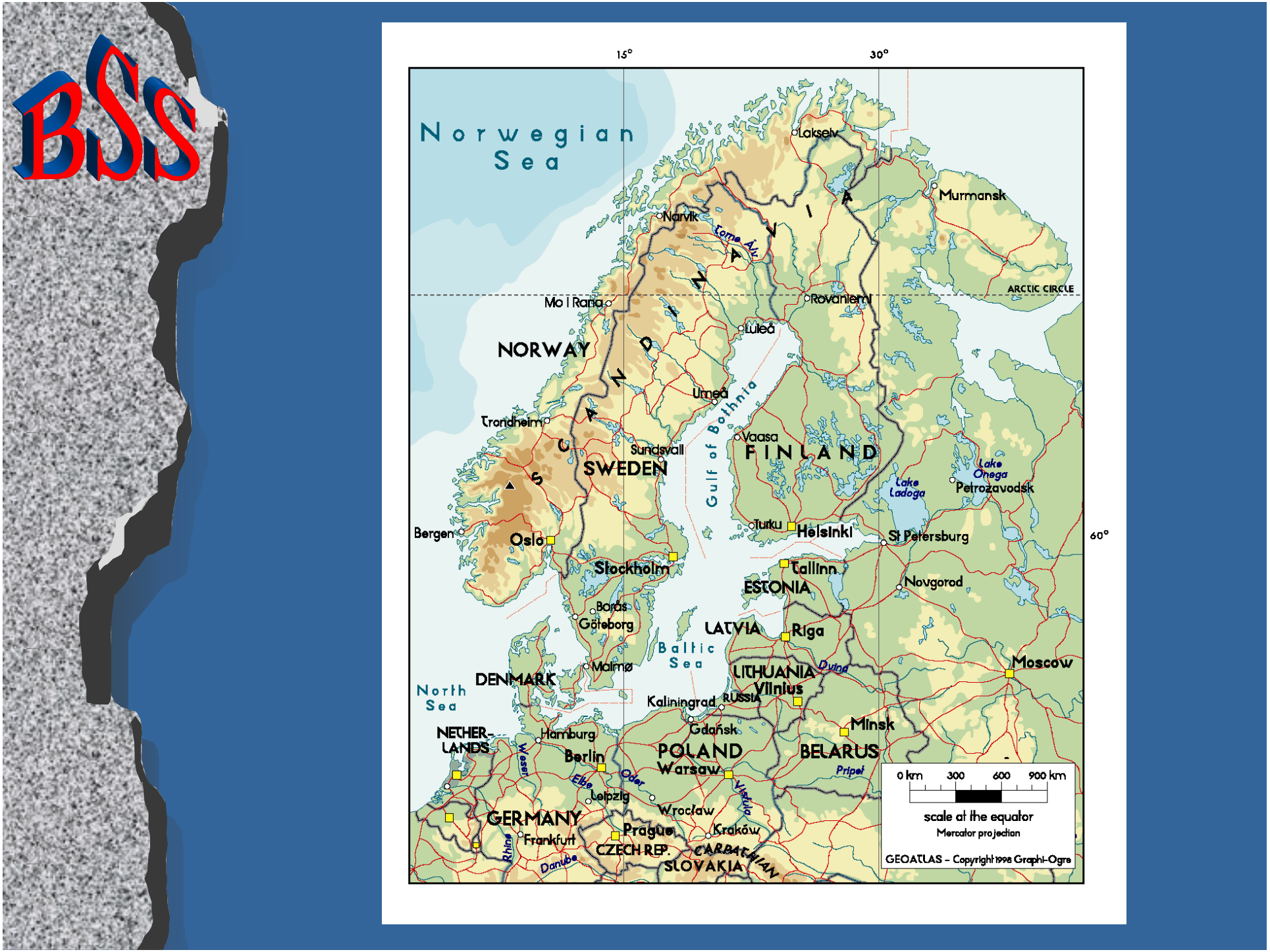
The Baltic Soil Survey

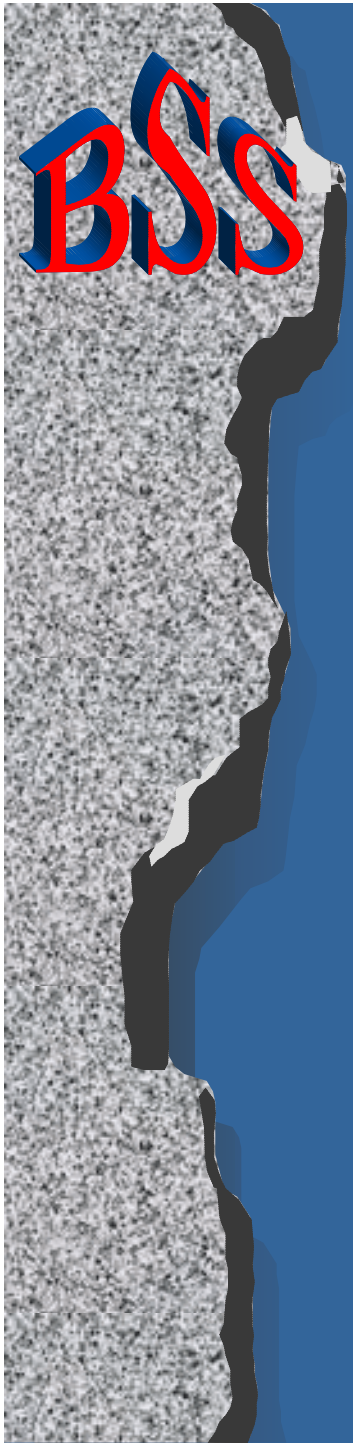
C. Reimann, U. Siewers, T. Tarvainen, L. Bityukova, J. Erikson, A. Gilucis, V. Gregorauskiene, V. Lukashev, N. Matinian & A. Pasieczna


15°
30°
60°
Norwegian Sea
Lakselv
Murmansk
Narvik
Torne Älv
ARCTIC CIRCLE
Mo I Rana
Rovaniemi
Luleå
NORWAY
SCANDINAVIA
Umeå
Gulf of Bothnia
Trondheim
Vaasa
Sundsvall
SWEDEN
FINLAND
Lake Onega
Lake Ladoga
Petrozavodsk
Bergen
Oslo
Turku
Helsinki
St Petersburg
Stockholm
Tallinn
ESTONIA
Novgorod
Borås
Göteborg
LATVIA
Riga
Baltic Sea
Malmö
LITHUANIA
Dvina
Moscow
DENMARK
Vilnius
North Sea
Kaliningrad
RUSSIA
Minsk
Gdańsk
NETHER-LANDS
Hamburg
Weser
POLAND
BELARUS
Berlin
Warsaw
Pripet
Elbe
Oder
Vistula
Leipzig
Wrocław
GERMANY
Kraków
Frankfurt
Prague
Rhine
CZECH REP.
CARPATHIAN
Danube
SLOVAKIA
0 km 300 600 900 km
scale at the equator
Mercator projection
GEOATLAS – Copyright 1998 Graphi-Ogre

Baltic Soil Survey

PROJECT AIM: create a comparable database of the chemical composition of AGRICULTURAL SOILS in Northern Europe

SIZE OF AREA:	ca. 1.8 mill. km^2
SAMPLE DENSITY:	1 site/ 2500 km^2
NUMBER OF SAMPLES: TOP:	774
BOTTOM:	773



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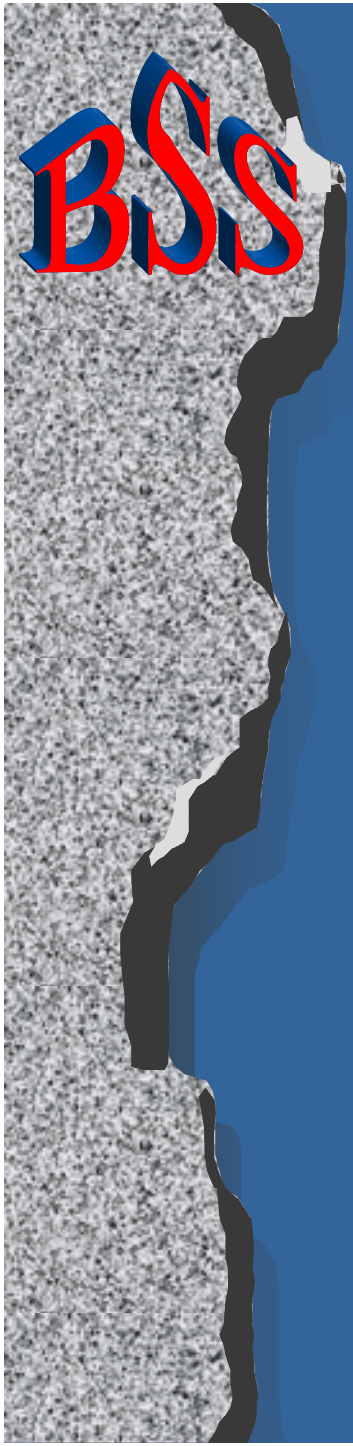
COUNTRY	ORGANISATION	COORDINATOR
1 Belarus	Academy of Sciences	V. Lukashev (†)
2 Estonia	Academy of Sciences	L. Bityukova
3 Finland	Geological Survey	T. Tarvainen
4 Germany	Geological Survey	U. Siewers
5 Latvia	Geological Survey	A. Gilucis
6 Lithuania	Geological Survey	V. Gregorauskiene
7 Norway	Geological Survey	C. Reimann
8 Poland	Geological Survey	A. Pasieczna
9 Russia	University Institute	N. Matinian
10 Sweden	University Institute	J. Eriksson



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PROJECT ORGANISATION:

NGU: - Organisation of sampling, distribution of field equipment, sampling instructions.

- Sample preparation.

- Ammonium acetate extraction, ICP-AES-, pH-, org.C-analyses.

- Quality control of all results.

BGR: - XRF-analyses of all samples.

- Printing of the atlas.

GTK: - Aqua regia extraction, ICP-AES-analyses.

- HF-$HCLO_4$-digestion, ICP-MS-analyses.

OTHER ORGANISATIONS:

-sampling in their country.

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WHY AGRICULTURAL SOIL?

It is difficult to find a “comparable” sample material that can be collected over such a large area.

Agricultural soils are “comparable” at least in relation to land-use. All samples were taken from ploughed fields.

Agricultural soils provide a direct link to the food-chain: over 100 million people live of the agricultural soils in the project area.

Access and sampling is easy and fast.

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Sample medium: AGRICULTURAL SOIL

2 layers: **TOP: 0-25 cm (or max. ploughing depth)**

BOTTOM: 50-75 cm (well below ploughed layer)

Large composite samples: 10 - 15 kg each

air dried

sieved to <2 mm

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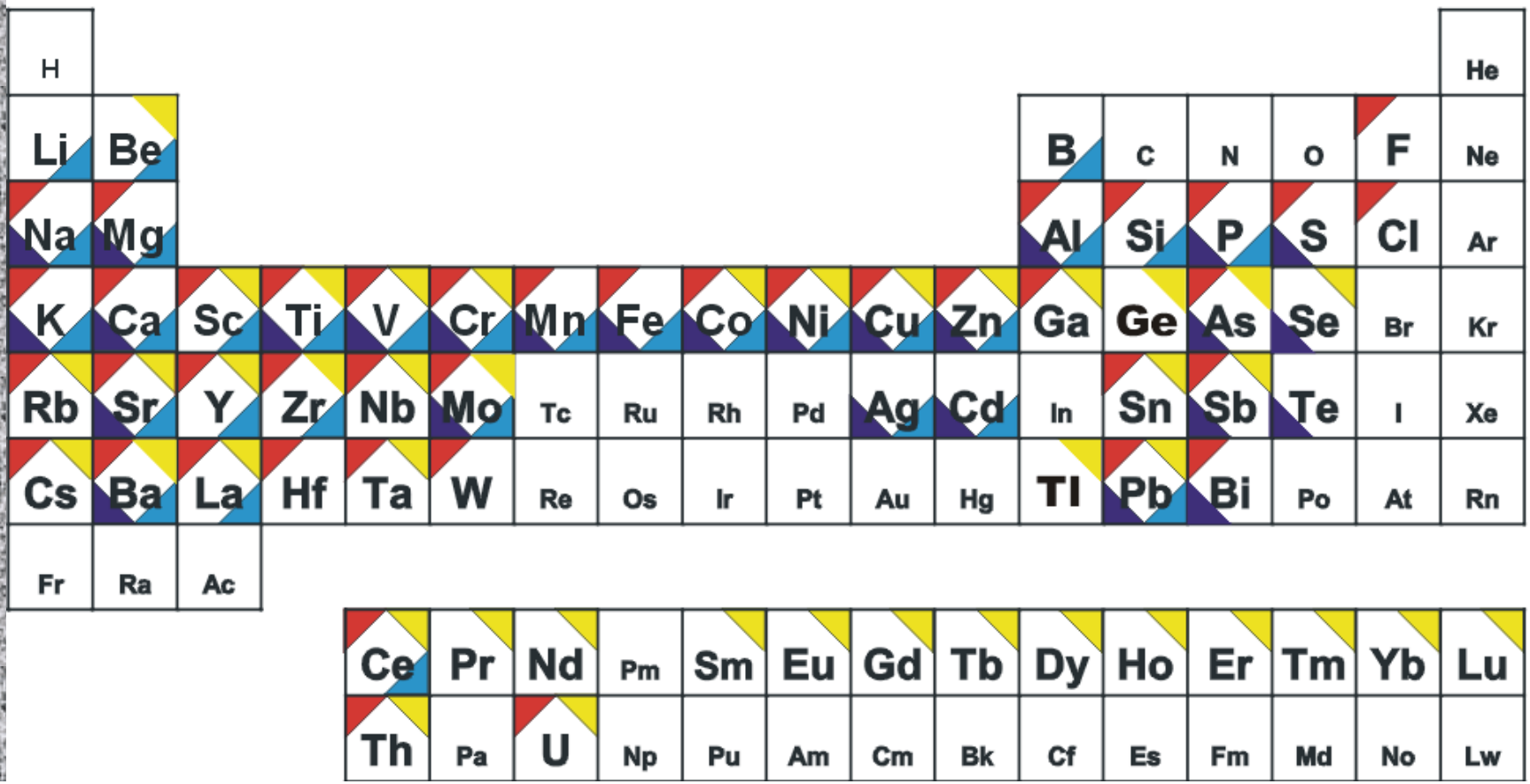
ANALYTICAL PROGRAM (62 elements + pH and LOI):

XRF (BGR), fused discs

ICP-MS, HF-digestion

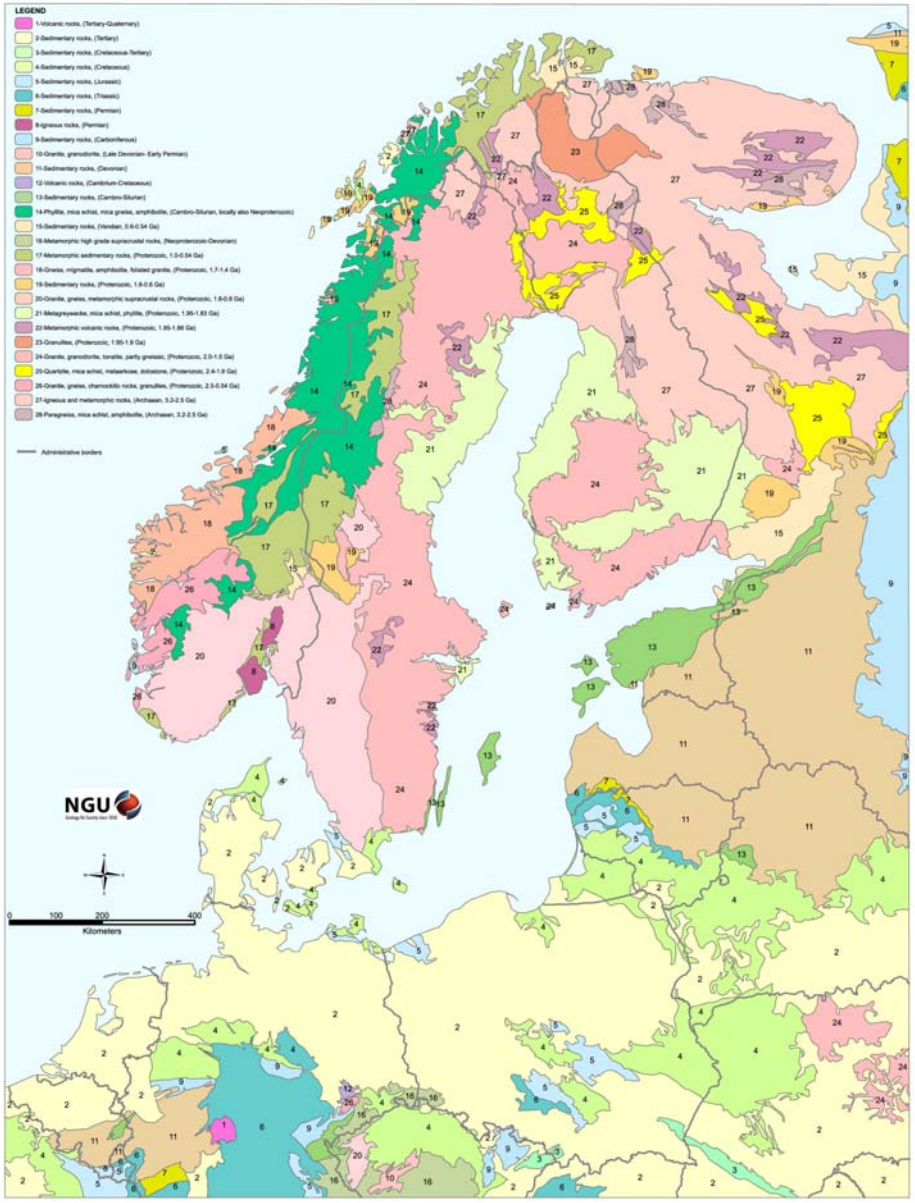
ICP-AES, aqua regia extraction

ICP-AES, ammonium acetat extraction



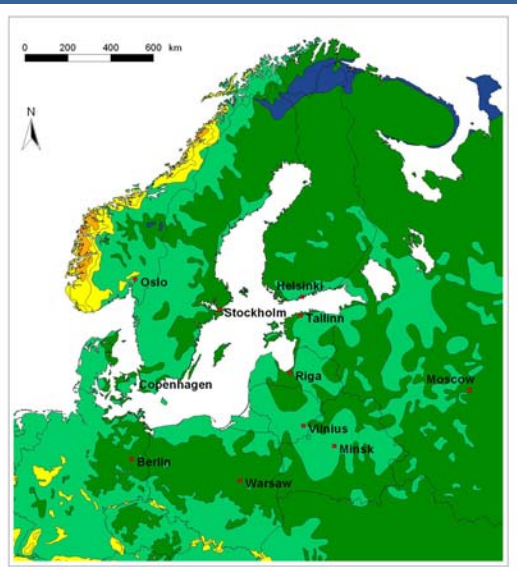
GEOLOGY

The main geological domains are: the Caledonides, the Precambrian basement and the European Platform

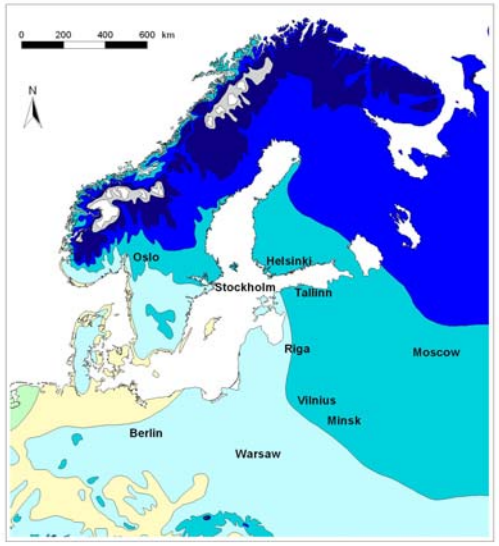


BSS

Large NATURAL gradients dominate the survey area

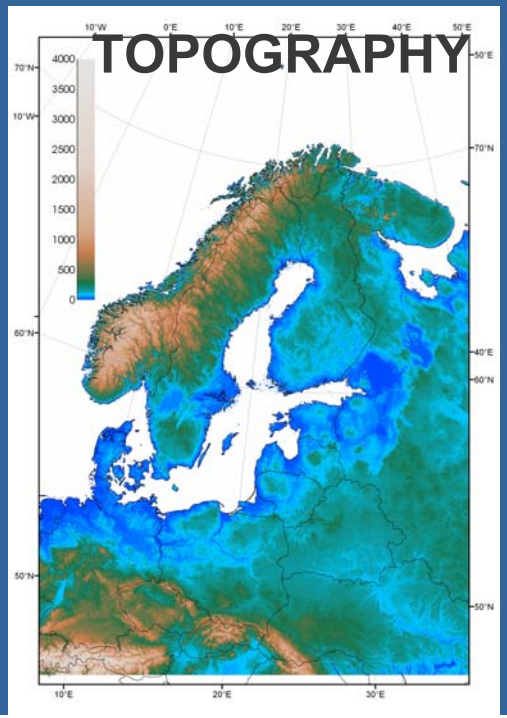


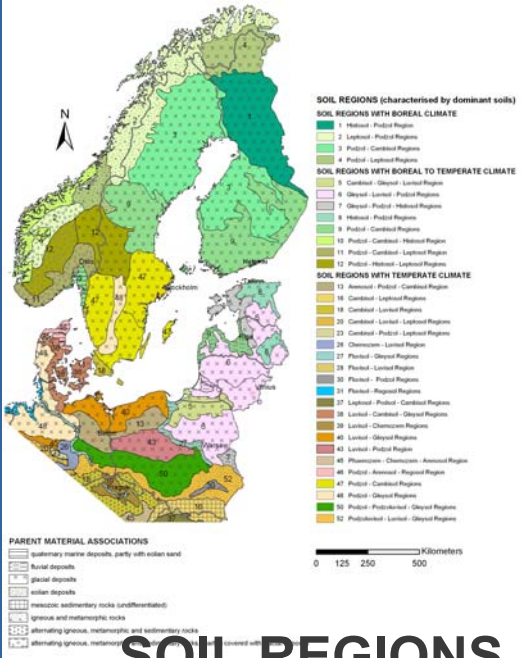
PRECIPITATION



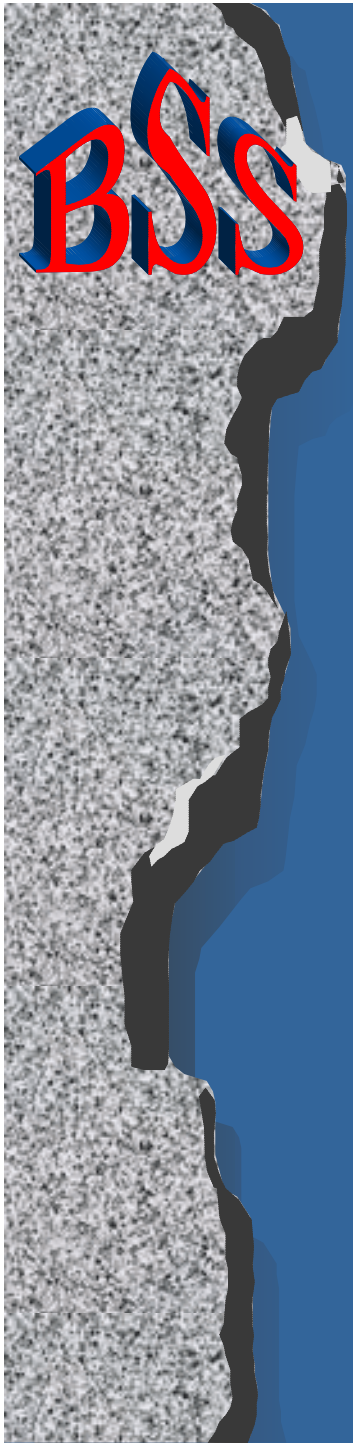
SNOW COVER

TEMPERATURE





SOIL REGIONS



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Many Processes Can Influence the Chemical Composition of Agricultural Soils, e.g.:

TOWARDS DEPLETION IN THE TOP-LAYER:

- Plant uptake and removal of elements via harvesting.
- Leaching of elements from TOP to BOTTOM.
- Lessivation.

TOWARDS ENRICHMENT IN THE TOP-LAYER:

- Element addition via fertilisers.
- Element addition via the atmosphere (e.g., pollution).
- Strong organic binding.
- Bio-accumulation.
- Upwards movement of elements.

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Is geochemical mapping possible?

With just one sample per 2500 km^2?

With a lot of different processes influencing the regional distribution of elements?

What will determine the regional distribution of the elements:

- **- bedrock geology?**
- **- agriculture?**
- **- pollution?**
- **- climate?**

???

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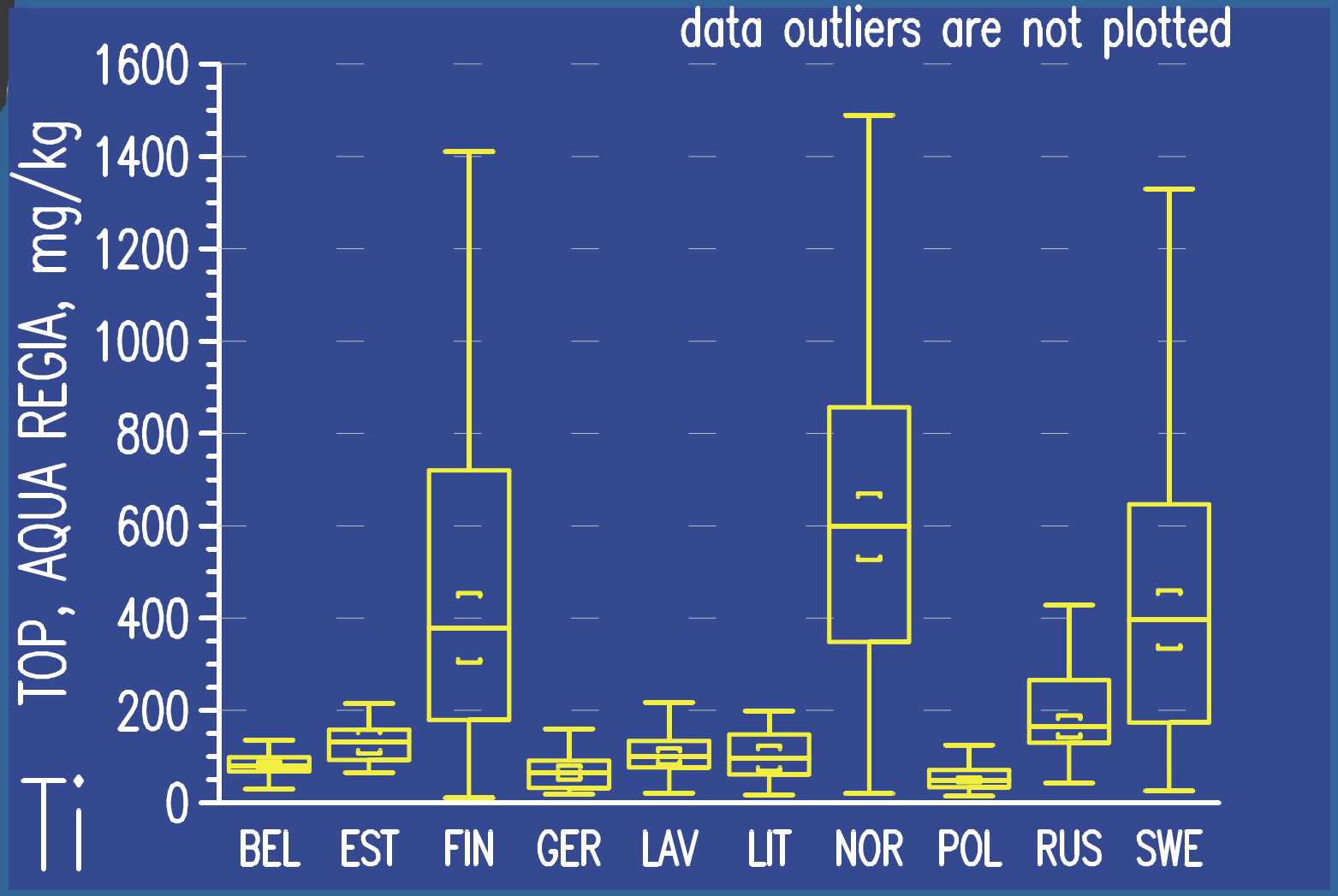

Differences in the median concentrations between countries can cover an order of magnitude.

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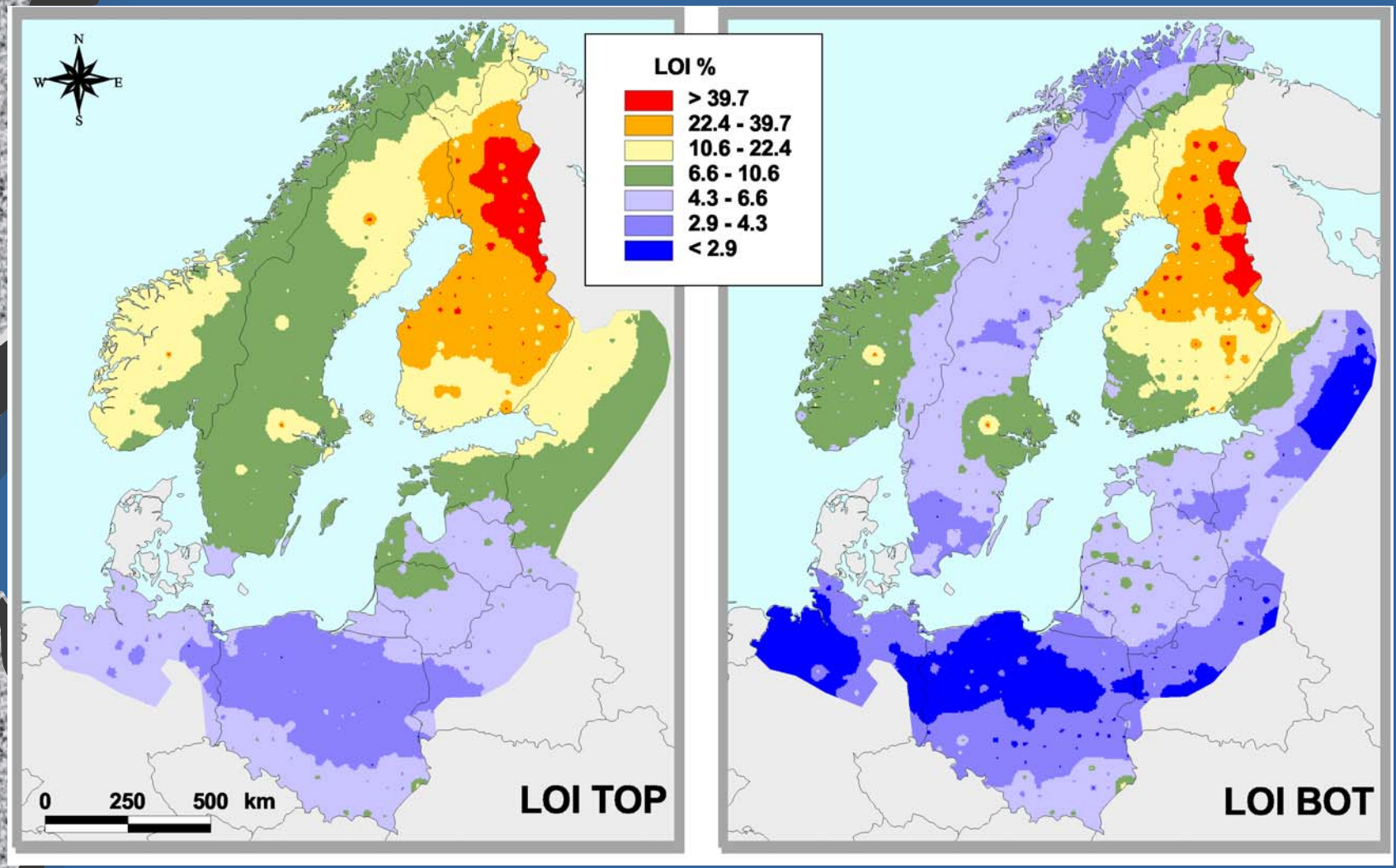
LOI: more organic material in the soils in the Nordic countries, esp. Finland. Less intensive agriculture. Cold, wet climate results in decreased decay of organic material.



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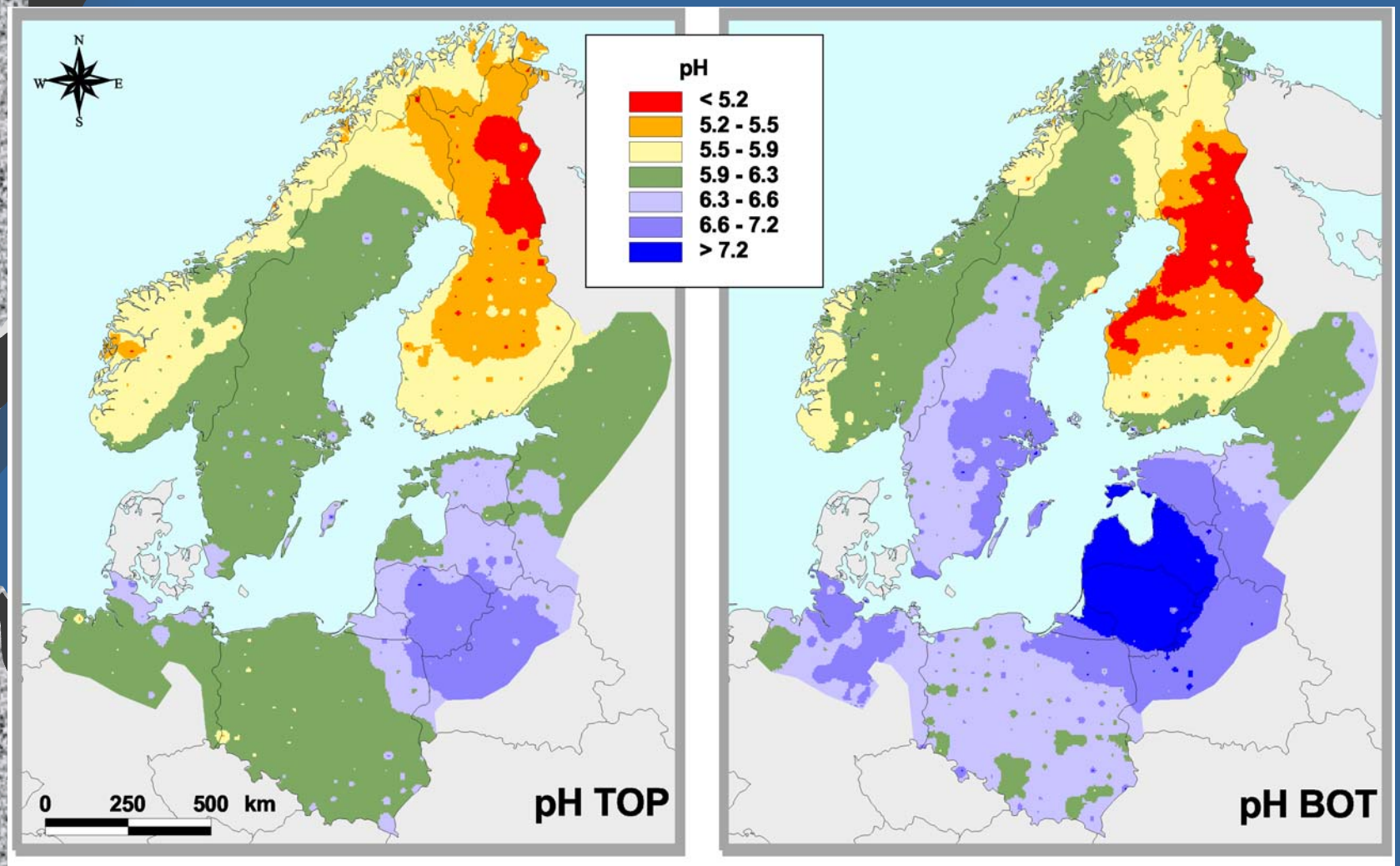
pH: is also climate-dependent. Low pH-values in the cold, wet parts of the Northern countries with organic-rich soils.



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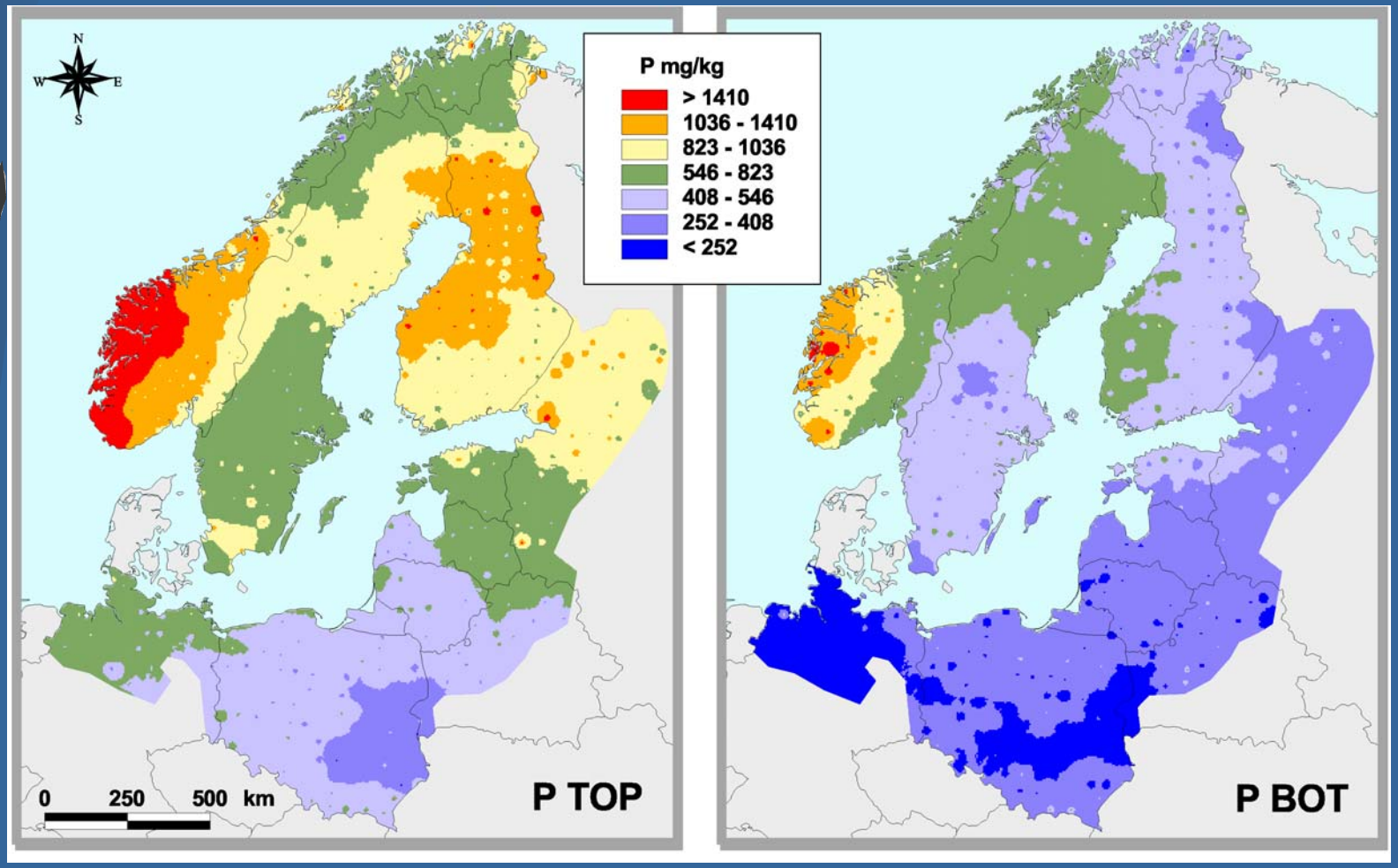
P: is an integral part of organic matter and thus highly enriched in the TOP-layer. Parts of the displayed patterns are a functrion of climate (Norway) , a part of the build-up in the TOP layer is due to over-fertilisation (e.g. Germany, Russia)



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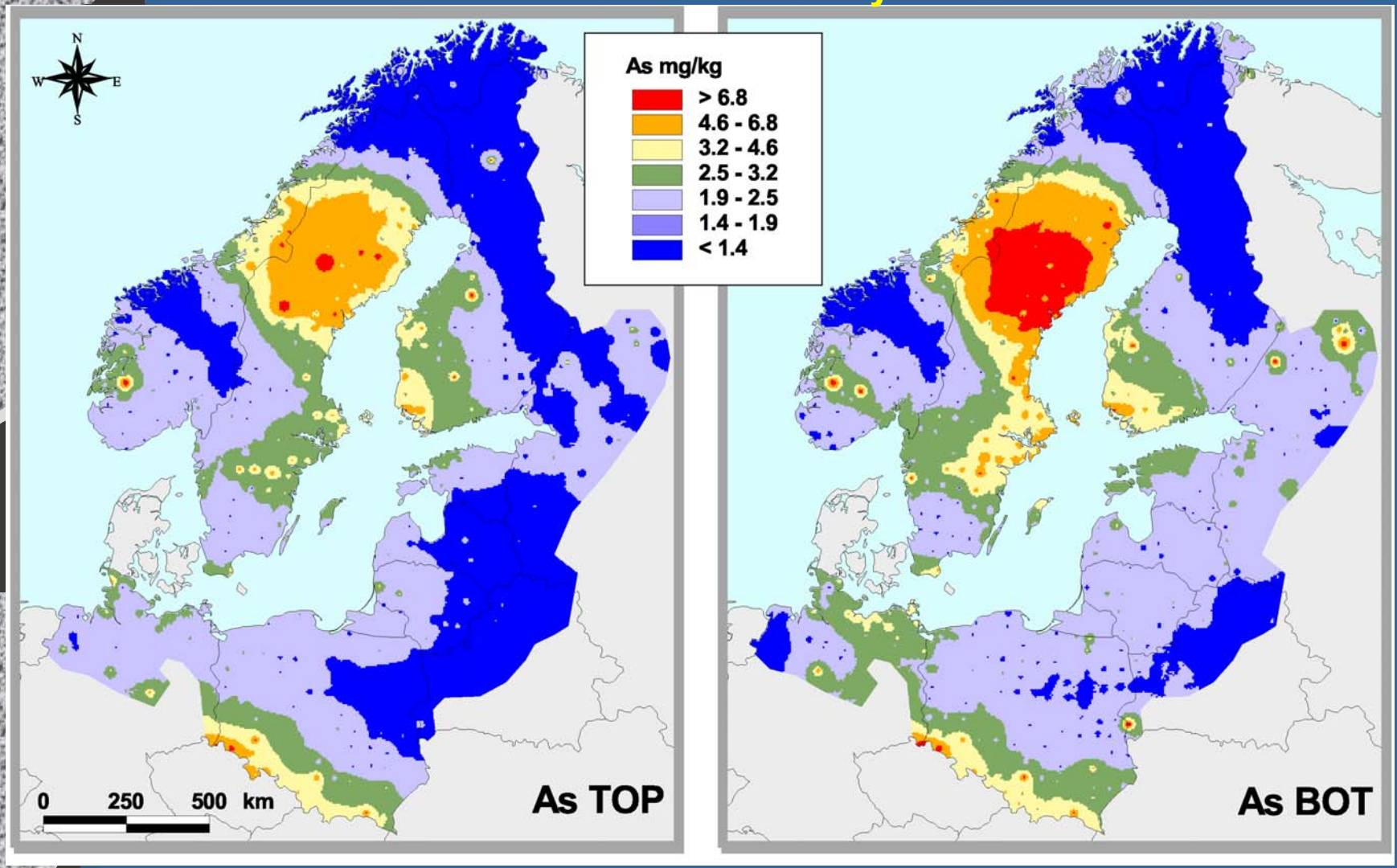
As: regional scale “bulls-eye” anomaly in central Sweden.

BOT-layer: black shales in Russia visible. S-Poland: clayey soils + different bedrocks + industry. Sweden?



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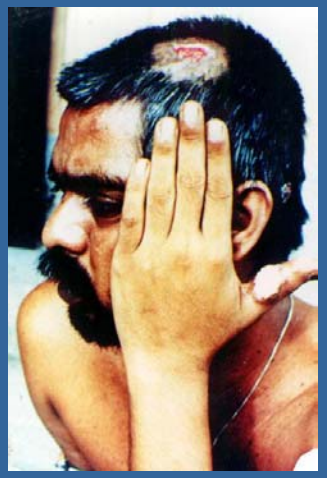
ARSENIC



Was one of the first chemicals recognised to cause cancer – already 1879…

Evidence that As in drinking water could cause skin cancer came in the 1930ies – a sufficiently low action level to protect the health of the general public was set in 1998 (European Union).

1990ies: an estimated 36 million people in the Bengal Delta are at risk from drinking ”clean” ground water.

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S Essential

B Essential in ultra trace quantities, maybe essential or essential to some organisms

Non-toxic

Toxic to highly toxic

Less toxic

Carcinogenic, documented

Carcinogenic, suspected

Ga No known biological role

Be Noteworthy concentrations observed in natural drinking water

H																	He
Li	**Be**											**B**	**C**	**N**	**O**	**F**	Ne
Na	**Mg**											**Al**	**Si**	**P**	**S**	**Cl**	Ar
K	**Ca**	Sc	Ti	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	Ga	Ge	**As**	**Se**	**Br**	Kr
Rb	Sr	Y	Zr	Nb	**Mo**	Tc	Ru	Rh	Pd	Ag	**Cd**	In	**Sn**	Sb	Te	**I**	Xe
Cs	**Ba**	La	Hf	Ta	**W**	Re	Os	Ir	Pt	Au	Hg	**Tl**	Pb	Bi	Po	At	**Rn**
Fr	Ra	Ac															

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	**U**	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lw**

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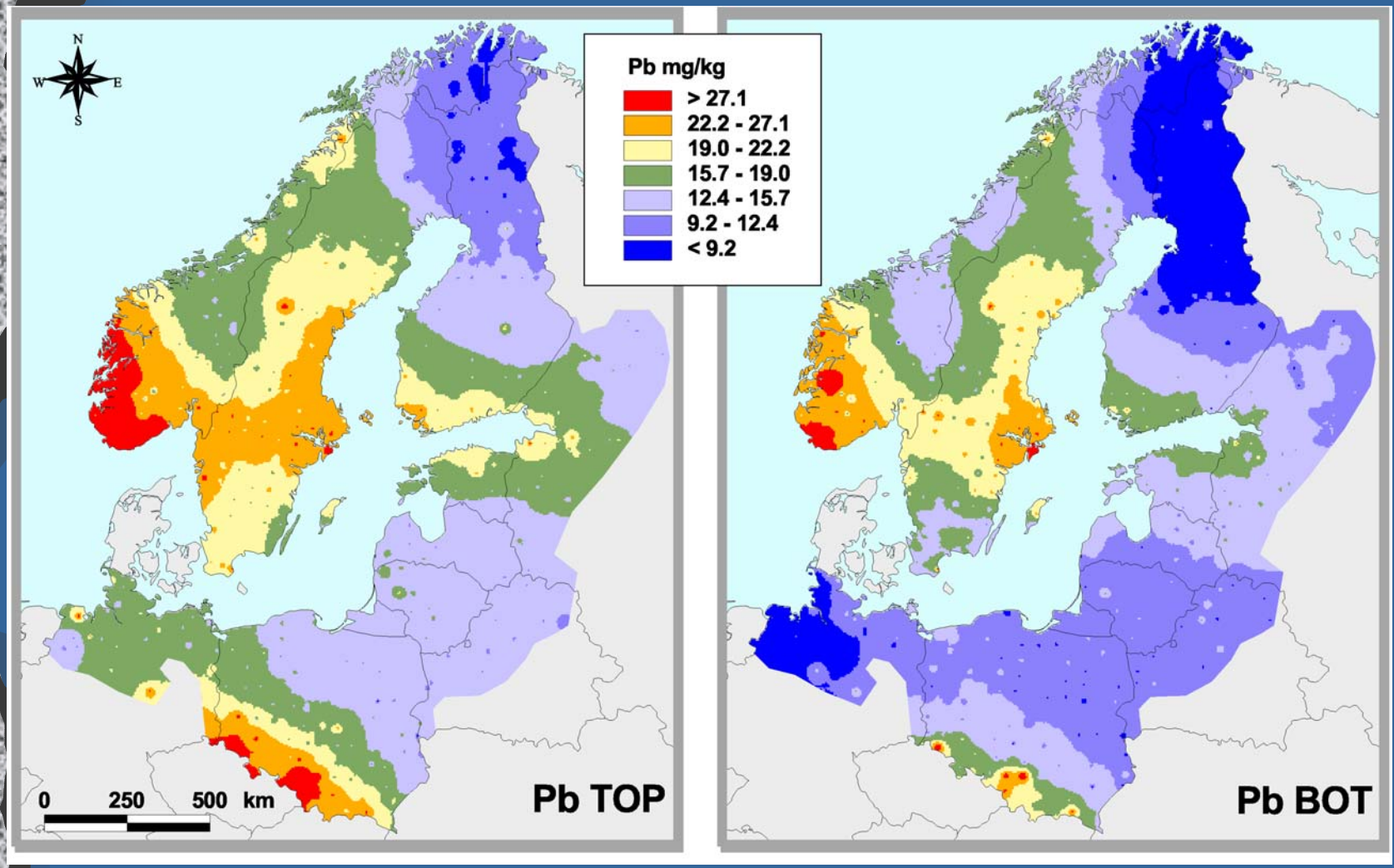
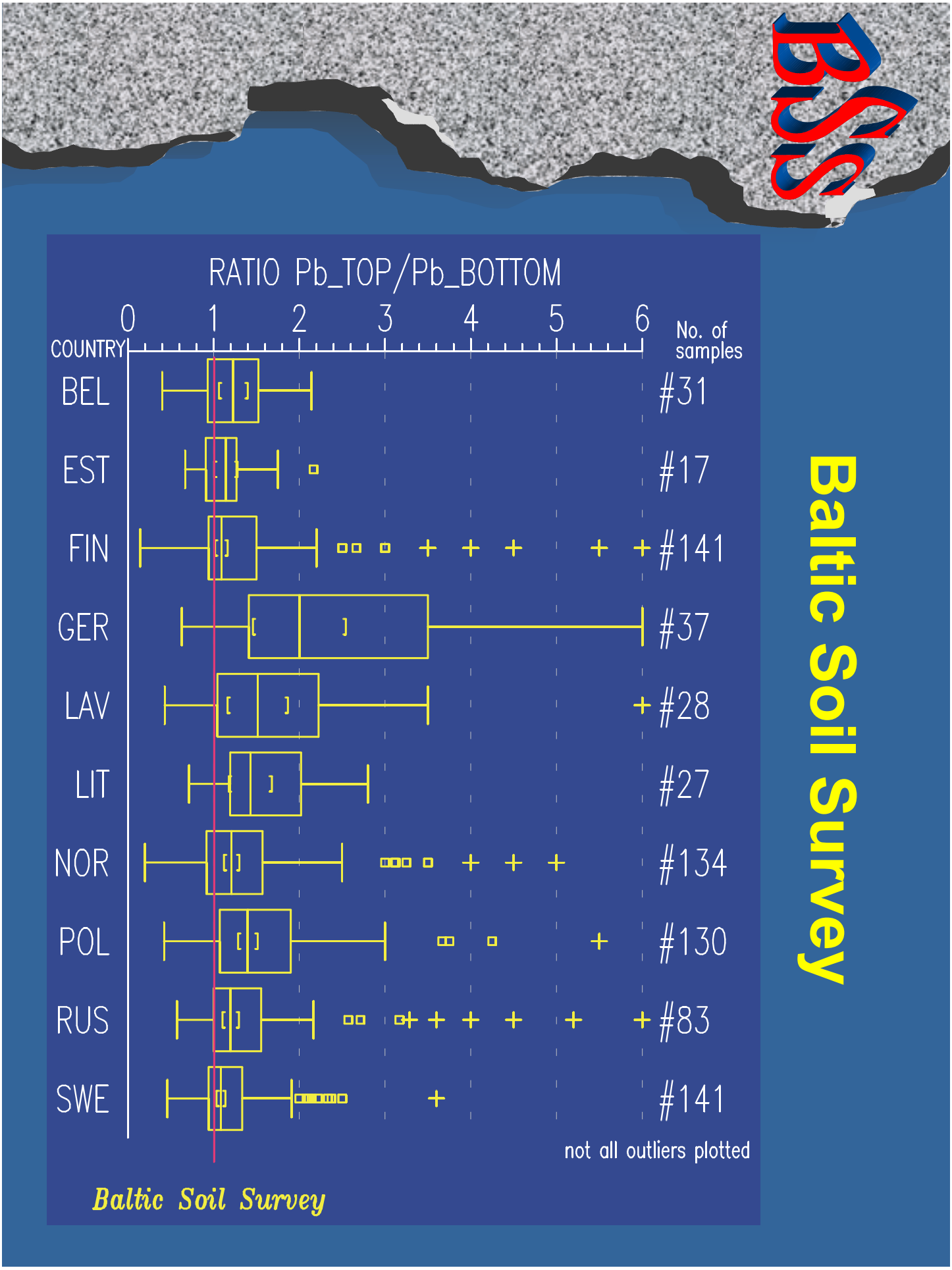
Pb: higher values in the TOP than in the BOT-layer. Note the minor impact of industry on the sub-continental-scale patterns.




BSS
Baltic Soil Survey
RATIO Pb_TOP/Pb_BOTTOM
0
1
2
3
4
5
6
COUNTRY
No. of samples
BEL
#31
EST
#17
FIN
#141
GER
#37
LAV
#28
LIT
#27
NOR
#134
POL
#130
RUS
#83
SWE
#141
not all outliers plotted
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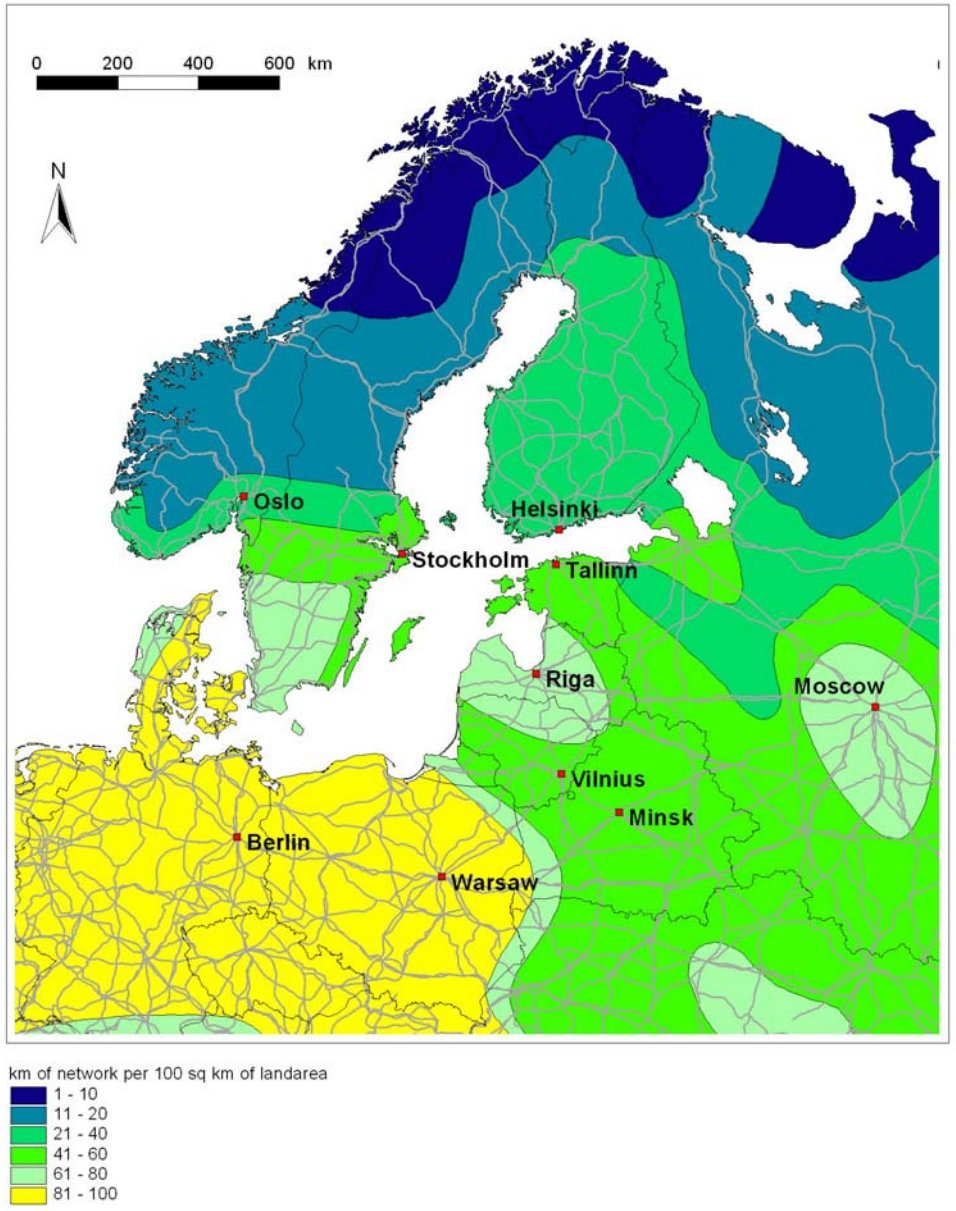
TRAFFIC DENSITY



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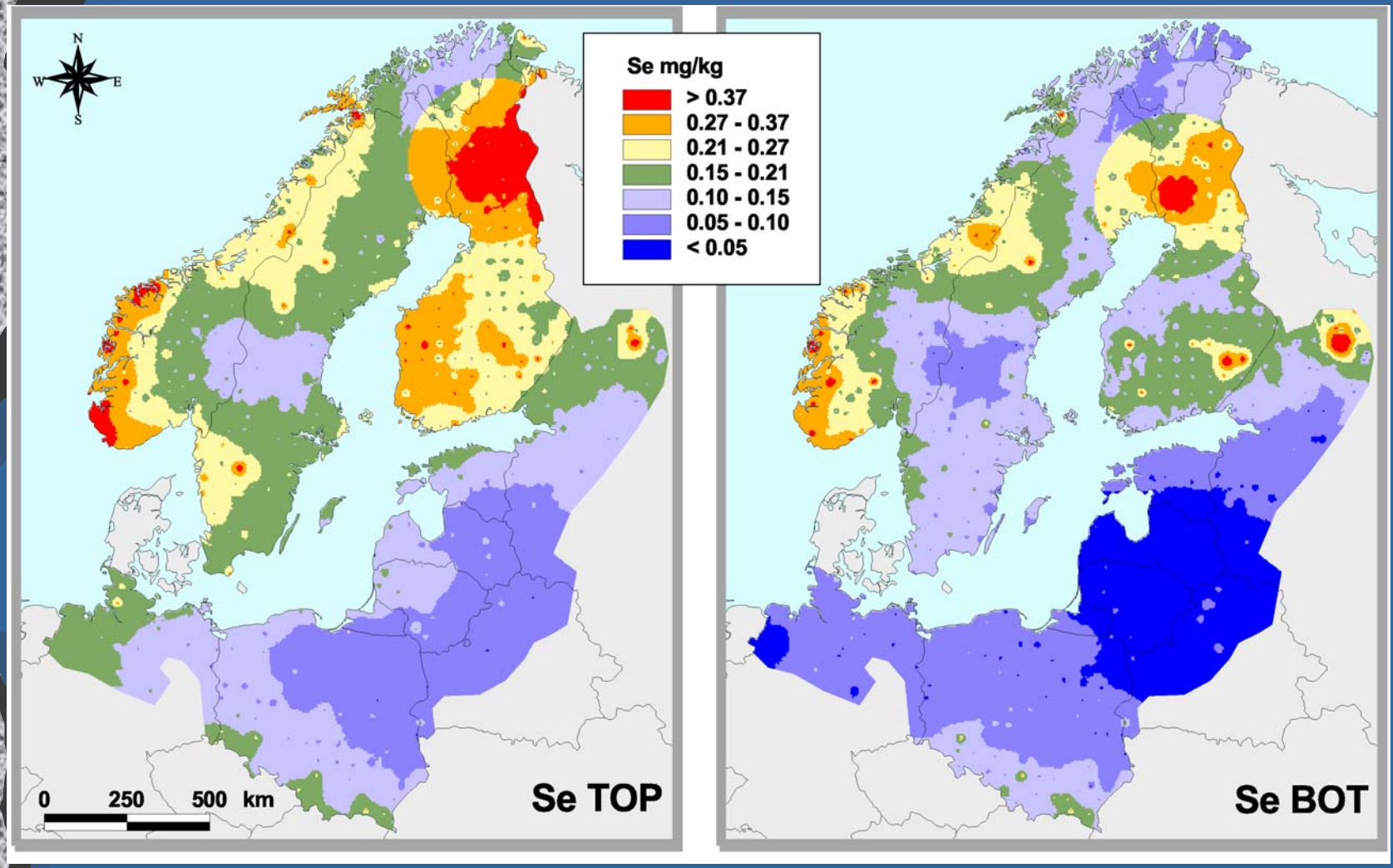
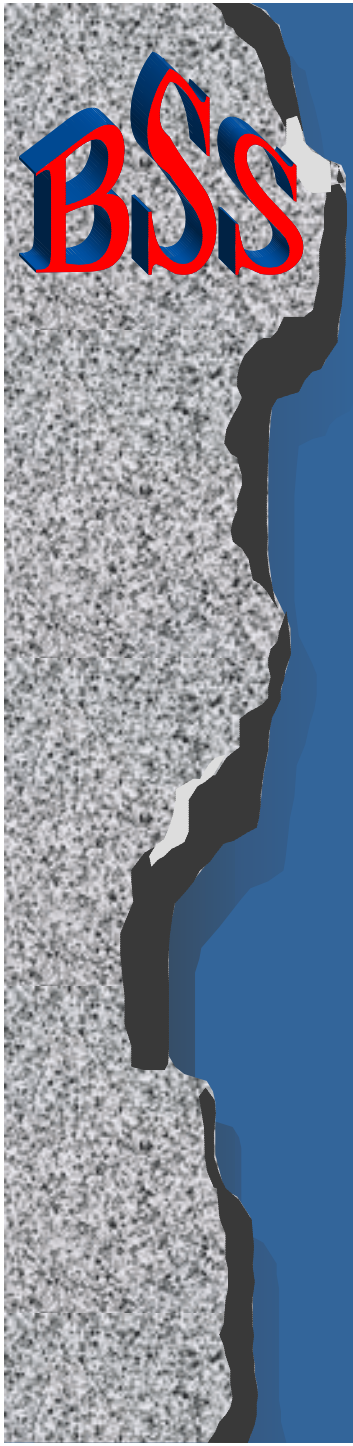
Se: influenced by: precipitation (Bergen), fertiliser (West vs. East Germany, Finland), organic material (Finland), black shales (Russia)





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Conclusions:

Maps for 42 elements + pH and Loss on ignition are presented in a geochemical atlas.

Large, regional scale geochemical patterns emerge, caused by a variety of processes.

Major differences (up to a factor of 12) even for the median element concentration are found between the 10 countries.

Agricultural soils from the three Nordic countries (Finland, Norway, Sweden) show by far the highest NATURAL concentrations for many elements.

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CONCLUSIONS:

9 elements and loss on ignition are generally enriched in the TOP-layer: S (4x) >> Cd >> P > LOI = Se (1.8x) > Pb > Zn > Bi > Sb > Mn (1.2x)

This enrichment is mostly due to natural processes.

On the sub-continental-scale human influence on the regional element distribution is surprisingly small.

Climate has a much larger influence on the regional scale distribution patterns than lithology.