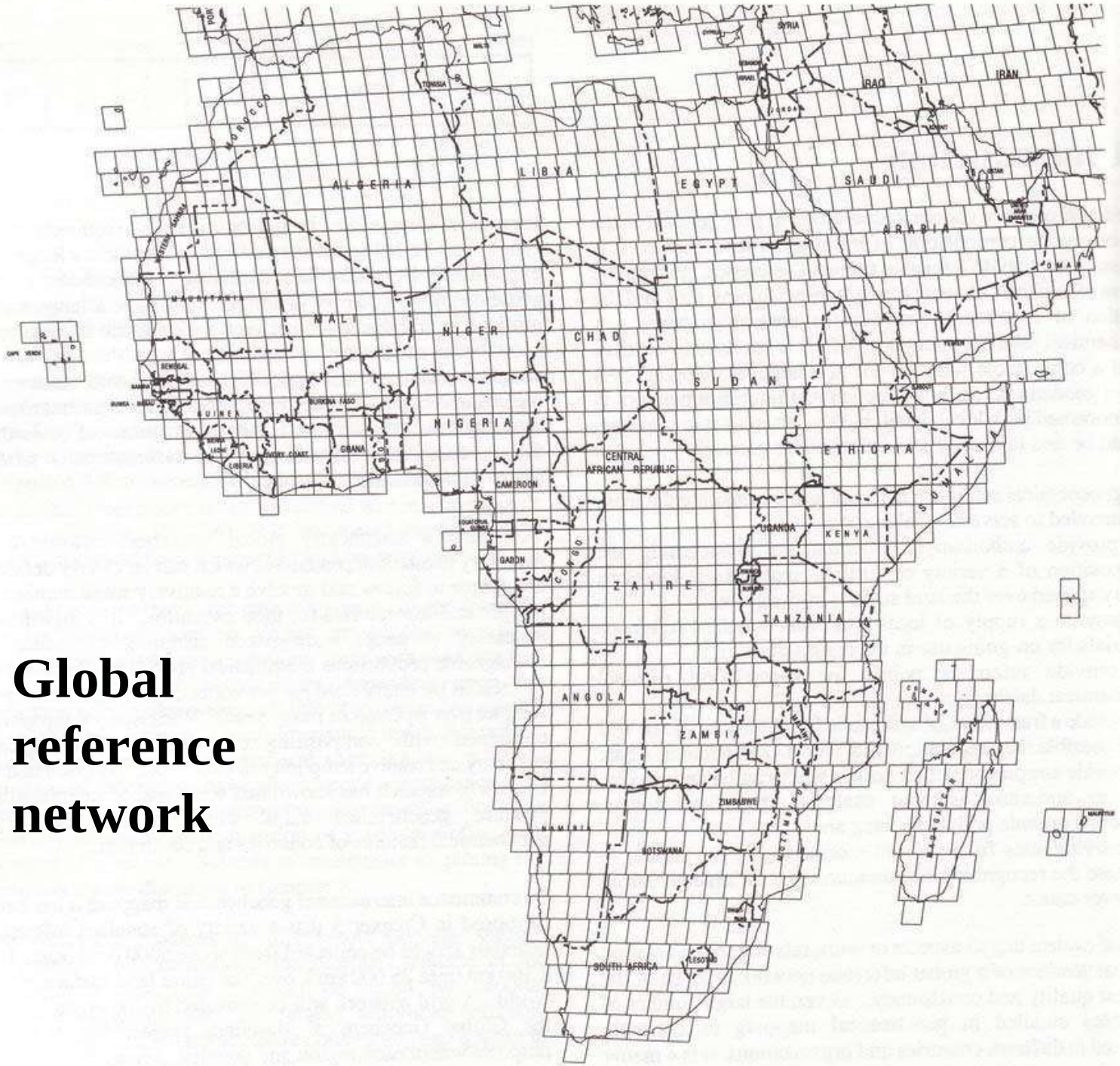
Baseline for radioactive and other polluting elements missing
More than 120 databases existed
10 different sample media
13 different analytical metods
Many ess. elements not measured
Impossible to compile a homogenous dataset
Harmonised geochemical database needed

Global geochemical database

FOREGS Geochemical baseline mapping



Global reference network

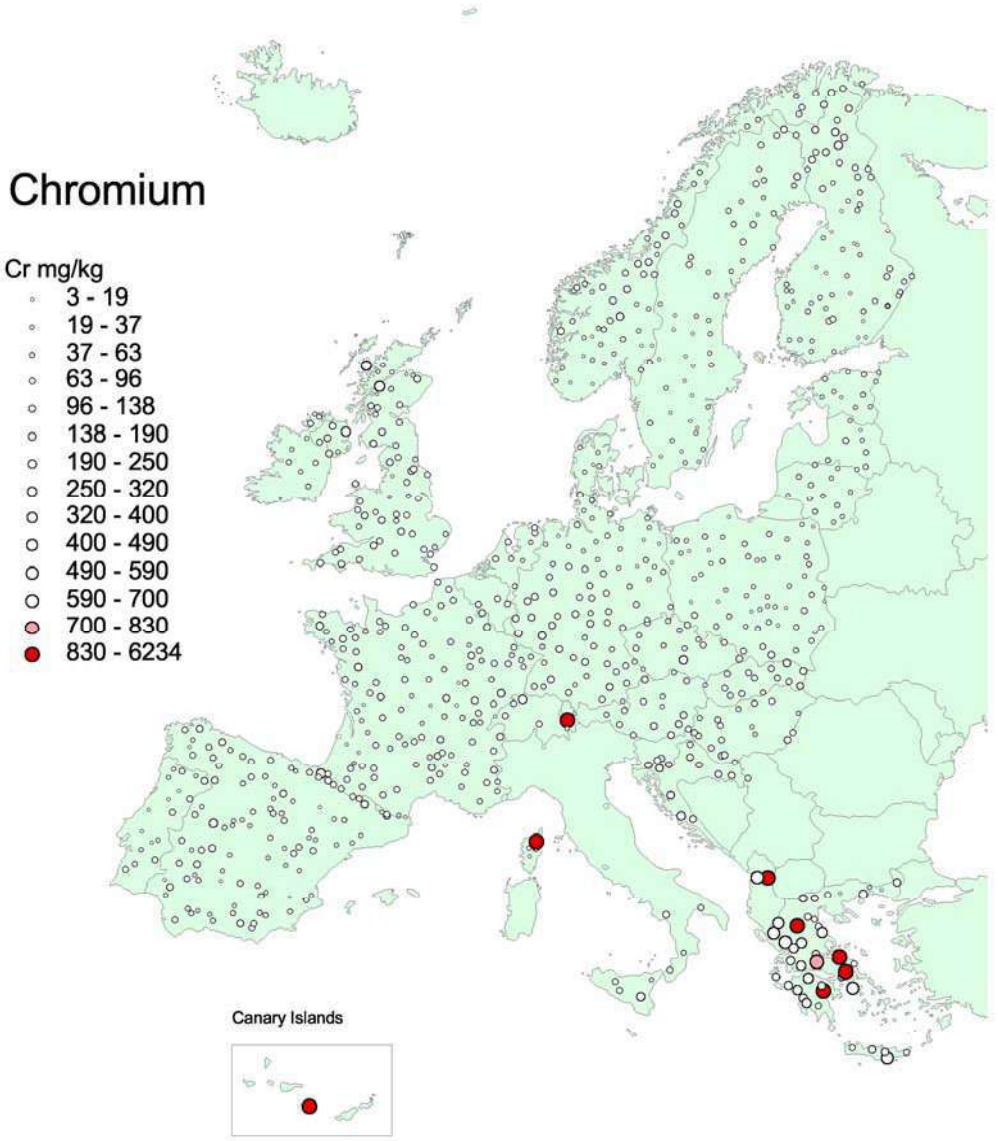


FOREGS FIELD MANUAL

- Stream water (filtered and unfiltered)
- Stream sediment (mineral sediment, <0.150 mm)
- Residual soil, upper horizon (topsoil) 0 - 25 cm without the top organic layer (<2 mm)
- Residual soil, lower (C) horizon (subsoil); a 25 cm layer within a depth range of 50 cm - 200 cm (<2 mm)
- Humus where present
- Overbank sediment, upper horizon 0-25 cm (<0.150 mm, optional)
- Overbank sediment, bottom layer (<0.150 mm, optional)
- Floodplain sediment, upper horizon 0 - 25 cm (<2 mm)
- Floodplain sediment, bottom layer (<2 mm, optional)

Topsoil

Chromium



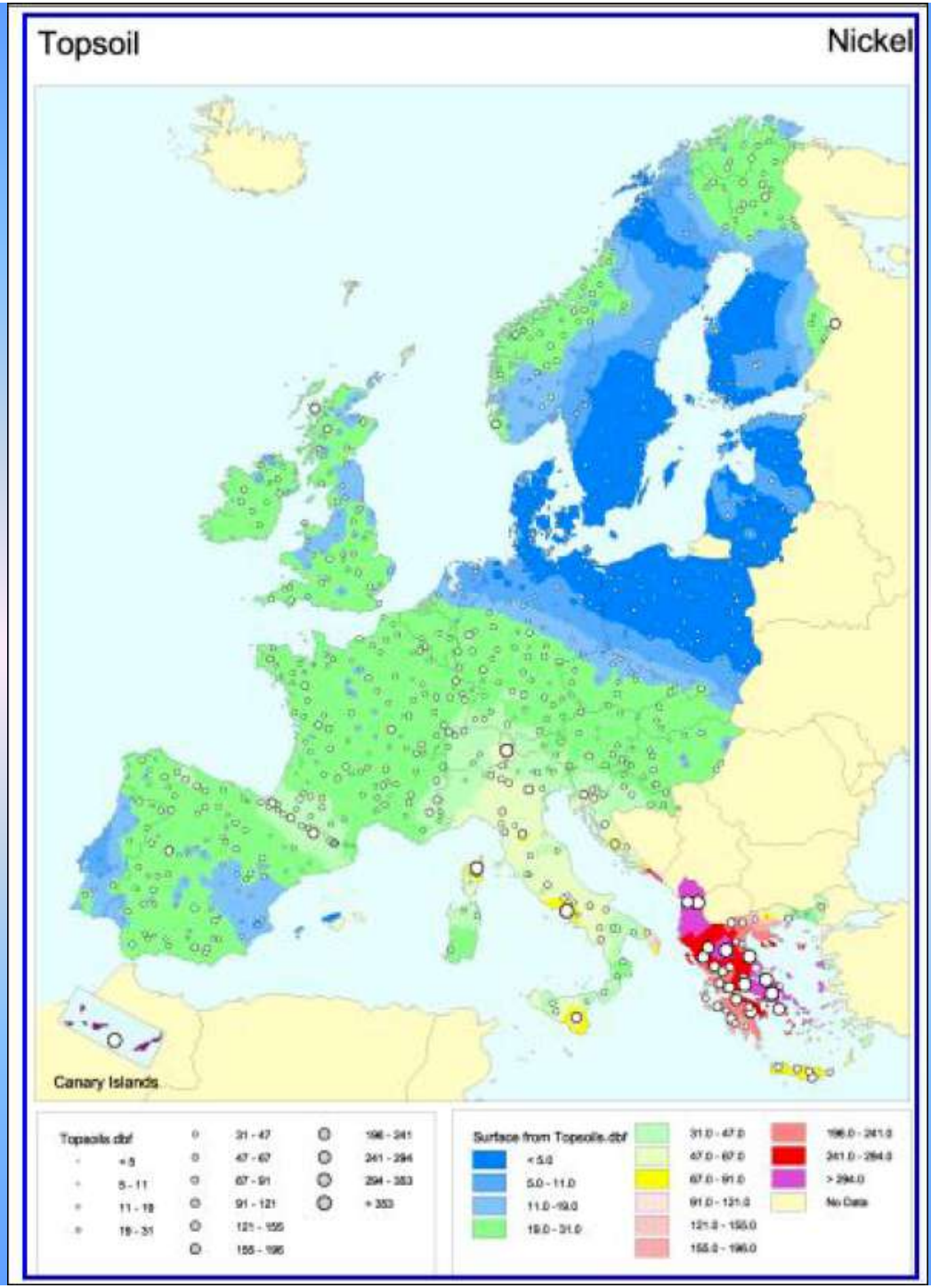
FOREGS

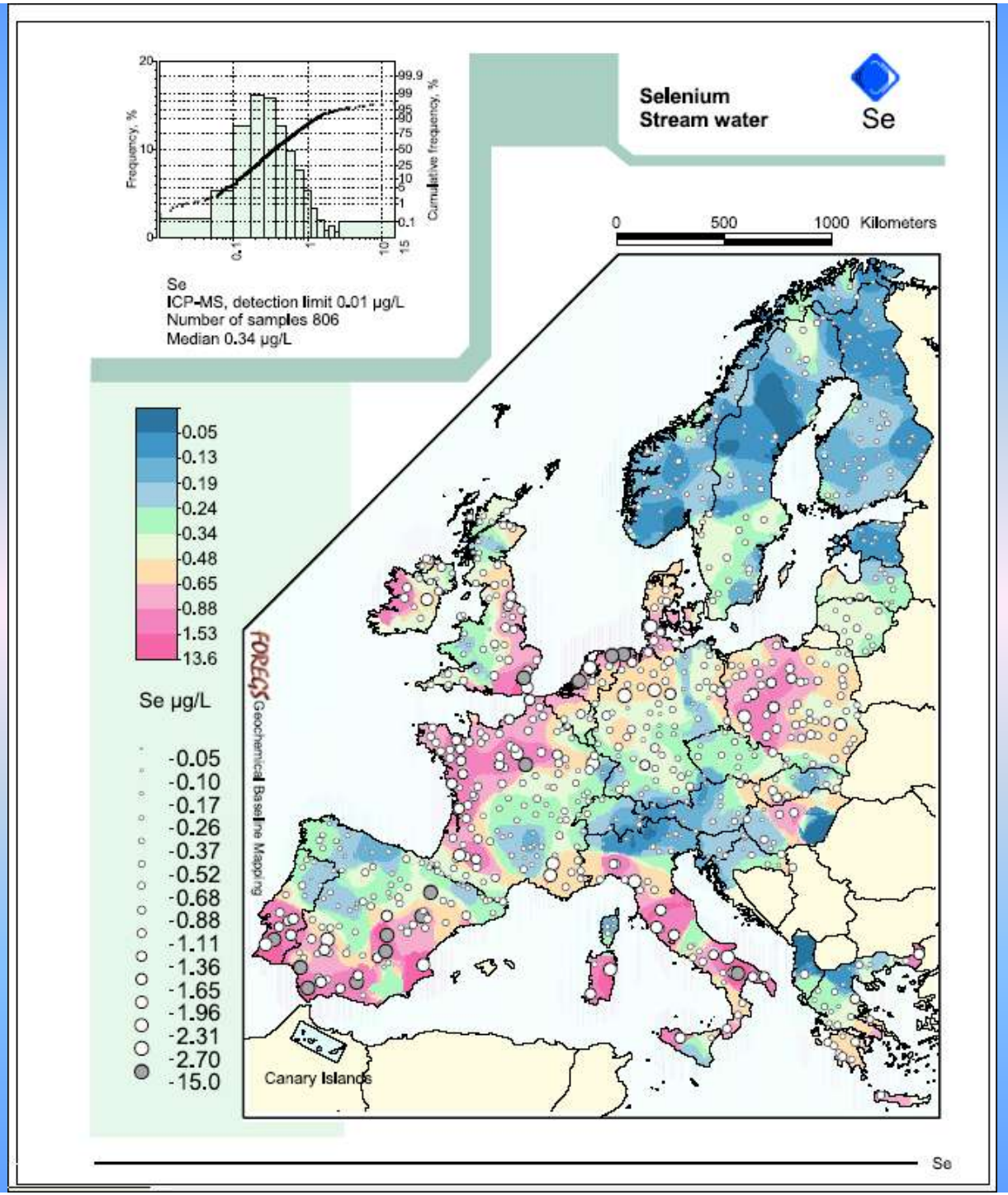
Geochemical baseline mapping
Field database version 1.0
Laboratory BGR, XRF, version 1.1
Projection Albers Equal-Area Conic

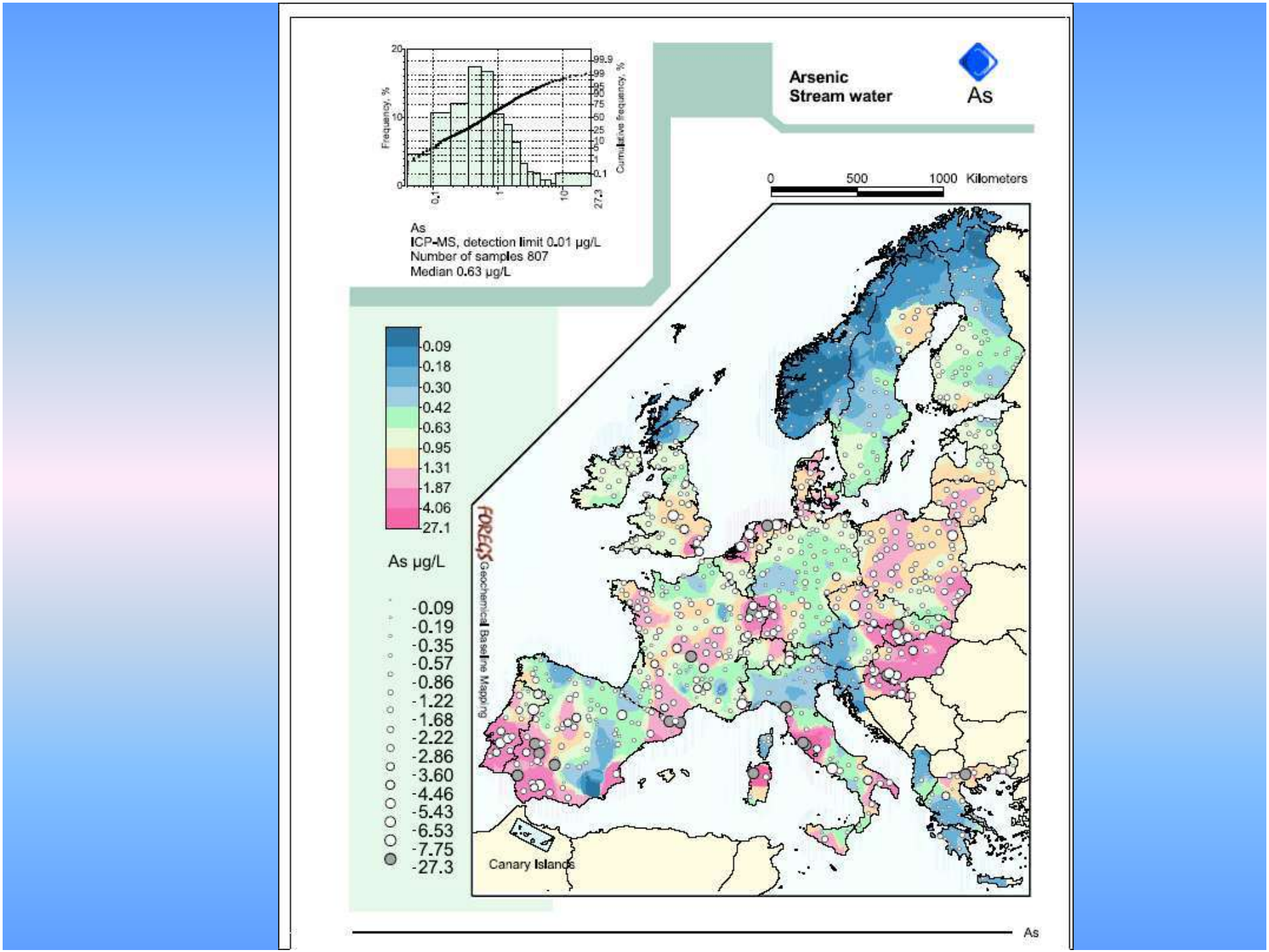
0 500 1000 Kilometers

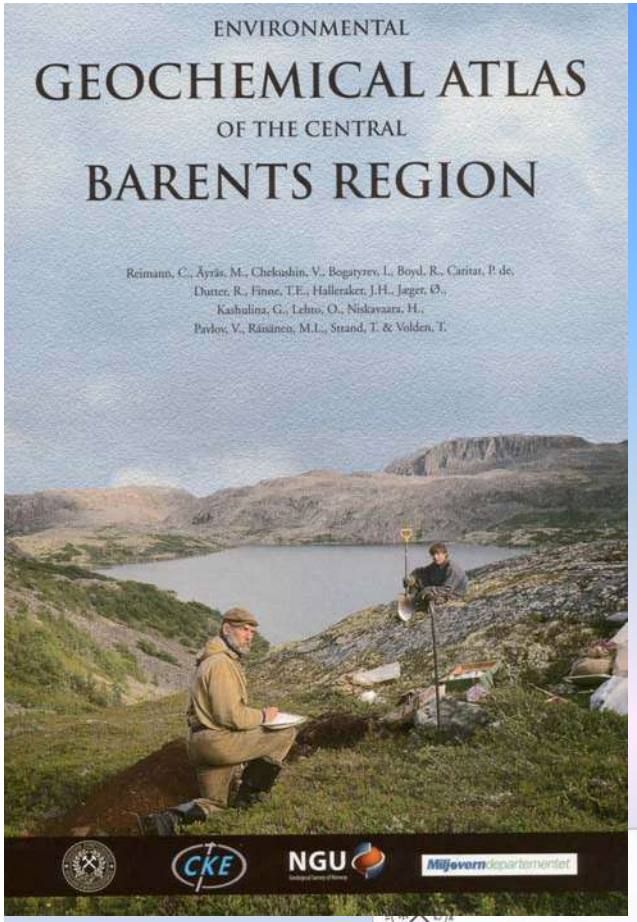
Table 1. A summary table of the Foregs Geochemical Baseline Mapping programme and the Barents Ecogeochemistry project

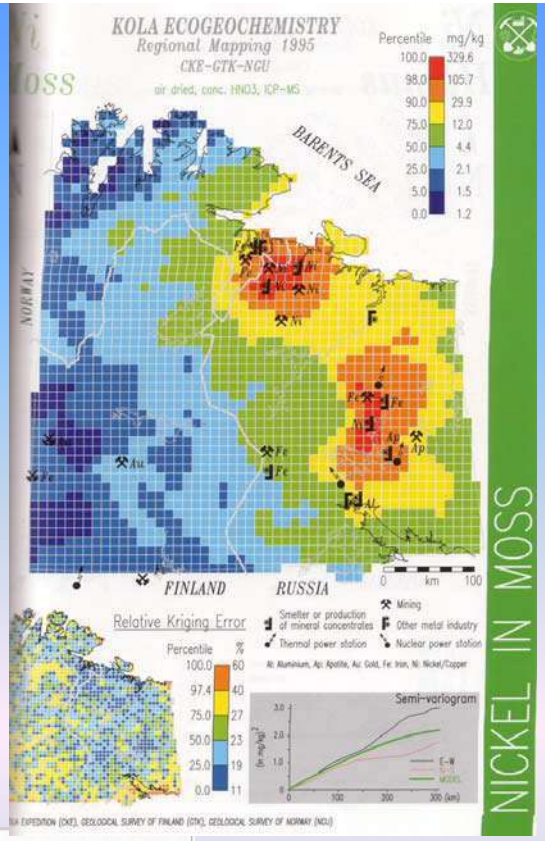
	Foregs	Barents
Survey area	4.2 mill. km^2	1.55 mill km^2
Participating organisations	Geological surveys of Austria, Albania, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Lithuania, The Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and UK; and from Italy Universita' di Napoli "Federico II", University of Padova, and Università degli Studi di Siena	Geological surveys of Finland and Norway, Finnish Nuclear Safety Organisation, S/C Mineral, St.Petersburg, Russia, ZAO Arkhangelskgeolrazvedka, Arkhangelsk, Russia, ZAO Mireko, Syktyvkar Komi Republic of Komi, Russia
Number of sampling sites	808	1384
Sample media		
Stream water	808 samples	1334 samples
Minerogenic stream sediment	801 samples	None
Floodplain sediment	749 samples	None
Organic soil layer (humus layer)	367 samples	1409 samples
Minerogenic top-soil	845 samples	None
Minerogenic sub-soil	789 samples	1415 samples
Terrestrial moss	None	1316 samples
Analysed elements and other parameters		
Soils	Ag, Al, As, Ba, Be , Bi, Ca, Cd, C , Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Hf, Hg, Ho, I, In, K, La, Lu, Mg, Mn, Mo , Na, Nb, Nd, Ni, P, Pb, pH, Pr, Rb, S, Sb, Sc , Si, Sm , Sn , Sr, Ta , Tb , Te , Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr, TOC, Grains size	Al, As, B, Ba, Be, Bi, C, Ca, Cd, Cl, Co, Cr, Cs, Cu, F, Fe, Ga, Hg, I, K, La, Li, LOI, Mg, Mn Mo N Na Nb Ni P Pb Rb S Sb, Sc, Si, Sr , Te, Th, Ti, Tl, U, V, Zn, and Zr
Organic soil	Ba, Cd, Co, Cu, Ga, La, Hg, Ni, Rb, Sr, and Zn	Al, Ag, As, B, Ba, Be, Bi, Br, C, Ca, Cd, Co, Cr, ^{134}Cs, ^{137}Cs, Cu, Fe, Hg, K, LOI, Li, Mg, Mn, Mo, N, Na, Ni, P, Pb, Rb, S, Sb, Se, Sn, Sr, Th, Ti, Tl, U, V, and Zn
Sediments	Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, In, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pr, Rb, S, Sb , Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr, and TOC,	
Water	Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Ho, I, In, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, Pb, pH, Pr, Rb, Sb, Se, Si, Sm, Sn , Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr, EC, HCO_3^-, Br^-, Cl^-, F^-, NO_3^-, SO_4^{2-}, and DOC	Ag, Al, Alkalinity, As, B, Ba, Be, Bi, Br, Ca,Cd, Cl^-, Co, Cr. Cs, Cu, EC, F^-, Fe, Hg, I^-, K, La, Li, Mg, Mn, Mo, Na, Ni, NO_3^-, P, Pb, pH, Rb, Sc, Sb, Se, Si, SO_4^{2-}, Sn, Sr, Th, Ti, Tl, U, V, Zn, Y, and Zr,
Moss		Al, Ag, As, B, Ba, Be, Bi, Br, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Na, P, S, Mo, Ni, Pb, Rb, Sb, Se, Sn, Sr, Th, Tl, U, V, and Zn
Time period	1996 (1986) – 2005	1999 (1998) – 2004
Number of participating countries	2 (6)	26


Topsoil
Nickel
Canary Islands
Topsoils.dbf
< 5
5 - 11
11 - 19
19 - 31
31 - 47
47 - 67
67 - 91
91 - 121
121 - 155
155 - 196
196 - 241
241 - 294
294 - 353
> 353
Surface from Topsoils.dbf
< 5.0
5.0 - 11.0
11.0 - 19.0
19.0 - 31.0
31.0 - 47.0
47.0 - 67.0
67.0 - 91.0
91.0 - 121.0
121.0 - 155.0
155.0 - 196.0
196.0 - 241.0
241.0 - 294.0
> 294.0
No Data

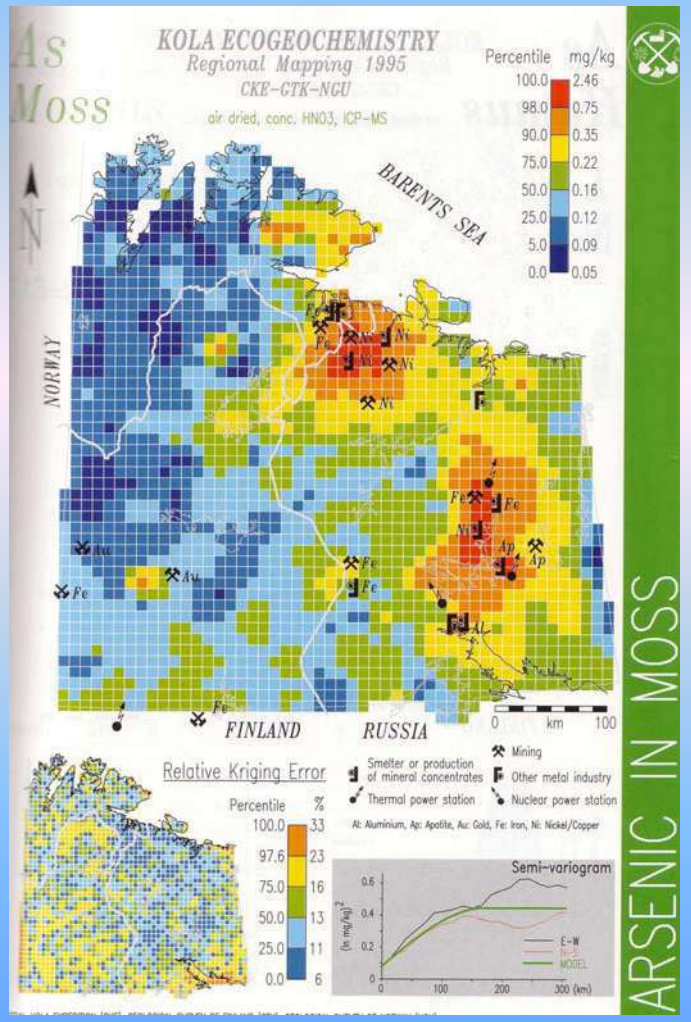

Selenium
Stream water
Se
Frequency, %
Cumulative frequency, %
99.9
99
95
90
75
50
25
10
5
1
0.1
0
500
1000 Kilometers
Se
ICP-MS, detection limit 0.01 µg/L
Number of samples 806
Median 0.34 µg/L
0.05
0.13
0.19
0.24
0.34
0.48
0.65
0.88
1.53
13.6
Se µg/L
-0.05
-0.10
-0.17
-0.26
-0.37
-0.52
-0.68
-0.88
-1.11
-1.36
-1.65
-1.96
-2.31
-2.70
-15.0
FOREGS Geochemical Baseline Mapping
Canary Islands
Se

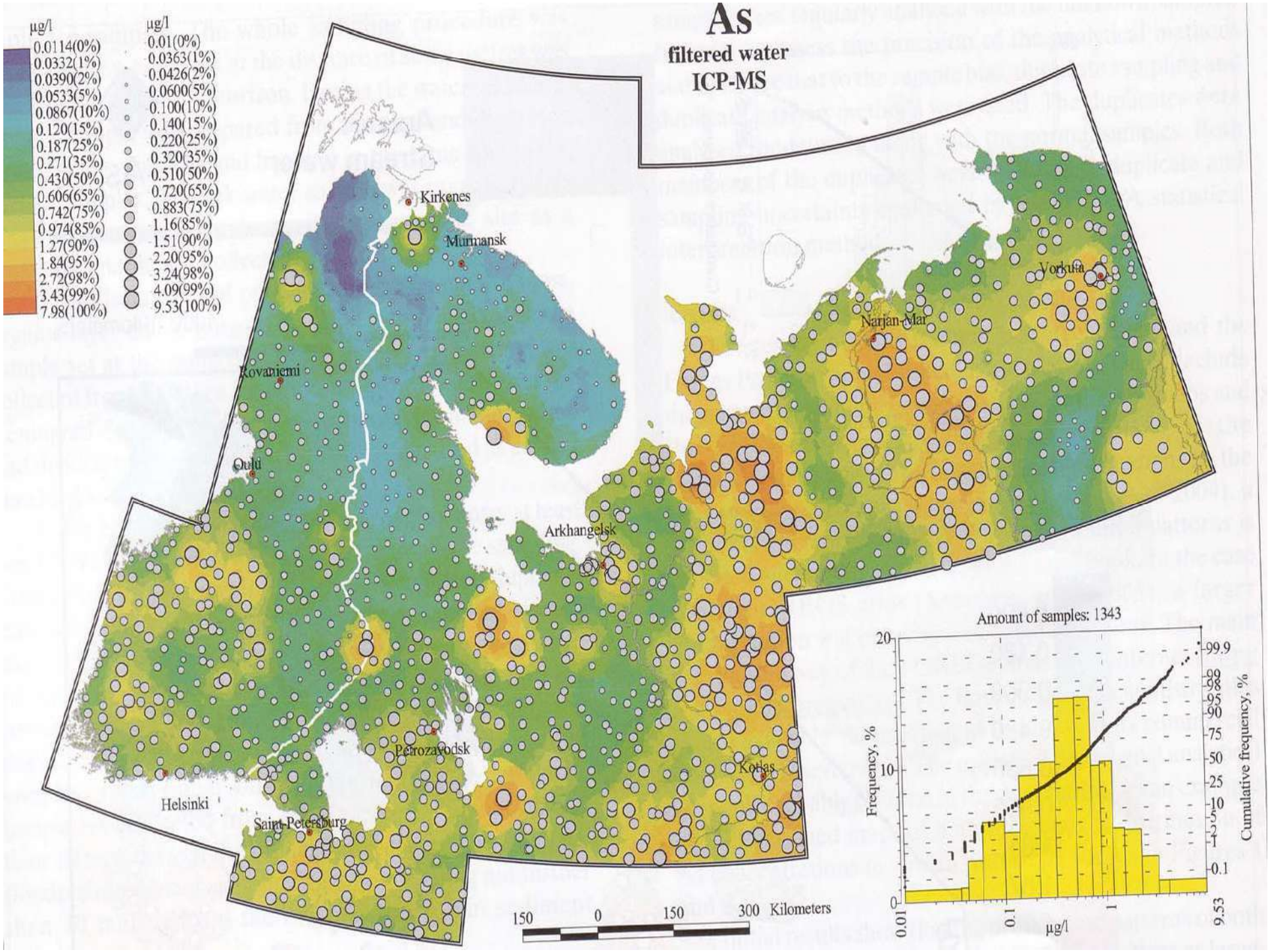

Arsenic
Stream water
As
Frequency, %
Cumulative frequency, %
0.1
1
10
27.3
As
ICP-MS, detection limit 0.01 µg/L
Number of samples 807
Median 0.63 µg/L
0
500
1000 Kilometers
0.09
0.18
0.30
0.42
0.63
0.95
1.31
1.87
4.06
27.1
As µg/L
0.09
0.19
0.35
0.57
0.86
1.22
1.68
2.22
2.86
3.60
4.46
5.43
6.53
7.75
27.3
FOREGS Geochemical Baseline Mapping
Canary Islands
As

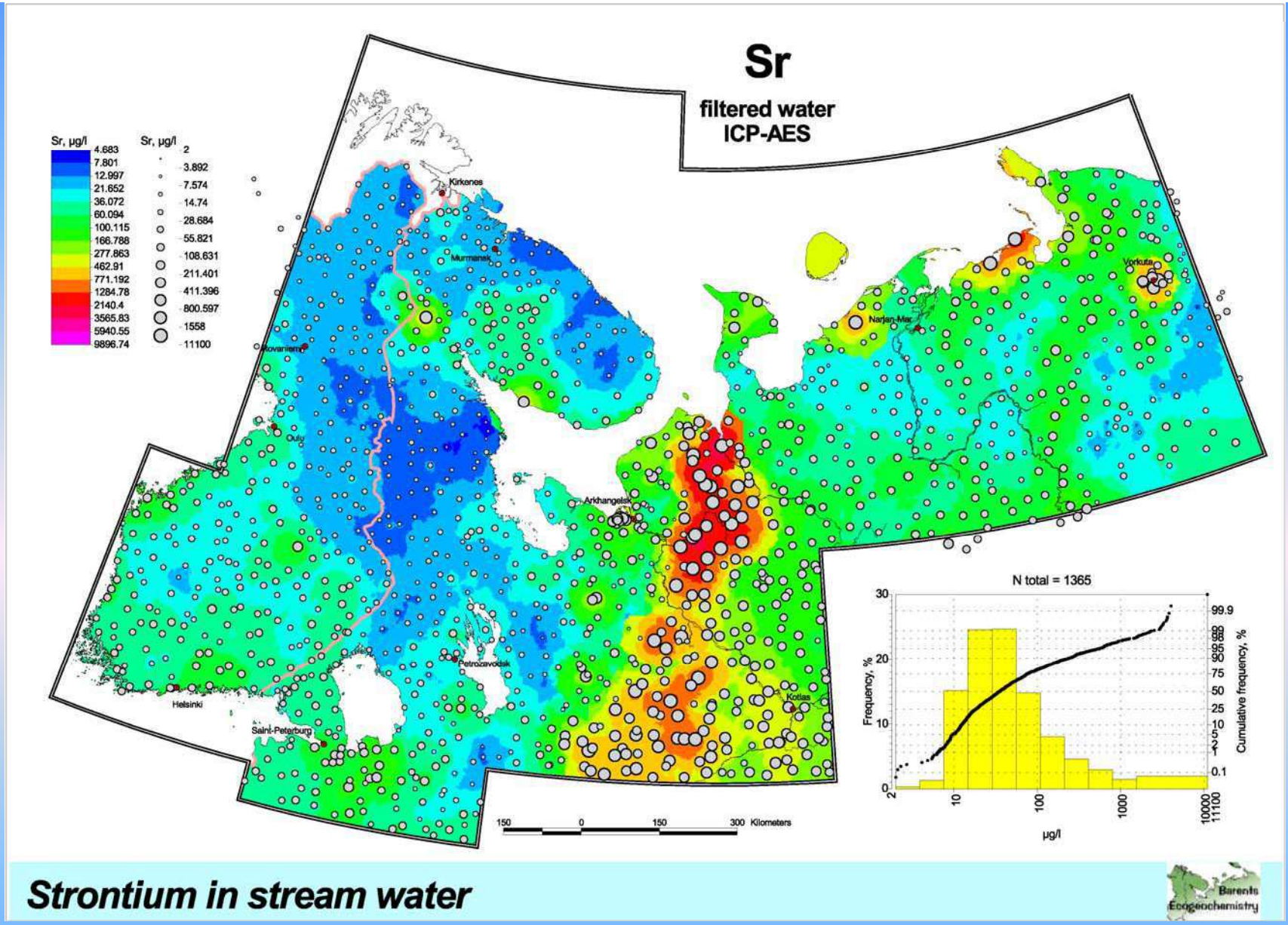

ENVIRONMENTAL
GEOCHEMICAL ATLAS
OF THE CENTRAL
BARENTS REGION
Reimann, C., Äyräs, M., Chekushin, V., Bogatyrev, I., Boyd, R., Caritat, P. de, Dutter, R., Finne, T.E., Halleraker, J.H., Jæger, Ø., Kashulina, G., Lehto, O., Niskavaara, H., Pavlov, V., Räisänen, M.L., Strand, T. & Volden, T.
CKE
NGU
Miljøverndepartementet


KOLA ECOGEOCHEMISTRY
Regional Mapping 1995
CKE-GTK-NGU
air dried, conc. HNO3, ICP-MS
Percentile mg/kg
100.0 329.6
98.0 105.7
90.0 29.9
75.0 12.0
50.0 4.4
25.0 2.1
5.0 1.5
0.0 1.2
BARENTS SEA
NORWAY
FINLAND
RUSSIA
0 km 100
Relative Kriging Error
Percentile %
100.0 60
97.4 40
75.0 27
50.0 23
25.0 19
0.0 11
Smelter or production of mineral concentrates
Thermal power station
Mining
Other metal industry
Nuclear power station
Al: Aluminium, Ap: Apatite, Au: Gold, Fe: Iron, Ni: Nickel/Copper
Semi-variogram
E-W
N-S
MODEL
NICKEL IN MOSS


North Atlantic Ocean
EUROPE
Varanger Peninsula
Barents Sea
Rybachi Peninsula
NORWAY
RUSSIA
FINLAND
Lakselv
Kirkenes
Nikel
Zapoljarniy
Murmansk
Ivalo
Olenogorsk
Monchegorsk
Lovozero
Khibiny Mnts
Kirovsk
Apatity
Kovdor
Kandalaksha
Rovaniemi
Arctic Circle
White Sea
0 km 50 100 150 200

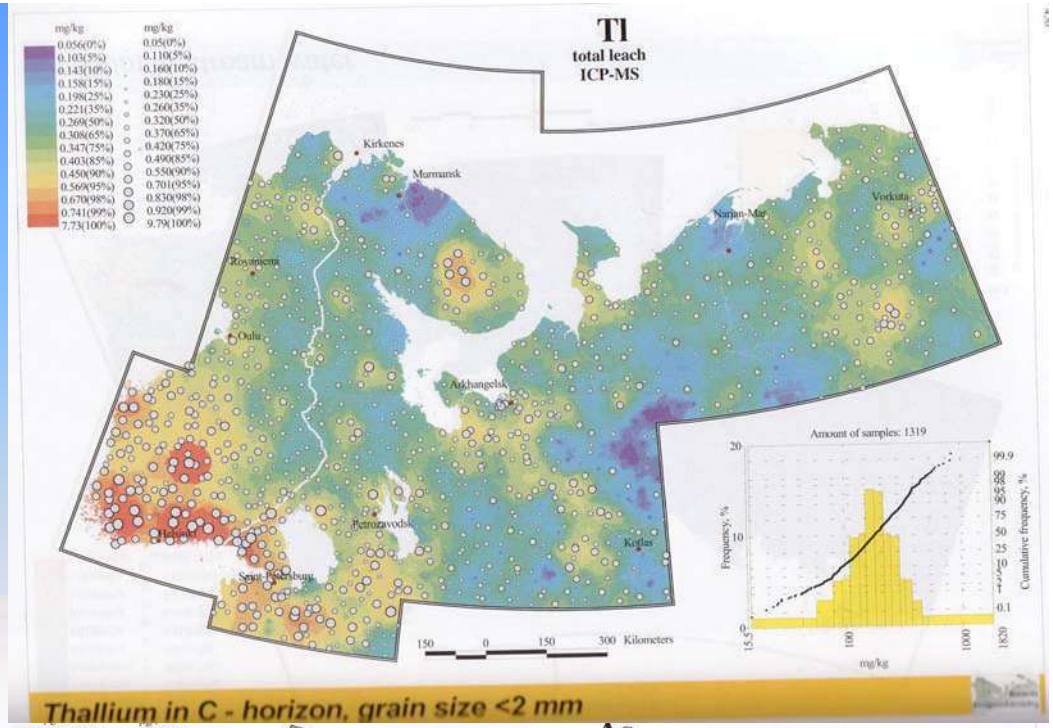

KOLA ECOGEOCHEMISTRY
Regional Mapping 1995
CKE-GTK-NGU
air dried, conc. HNO3, ICP-MS
Percentile mg/kg
100.0 2.46
98.0 0.75
90.0 0.35
75.0 0.22
50.0 0.16
25.0 0.12
5.0 0.09
0.0 0.05
BARENTS SEA
NORWAY
FINLAND
RUSSIA
0 km 100
Relative Kriging Error
Percentile %
100.0 33
97.6 23
75.0 16
50.0 13
25.0 11
0.0 6
Smelter or production of mineral concentrates
Thermal power station
Mining
Other metal industry
Nuclear power station
Al: Aluminium, Ap: Apatite, Au: Gold, Fe: Iron, Ni: Nickel/Copper
Semi-variogram
E-W
N-S
MODEL
ARSENIC IN MOSS


As
filtered water
ICP-MS
µg/l
0.0114(0%)
0.0332(1%)
0.0390(2%)
0.0533(5%)
0.0867(10%)
0.120(15%)
0.187(25%)
0.271(35%)
0.430(50%)
0.606(65%)
0.742(75%)
0.974(85%)
1.27(90%)
1.84(95%)
2.72(98%)
3.43(99%)
7.98(100%)
µg/l
0.01(0%)
0.0363(1%)
0.0426(2%)
0.0600(5%)
0.100(10%)
0.140(15%)
0.220(25%)
0.320(35%)
0.510(50%)
0.720(65%)
0.883(75%)
1.16(85%)
1.51(90%)
2.20(95%)
3.24(98%)
4.09(99%)
9.53(100%)
Kirkenes
Murmansk
Vorkuta
Narjan-Mar
Rovaniemi
Oulu
Arkhangelsk
Petrozavodsk
Kotlas
Helsinki
Saint-Petersburg
150 0 150 300 Kilometers
Amount of samples: 1343
Frequency, %
Cumulative frequency, %
µg/l
0.01
0.1
1
9.53

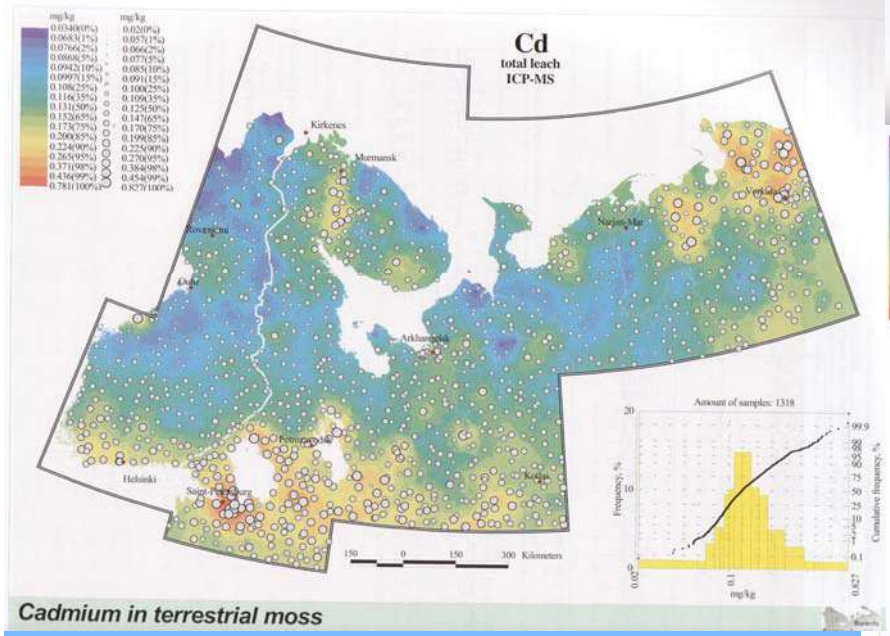


Natural element concentrations (especially strontium) of stream waters in the area of sulphate bearing carbonate rocks in Central Russia are in such a high level that they probably cause health risks. More detailed study is needed.

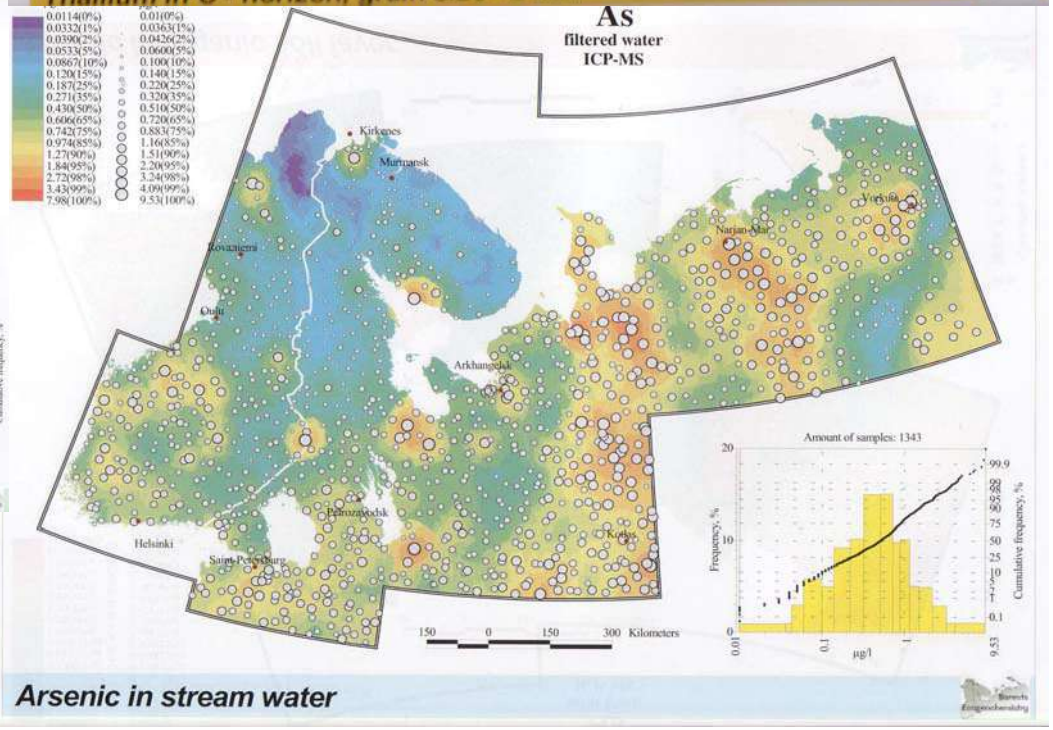
BARENTS ECOGEOCHEMISTRY



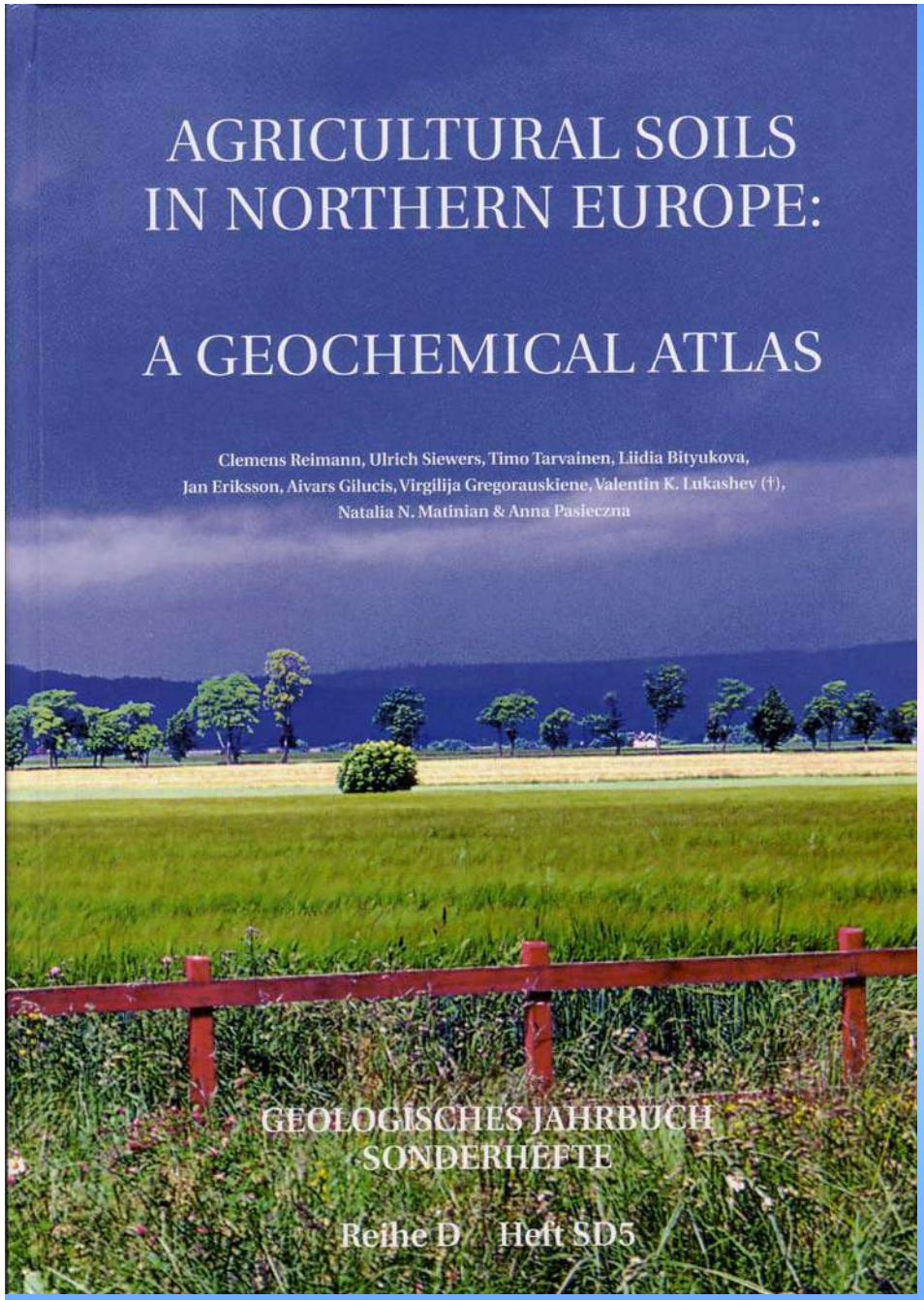
Thallium in C - horizon, grain size <2 mm

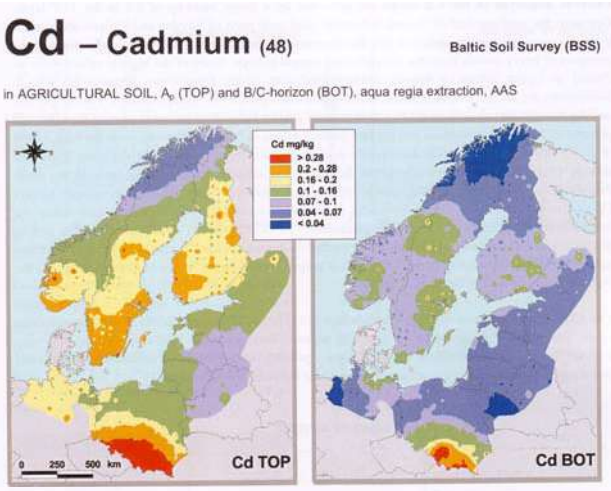


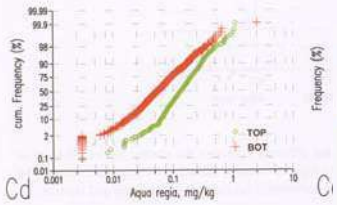
Cadmium in terrestrial moss



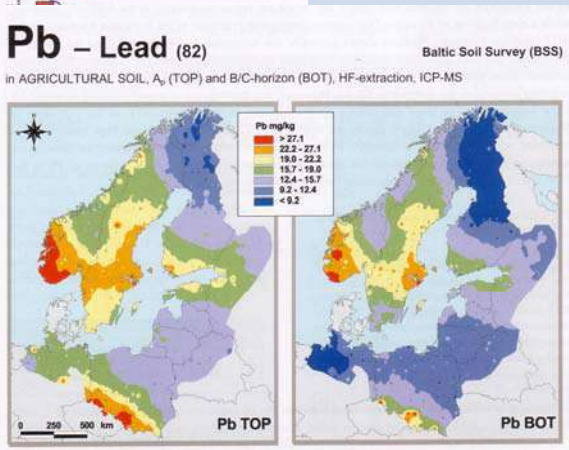
Arsenic in stream water

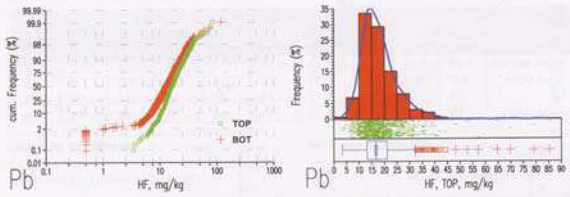






Cd in agricultural soils from Northern Europe mg/kg	TOP N=744
MINIMUM	<0.005
MEDIAN	**0.13**
MAXIMUM	1.1
MAD	0.053





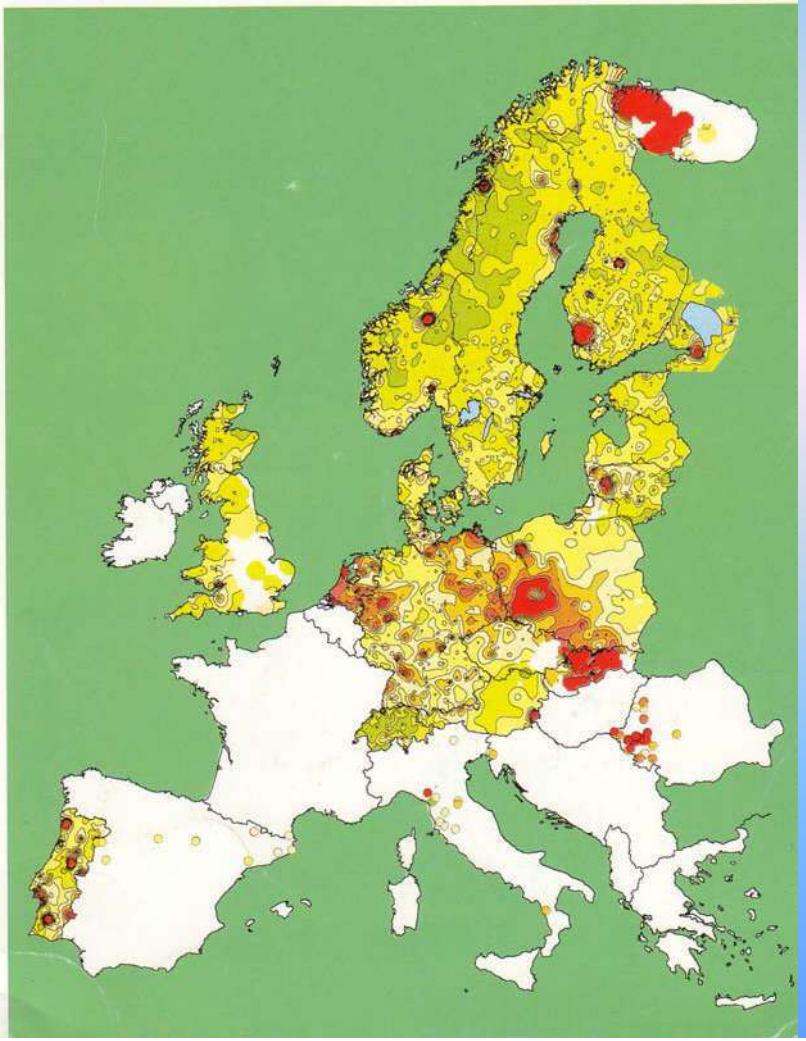
Pb in agricultural soils from Northern Europe mg/kg	Ammonium acetate TOP N=743	Ammonium acetate BOT N=746	Aqua regia TOP N=744	Aqua regia BOT N=746	HF TOP N=747	HF BOT N=747	XRF (total) TOP N=748	XRF (total) BOT N=747
MINIMUM	<0.5	<0.25	<0.1	0.3	3.4	<1	<4	<4
MEDIAN	**0.7**	**0.3**	**8**	**5**	**17**	**13**	**15**	**12**
MAXIMUM	6	6	76	73	85	118	85	109
MAD	0.41	0.22	2.4	2.7	3.9	4.0	5.0	4.0

Environment - monitoring

Atmospheric Heavy Metal Deposition in Europe

– estimation based on moss analysis

Nord



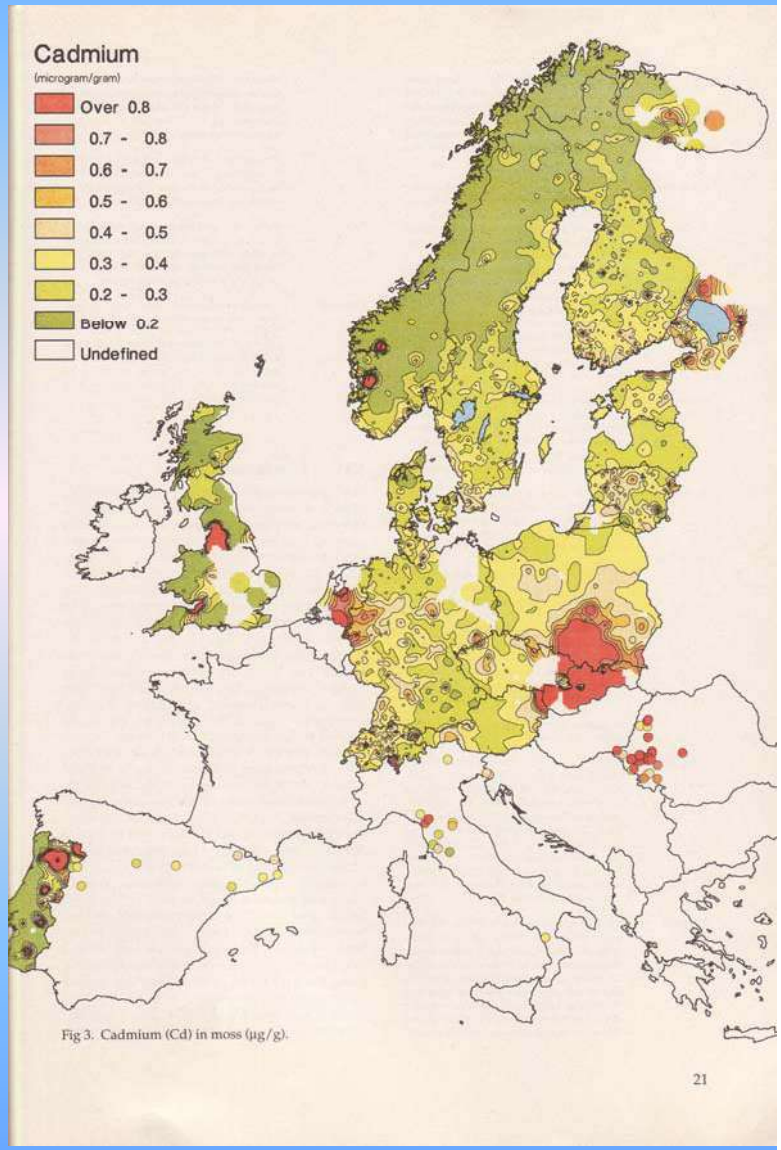


Fig 3. Cadmium (Cd) in moss (µg/g).

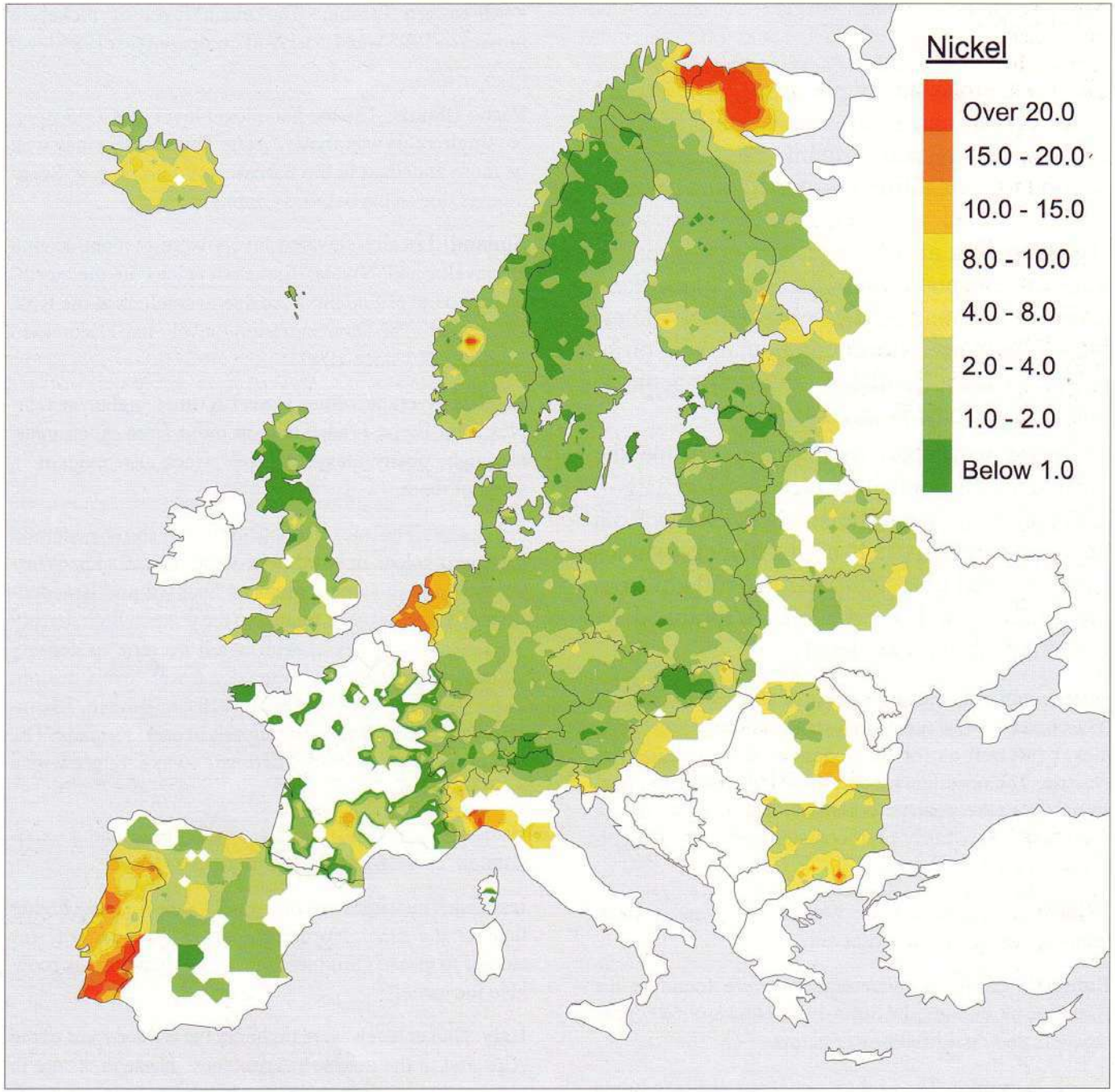
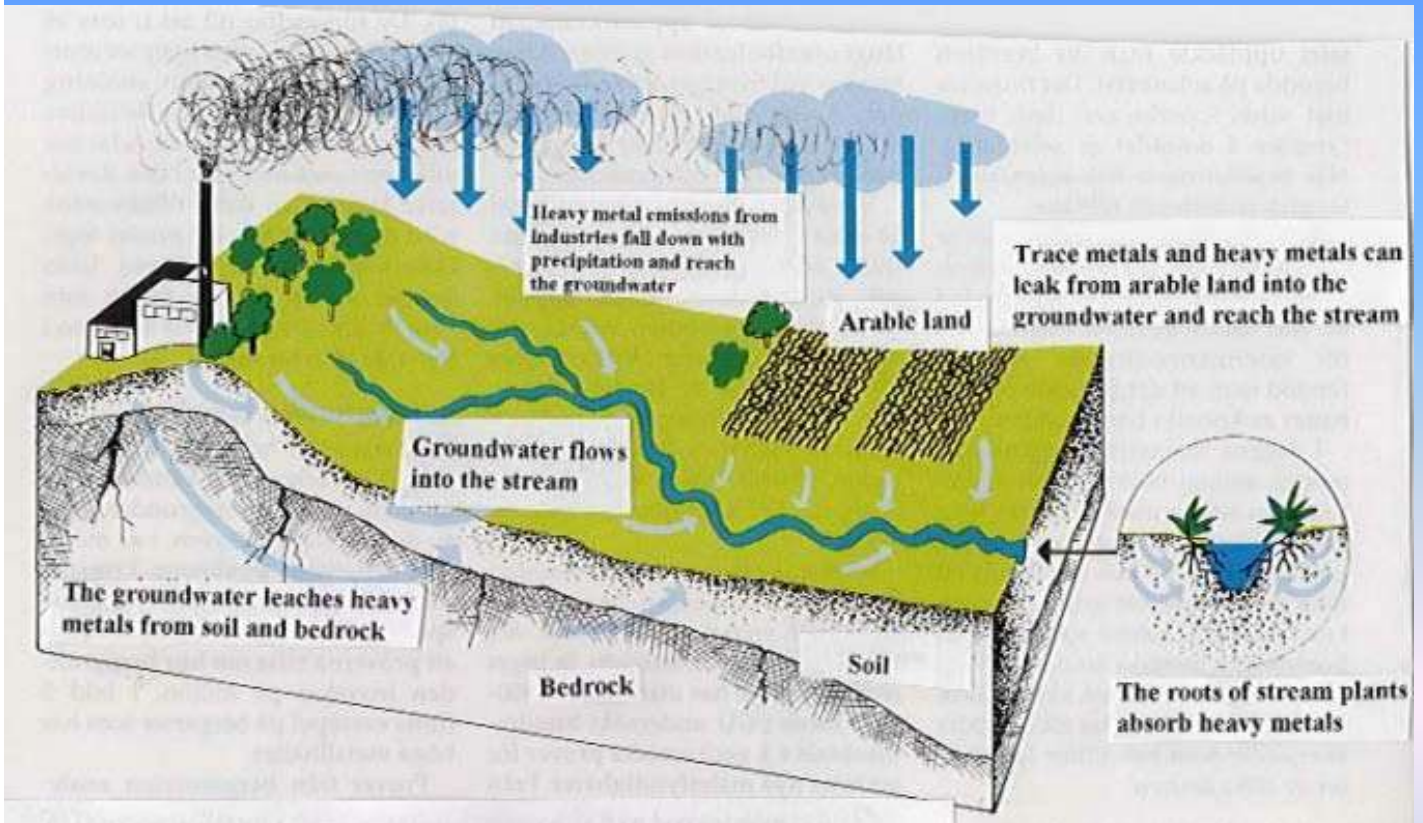
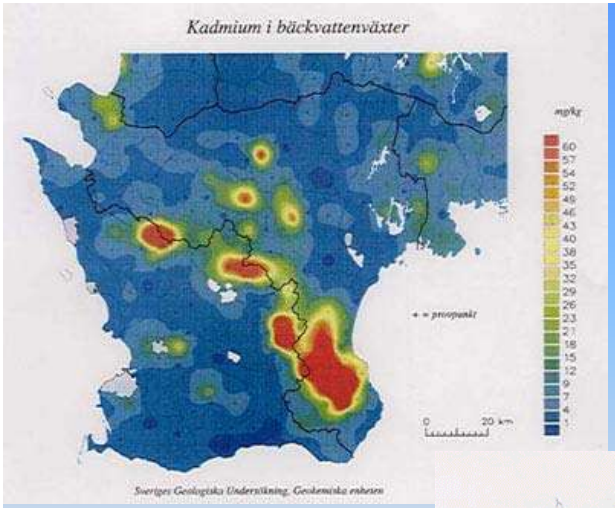
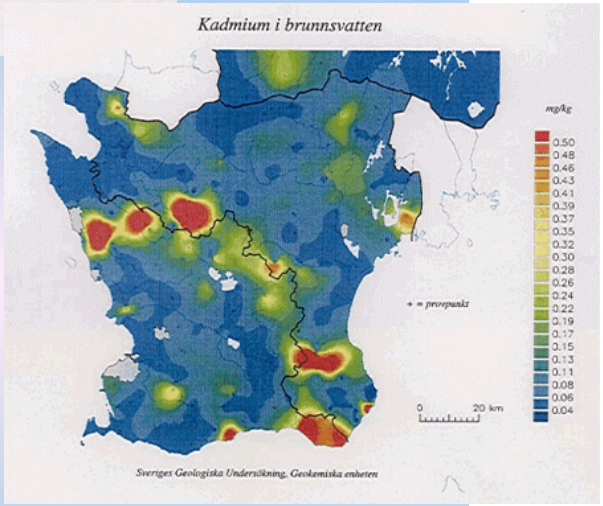


Fig 15 Nickel (Ni) in moss (µg/g).



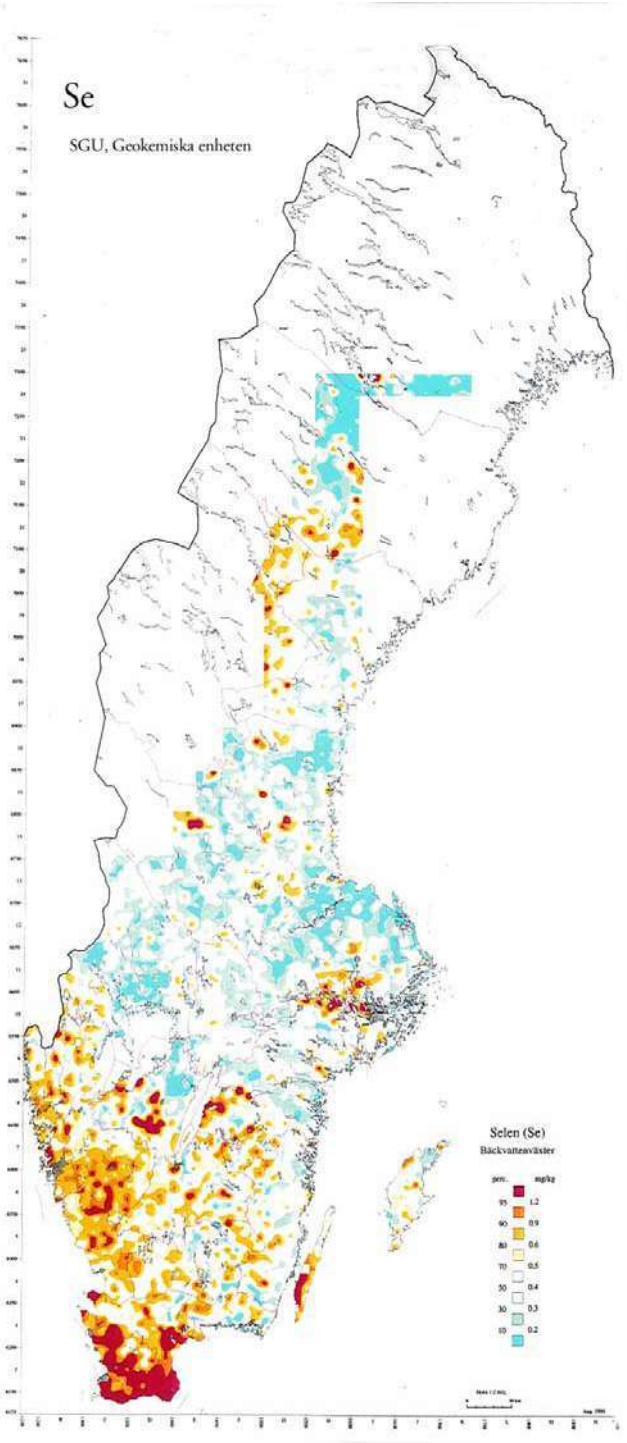
The heavy metals in plant roots can be derived from bedrock and soils but also from industrial pollution and fertilization of arable land



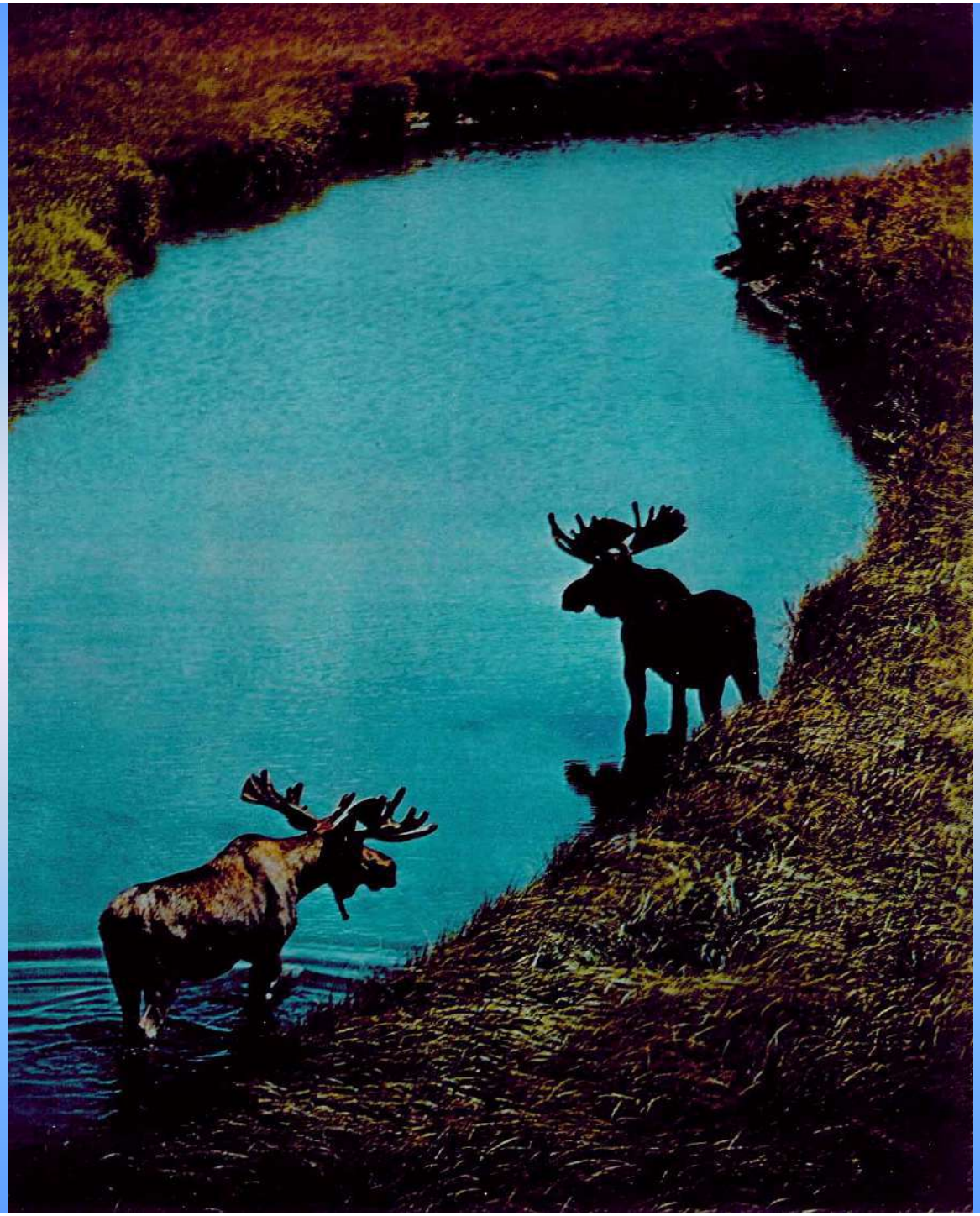


Cd / Se

Health effects?



THE MOOSE DISEASE IN SWEDEN



?

METAL CONTENTS IN MOOSE
1982-1992

Cu -50%

Cr -80%

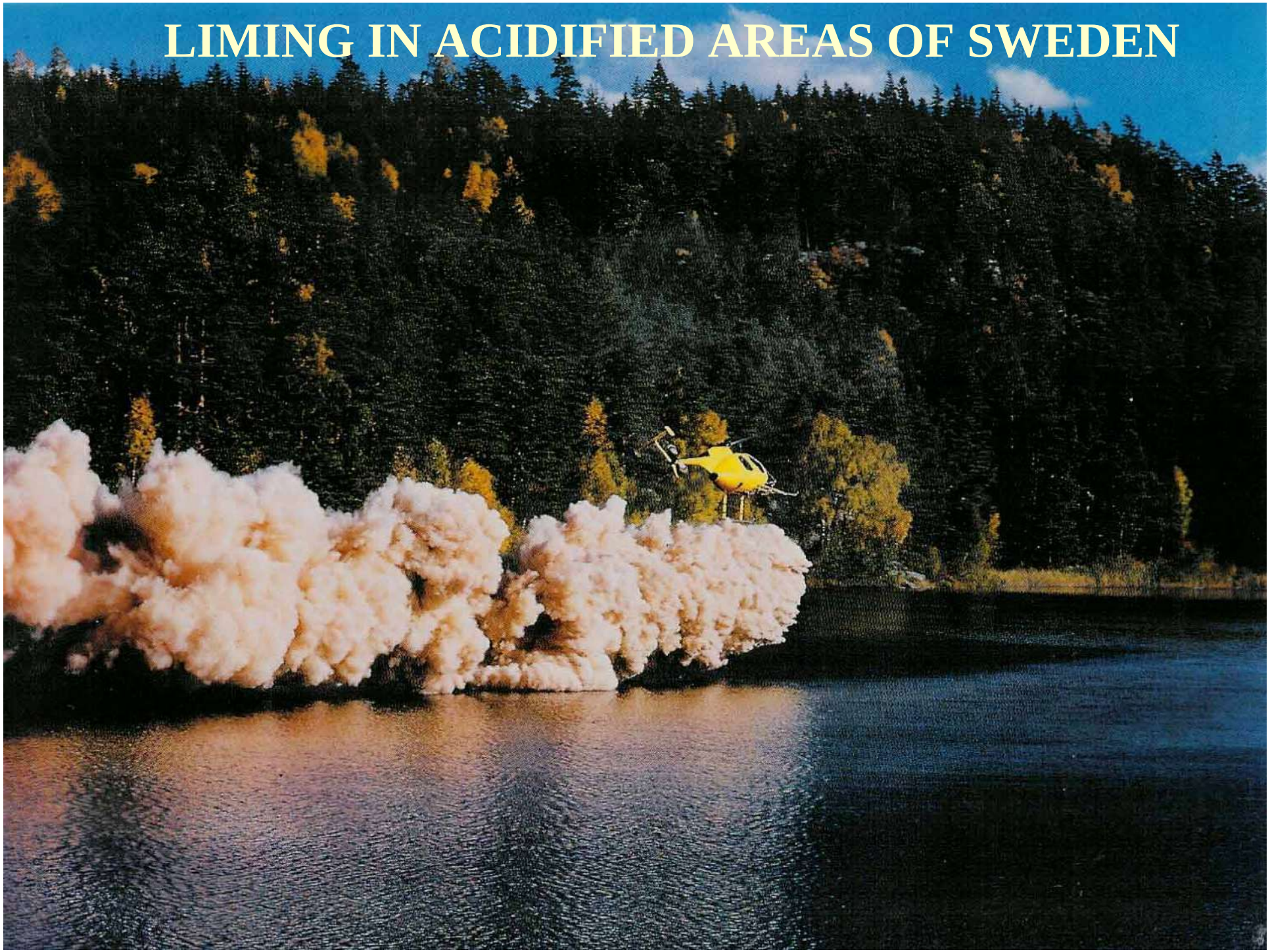
Fe -

Zn -

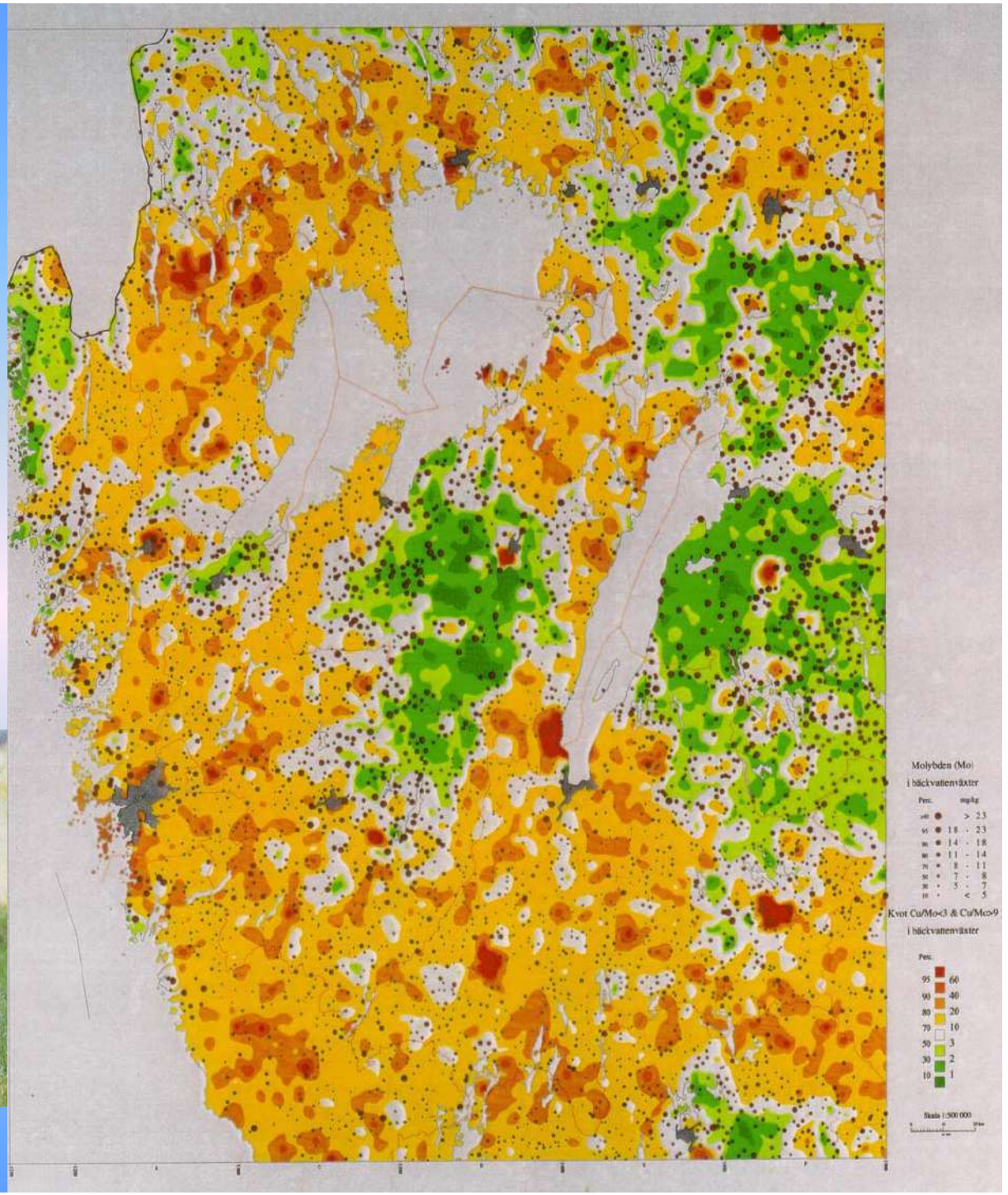
Cd -30%

Mo +24%

LIMING IN ACIDIFIED AREAS OF SWEDEN



Risk areas for cattle, moose, deer etc



Evidence of a Relationship Between Childhood-Onset Type I Diabetes and Low Groundwater Concentration of Zinc

BENGT HAGLUND, PHD
KATARINA RYCKENBERG, BSC
OLLE SELINUS, PHD
GISELA DAHLQUIST, MD, PHD

OBJECTIVE — Zinc deficiency has shown to increase the risk for diabetes in diabetes-prone experimental animals. Low concentrations of zinc have also been shown in serum of recent onset cases with IDDM. The present study examines the hypothesis that exposure to a low concentration of zinc in drinking water could increase the risk for future onset of IDDM.

RESEARCH DESIGN AND METHODS — Using the Swedish childhood diabetes reg-

children who developed diabetes 3 years later with that of population-based age-matched healthy control subjects.

RESEARCH DESIGN AND METHODS

Cases and control subjects

This study was based on incident childhood diabetes cases from 1 July 1977 to

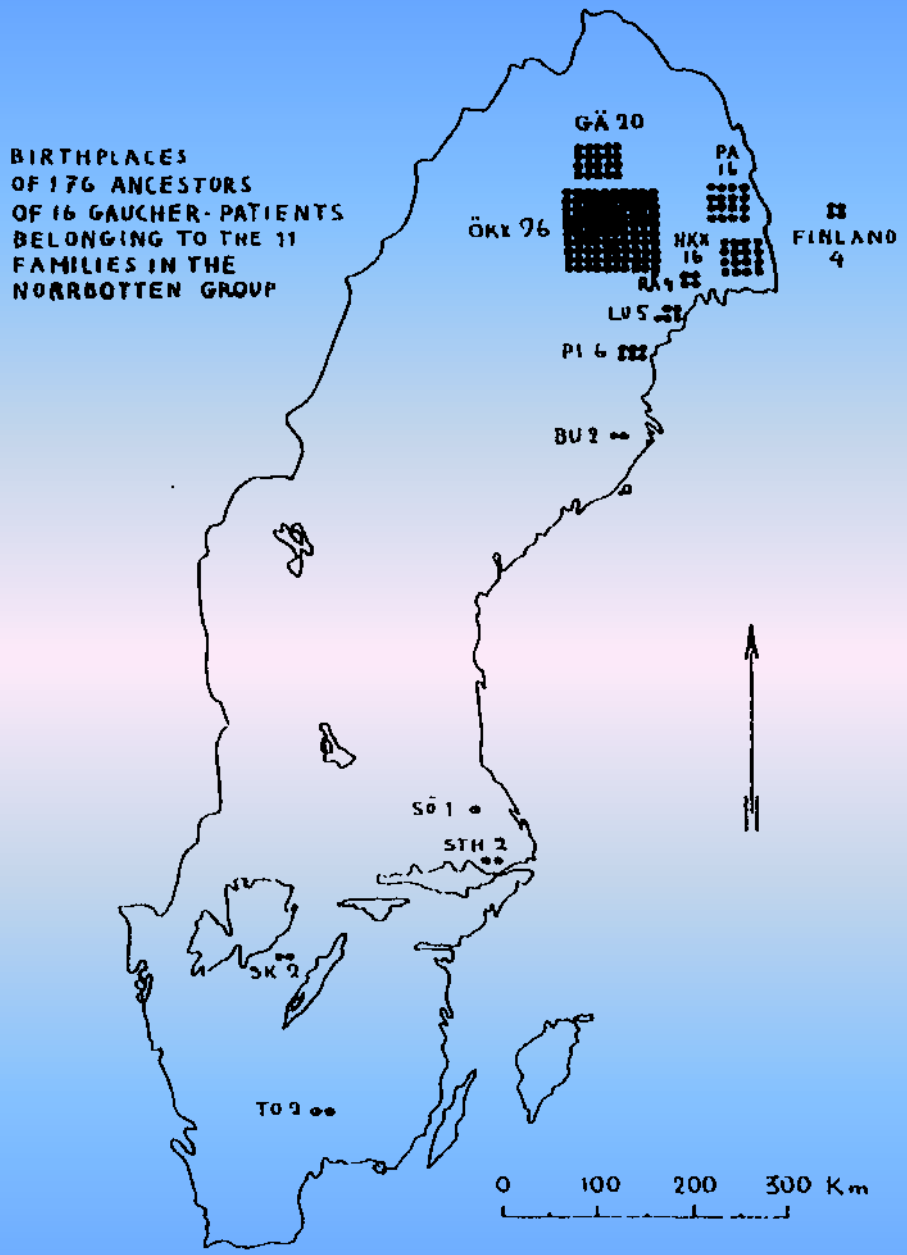
DIABETES TYPE 1

Karolinska Institute

The National Board of Health and Welfare

Geological Survey of Sweden

”CONCLUSION It is concluded that this study for the first time provides evidence that a low groundwater content of zinc, which may reflect long-term exposure through drinking water, is associated with later development of childhood onset diabetes.”

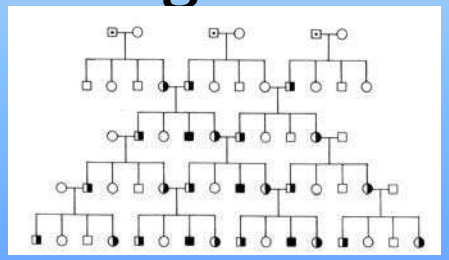


MORBUS GAUCHER

300 cases

dysfunction in the lipid metabolism in the body, an inherited chemical malformation.

Spleen and liver enlargenment



Splendid genealogy records in Sweden

Environmental Geochemical Monitoring Network

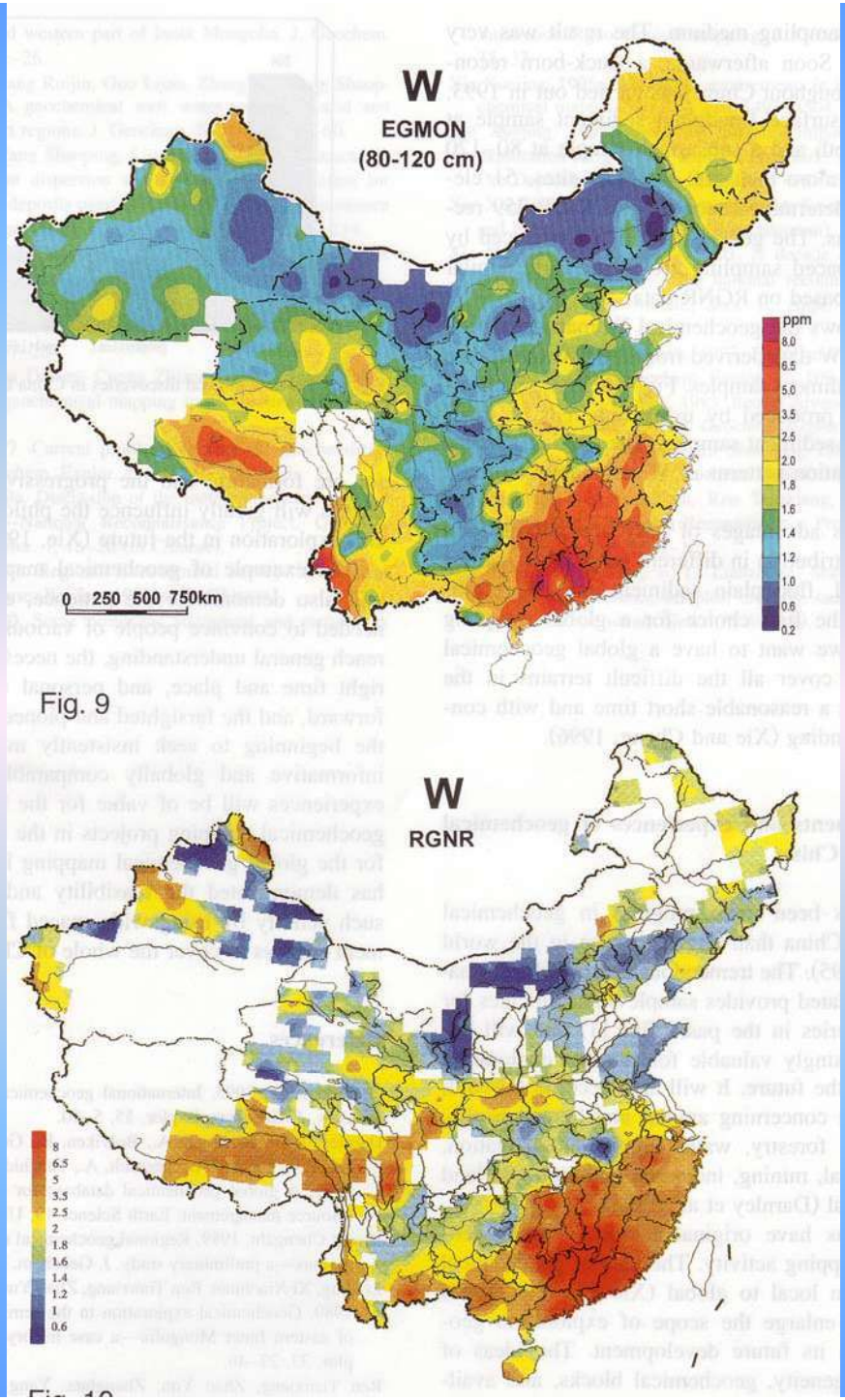
5000 cells

71 elements

Regional Geochemistry - National Reconnaissance

Stream sed.

400 000 samples



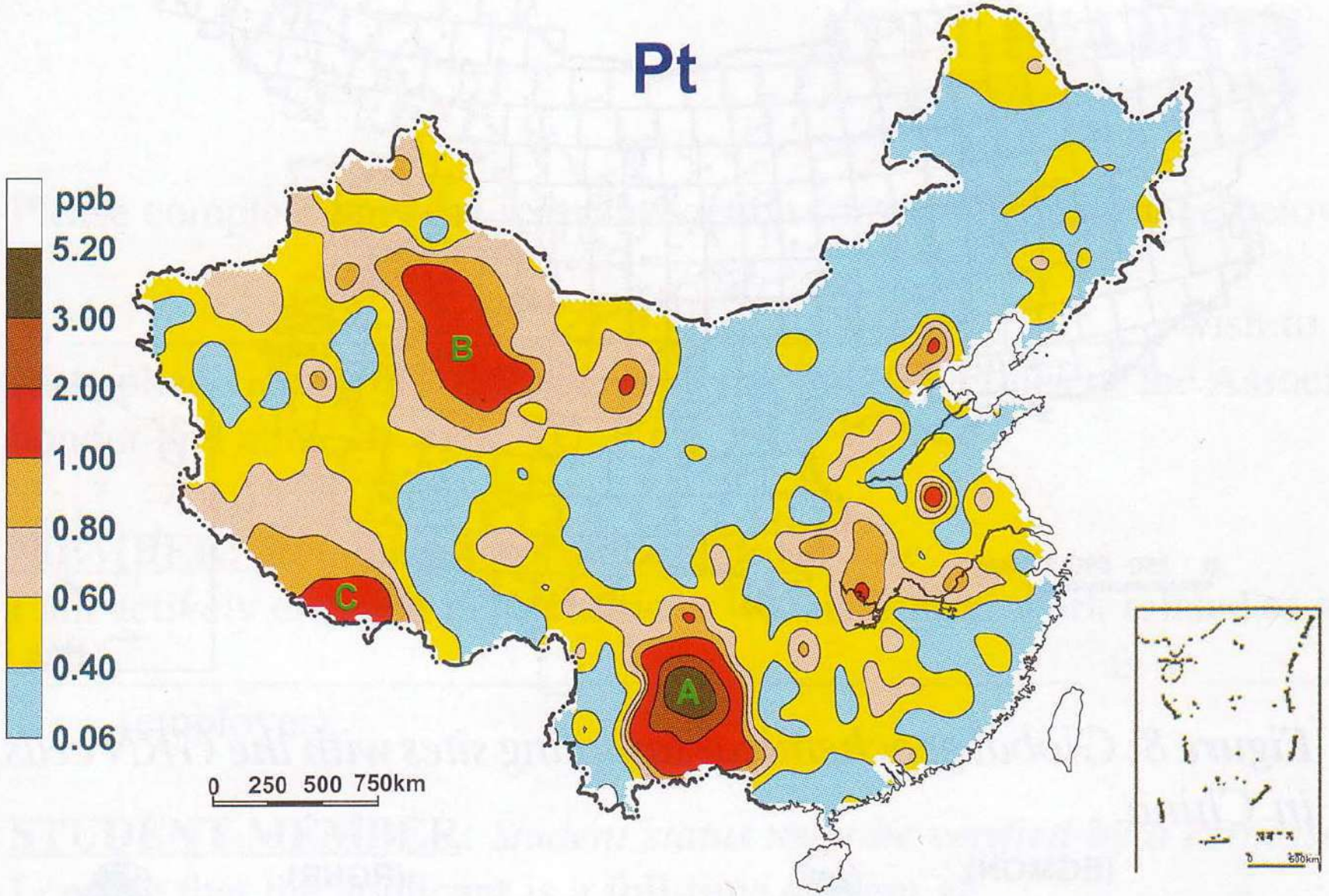
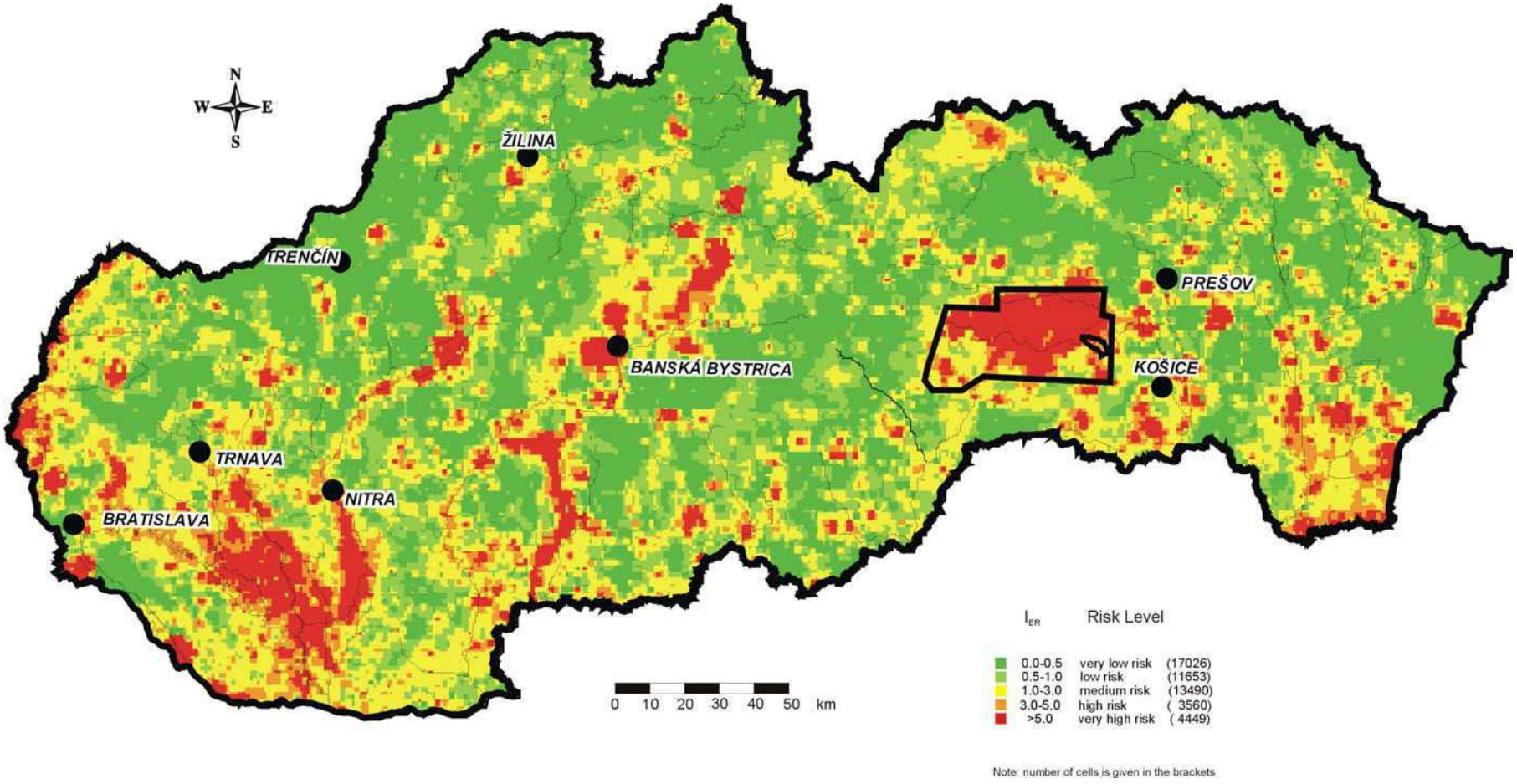


Figure 10: Geochemical distribution of Pt in China.

pilot area

Environmental Risk Assessment Map of the Slovak Republic



MATERIALS

GEOCHEMICAL DATA & HEALTH INDICATORS

GEOCHEMICAL DATA

- **Data from GEOCHEMICAL ATLAS**
- **New samples and new analyses in SGR Mts.**
  - **Soils** (A horizon, 816 samples)
  - **Stream sediments** (1 844 samples)
  - **Groundwater** (797 samples)
  - **Surface water** (754 samples)
  - **Vegetables** (13 samples)

Total contents, toxicity tests (acute and chronic)**, mobility and bioavailability** (5-step extraction)**, valence of some metals** (Sb^{3-5}, As^{3-5}, Cr^{t-6})**, mainly toxic metal** (Al, As, Cd, Cu, Cr^{6+}, Hg, Pb, Sb) **organic macro and micro pollutants.**

HEALTH INDICATORS

MEDICAL AND DEMOGRAPHIC DATA

- **Data from national databases**
- **Direct medical research in pilot area**

Health indicators – selected and standardized according to WHO methodology

- **Data from state registers**
- **Data validated by SHI**
- **Data represent average values of 5-years period (1993-1997)**

6 main basic groups of Health indicators are used

- ✓ **Demographic data**
- ✓ **Data of reproductive health**
- ✓ **Total mortality**
- ✓ **Cancer mortality**
- ✓ **Chronic lung diseases**
- ✓ **Cardiovascular diseases**

In each of mentioned groups several separate groups (according to age and sex) and several individual diagnosis are evaluated.

EPIDEMIOLOGICAL – MEDICAL research (ZLATA IDKA vill.)

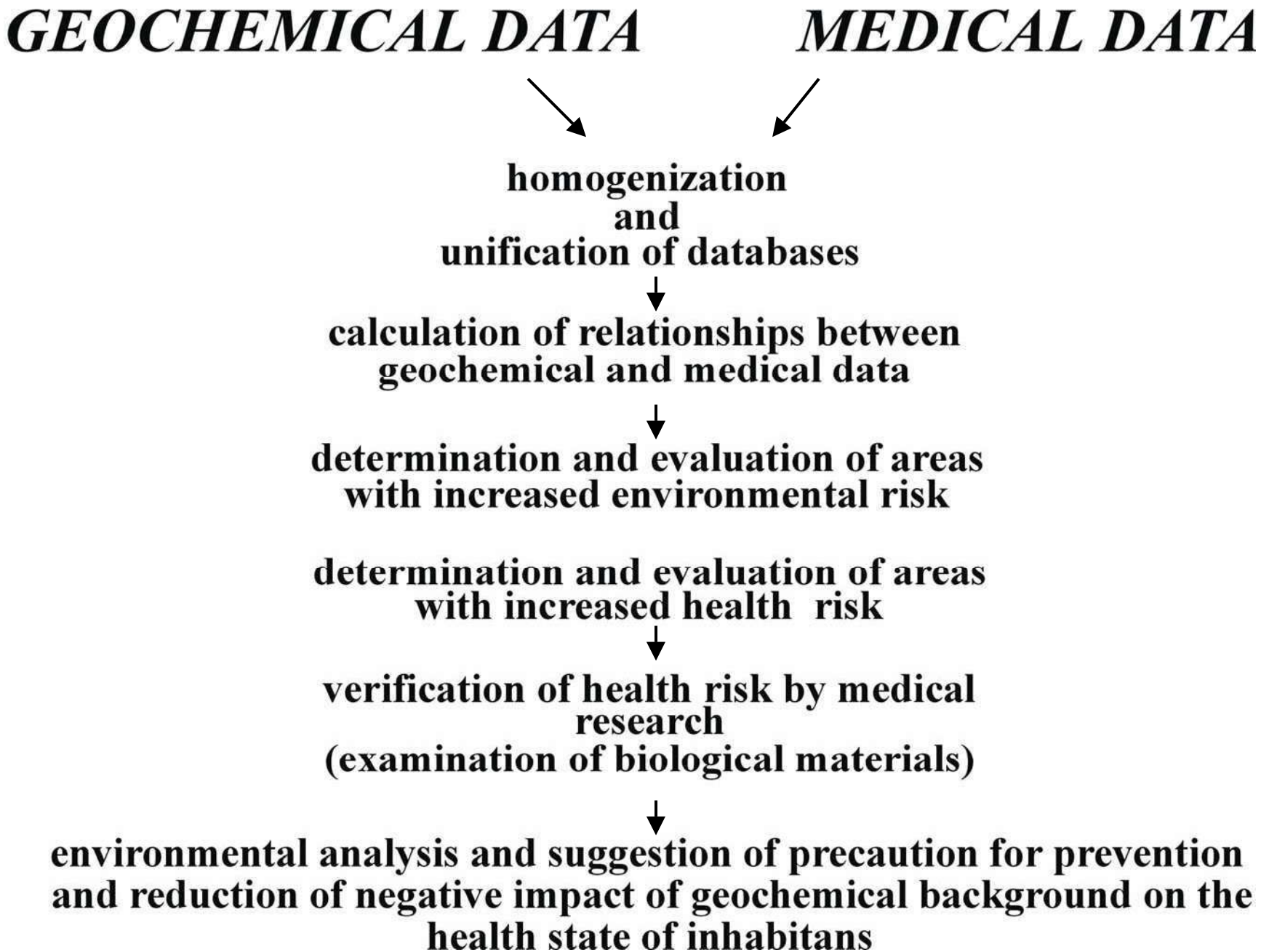
determination of As, Sb in biological materials of people

Hair – 71 respondents

Nails – 73 respondents

Urine – 116 respondents

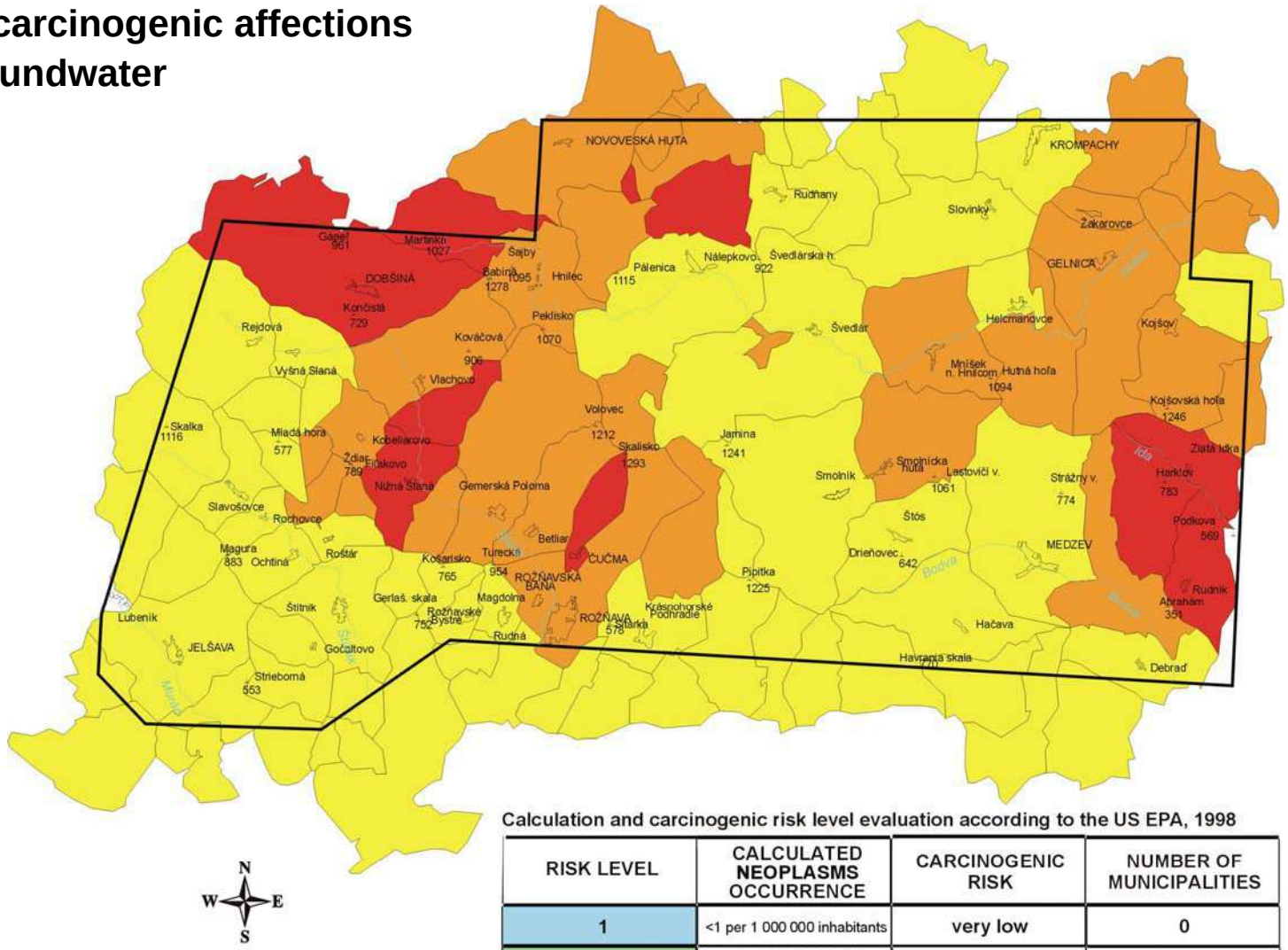
Blood – 117 respondents


GEOCHEMICAL DATA
MEDICAL DATA
homogenization
and
unification of databases
calculation of relationships between
geochemical and medical data
determination and evaluation of areas
with increased environmental risk
determination and evaluation of areas
with increased health risk
verification of health risk by medical
research
(examination of biological materials)
environmental analysis and suggestion of precaution for prevention
and reduction of negative impact of geochemical background on the
health state of inhabitans

HEALTH RISK

- **calculated for soils and groundwater**
- **from potential toxic elements: As, Sb, Cu, Cr, Pb, Zn, Be, Cd, Hg, Ba**
- **for each of 100 municipalities in SGR**
- **carcinogenic and chronic risk**
- **for adults** (70 y) **and children** (12 y)
- **the way of input of contaminants – ingestion**
- **reference dose, calculation ADD, CSF – according to US EPA, 1998**
- **calculation was realised by software Risk ASS, US EPA, 1998**
- **chronic and carcinogenic risk level – excess lifetime chronic and carcinogenic affections assessed according to US EPA**
- **calculations of Health risk are presented in numeric** (for 100 municipalities) **and map form**

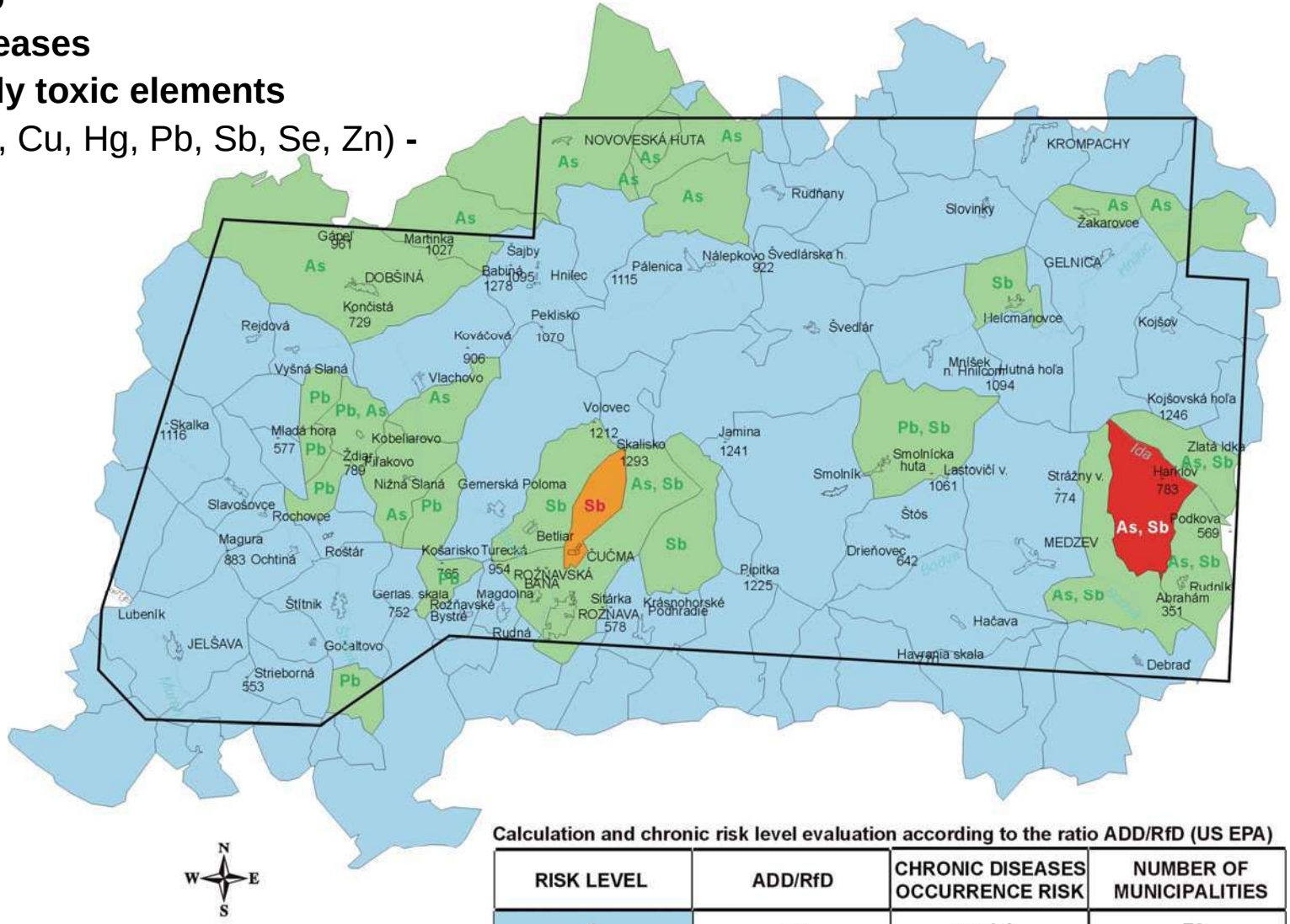
Risk level map of carcinogenic affections from Arsenic - groundwater



Calculation and carcinogenic risk level evaluation according to the US EPA, 1998

RISK LEVEL	CALCULATED **NEOPLASMS** OCCURRENCE	CARCINOGENIC RISK	NUMBER OF MUNICIPALITIES
1	<1 per 1 000 000 inhabitants	very low	0
2	>1 per 1 000 000 inhabitants <1 per 100 000 inhabitants	low	0
3	>1 per 100 000 inhabitants <1 per 10 000 inhabitants	medium	61
4	>1 per 10 000 inhabitants <1 per 1 000 inhabitants	high	29
5	>1 per 1 000 inhabitants	very high	10

Risk level map
of chronic diseases
from potentially toxic elements
(As, Ba, Cd, Cr, Cu, Hg, Pb, Sb, Se, Zn) **-**
groundwater

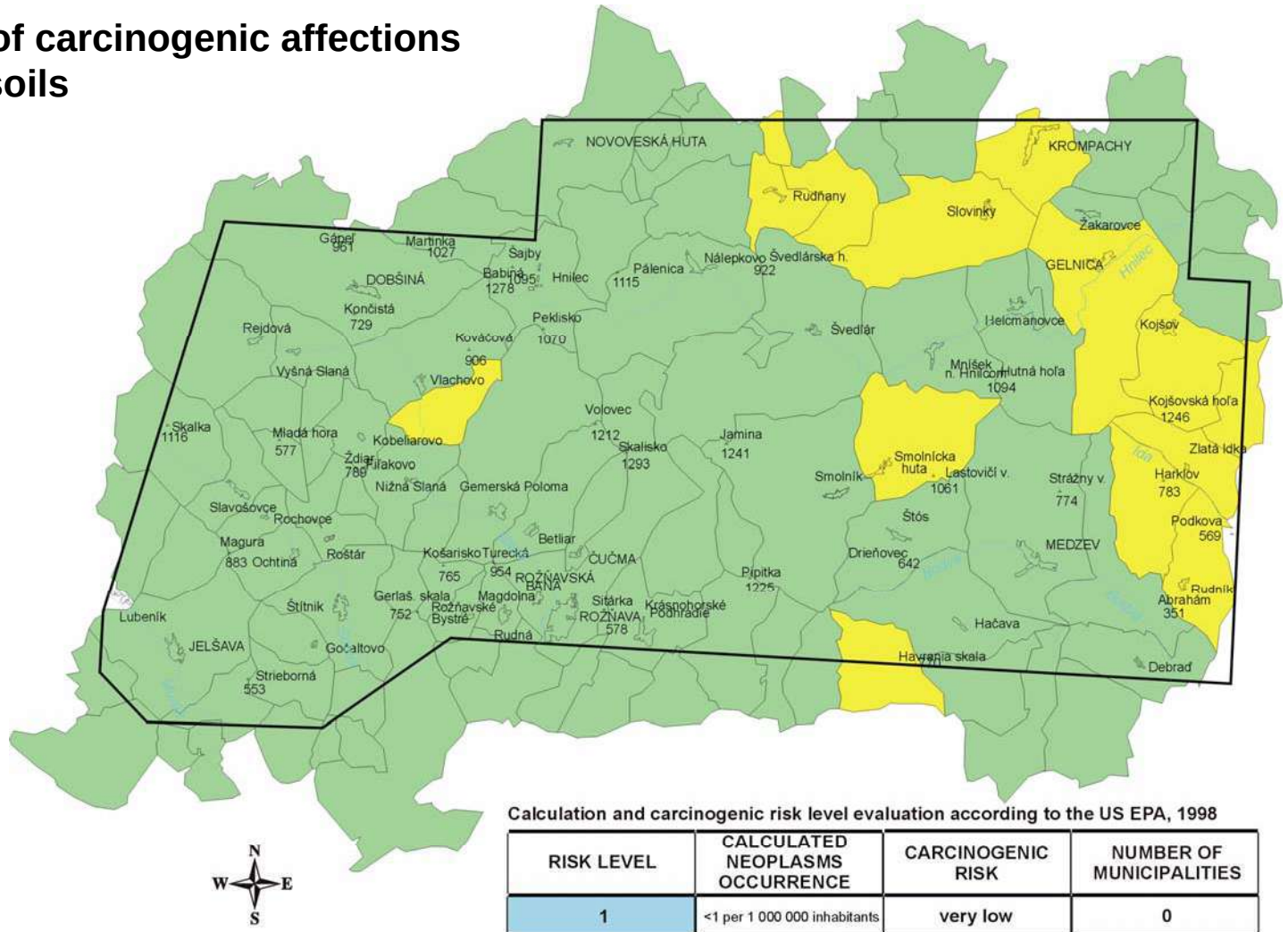


Calculation and chronic risk level evaluation according to the ratio ADD/RfD (US EPA)

RISK LEVEL	ADD/RfD	CHRONIC DISEASES OCCURRENCE RISK	NUMBER OF MUNICIPALITIES
1	≤ 1	no risk	72
2	> 1 ≤ 5	low	26
3	> 5 ≤ 10	medium	1
4	> 10	high	1

Symbols - risk elements

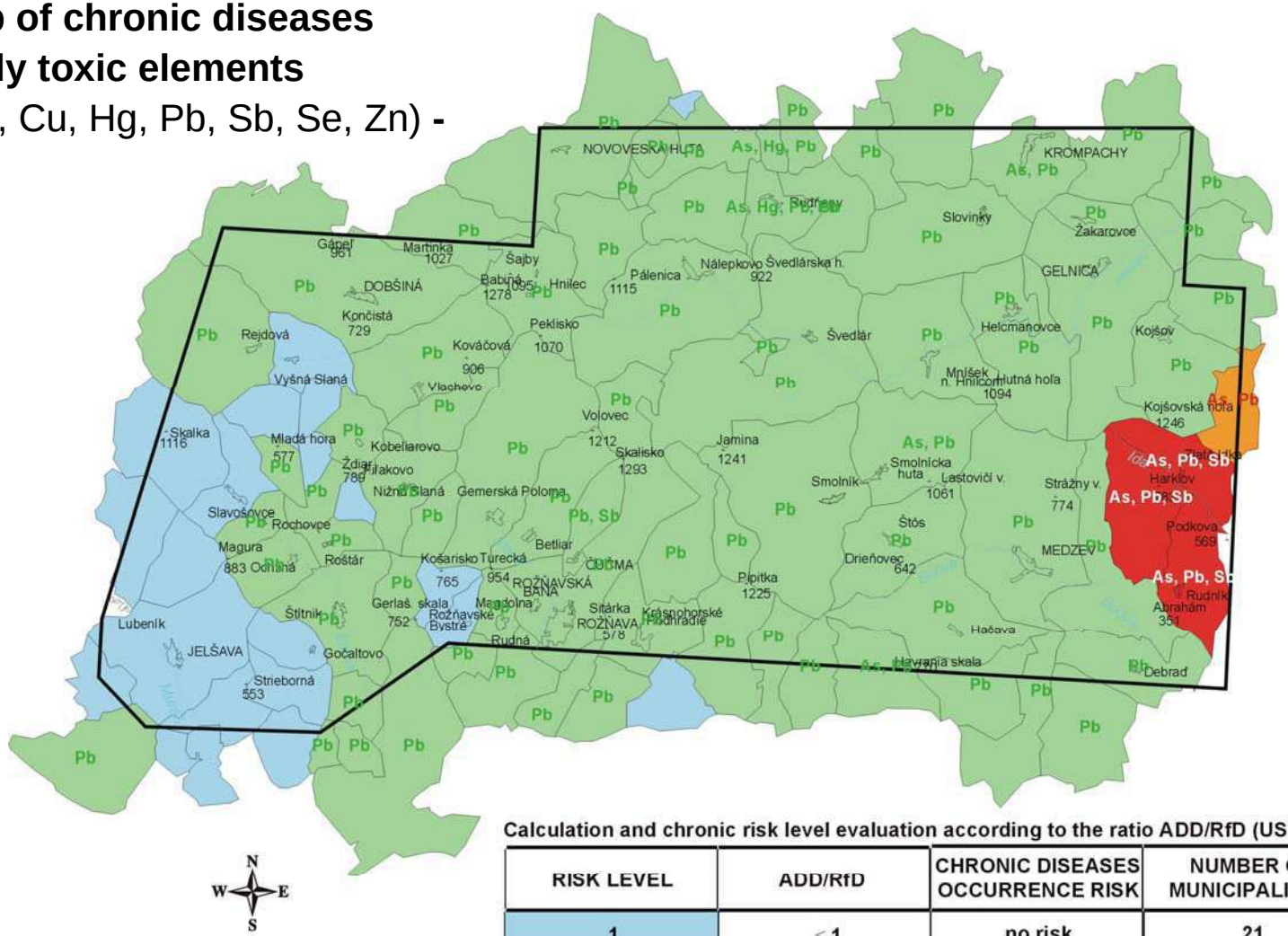
Risk level map of carcinogenic affections from Arsenic - soils



Calculation and carcinogenic risk level evaluation according to the US EPA, 1998

RISK LEVEL	CALCULATED NEOPLASMS OCCURRENCE	CARCINOGENIC RISK	NUMBER OF MUNICIPALITIES
1	<1 per 1 000 000 inhabitants	very low	0
2	>1 per 1 000 000 inhabitants <1 per 100 000 inhabitants	low	86
3	>1 per 100 000 inhabitants <1 per 10 000 inhabitants	medium	14
4	>1 per 10 000 inhabitants <1 per 1 000 inhabitants	high	0
5	>1 per 1 000 inhabitants	very high	0

Risk level map of chronic diseases from potentially toxic elements (As, Ba, Cd, Cr, Cu, Hg, Pb, Sb, Se, Zn) **- children, soils**



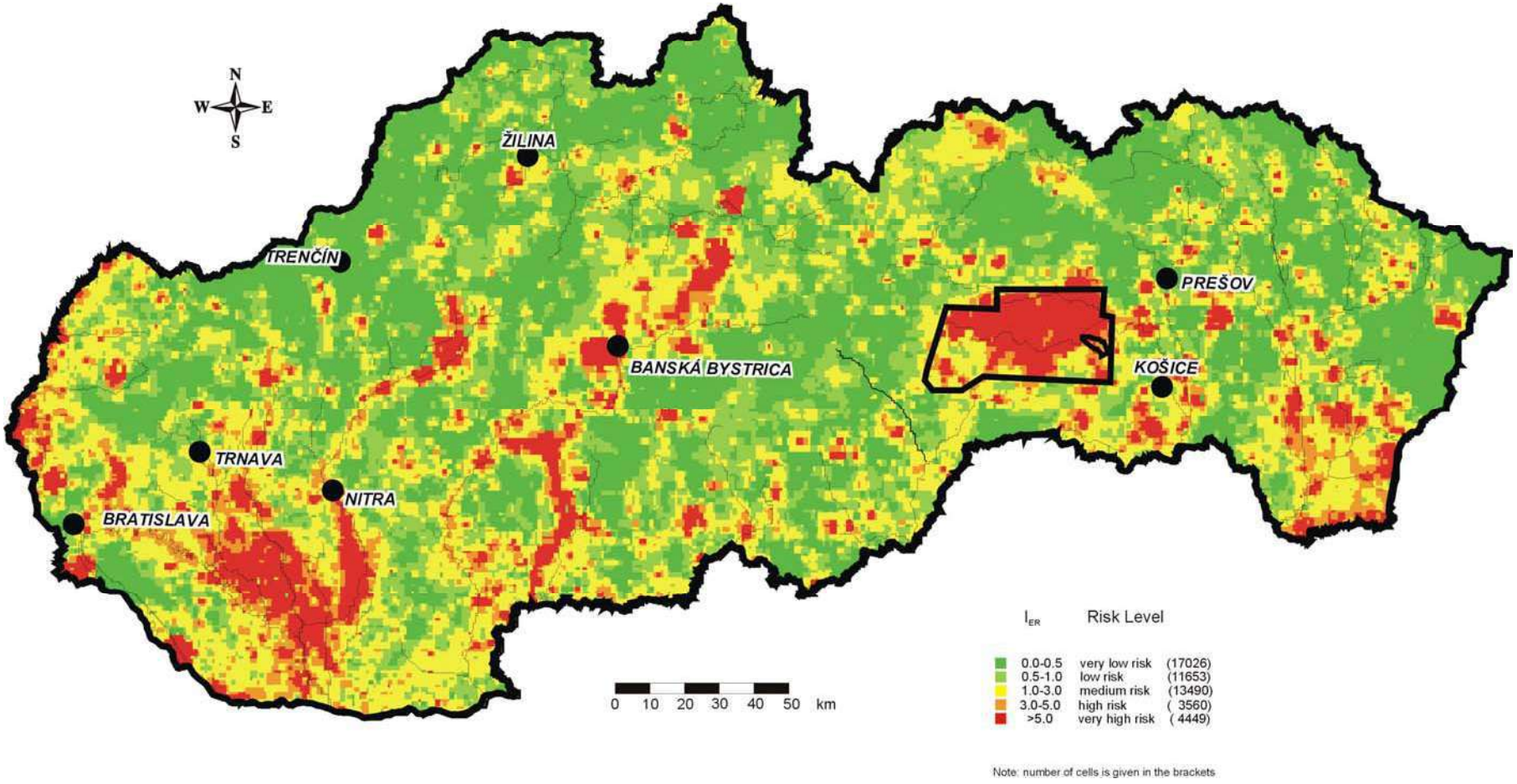
Calculation and chronic risk level evaluation according to the ratio ADD/RfD (US EPA)

RISK LEVEL	ADD/RfD	CHRONIC DISEASES OCCURRENCE RISK	NUMBER OF MUNICIPALITIES
1	≤ 1	no risk	21
2	> 1 ≤ 5	low	75
3	> 5 ≤ 10	medium	1
4	> 10	high	3

Symbols - risk elements

pilot area

Environmental Risk Assessment Map of the Slovak Republic



Extensive databases in Canada, China, EU, USA etc

Conclusions:

Quality control?

Speciation?

Sample type?

Purpose?