The FOREGS multi-media geochemical atlas

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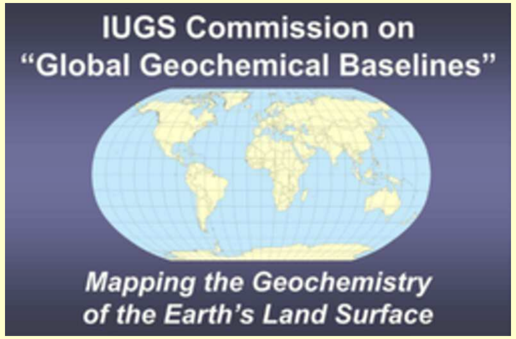
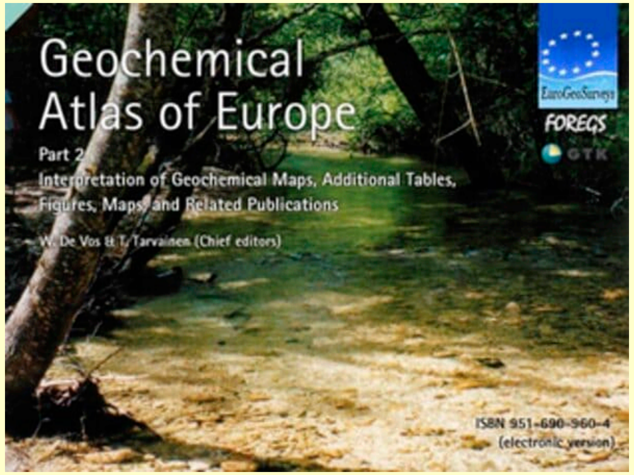


IUGS
International Union of Geological Sciences



EuroGeoSurveys
European Geoscience for Society
The Geological Surveys of Europe

FOREGS
Forum of the European Geological Surveys Directors

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Abbreviations of organisations

IGCP = UNESCO's International Geological Correlation Programme [259 & 360] – now International Geoscience Programme

IUGS = International Union of Geological Sciences

IAGC = International Association of GeoChemistry

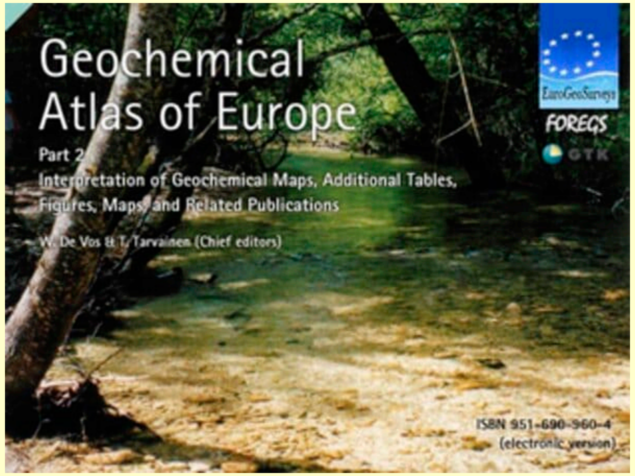
WEGS = Western European Geological Surveys

FOREGS = Forum of European Geological Surveys Directors [*former* Western European Geological Surveys, WEGS]

EGS = EuroGeoSurveys – Association of European Geological Surveys (since October 2005 has incorporated FOREGS)

Structure of Webinar

- Introduction
- 1986: First proposal for the multi-sample media sampling of Western Europe
- 1988: IGCP 259 “International Geochemical Mapping”
- 1993: Second proposal for the multi-sample media sampling of W. Europe
- 1995: Final report of IGCP 259 “International Geochemical Mapping”
- 1996: Third proposal for the multi-sample media sampling of Europe
- 1996: Director’s decision for the FOREGS Geochemical Mapping of Europe
- 1997-2006: FOREGS Geochemical Mapping of Europe
- Concluding remarks
- Synopsis and References



FOREGS
Forum of the European Geological Surveys Directors

IUGS Commission on “Global Geochemical Baselines”
Mapping the Geochemistry of the Earth’s Land Surface

EUROGEOSURVEYS
European Geoscience for Society
The Geological Surveys of Europe

IUGS
International Union of Geological Sciences

The Global Problem: Humans, since their appearance on earth, are modifying the natural environment in their attempt to live more comfortably. We have now reached a stage that ***our life support systems are in danger.***

https://learncomrades.com/evolution-of-human-beings/

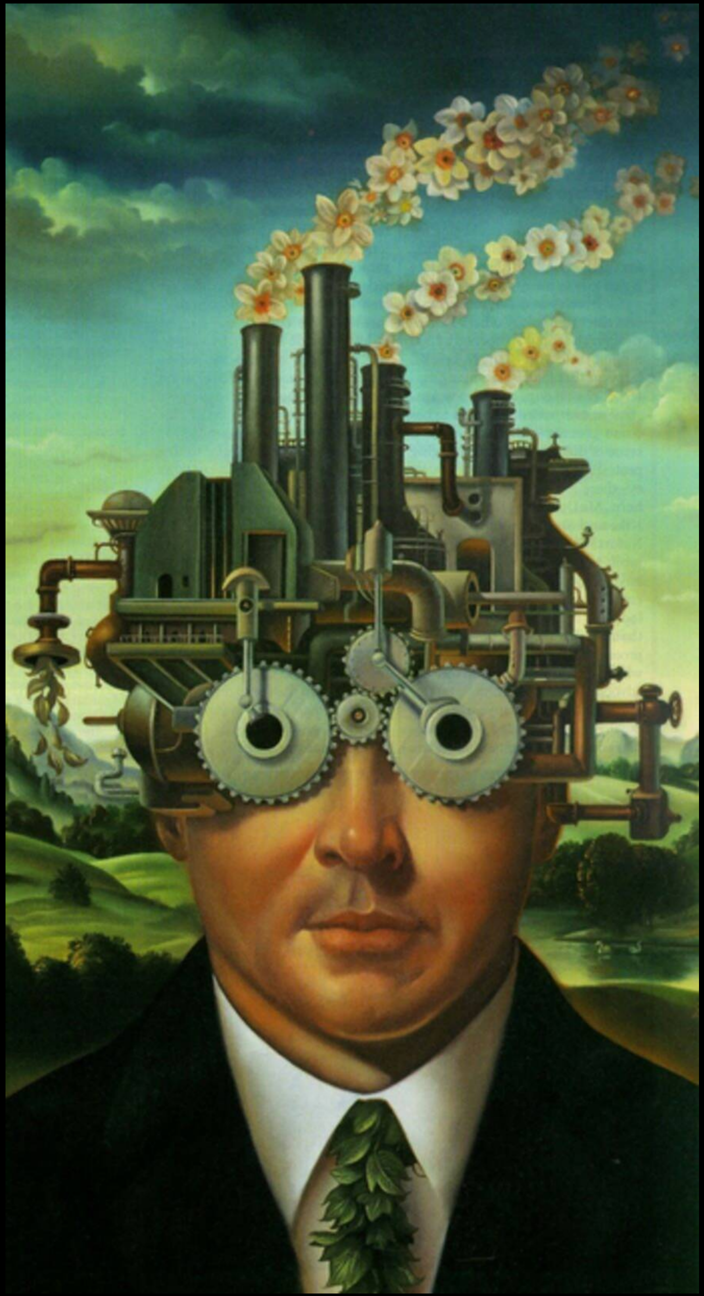
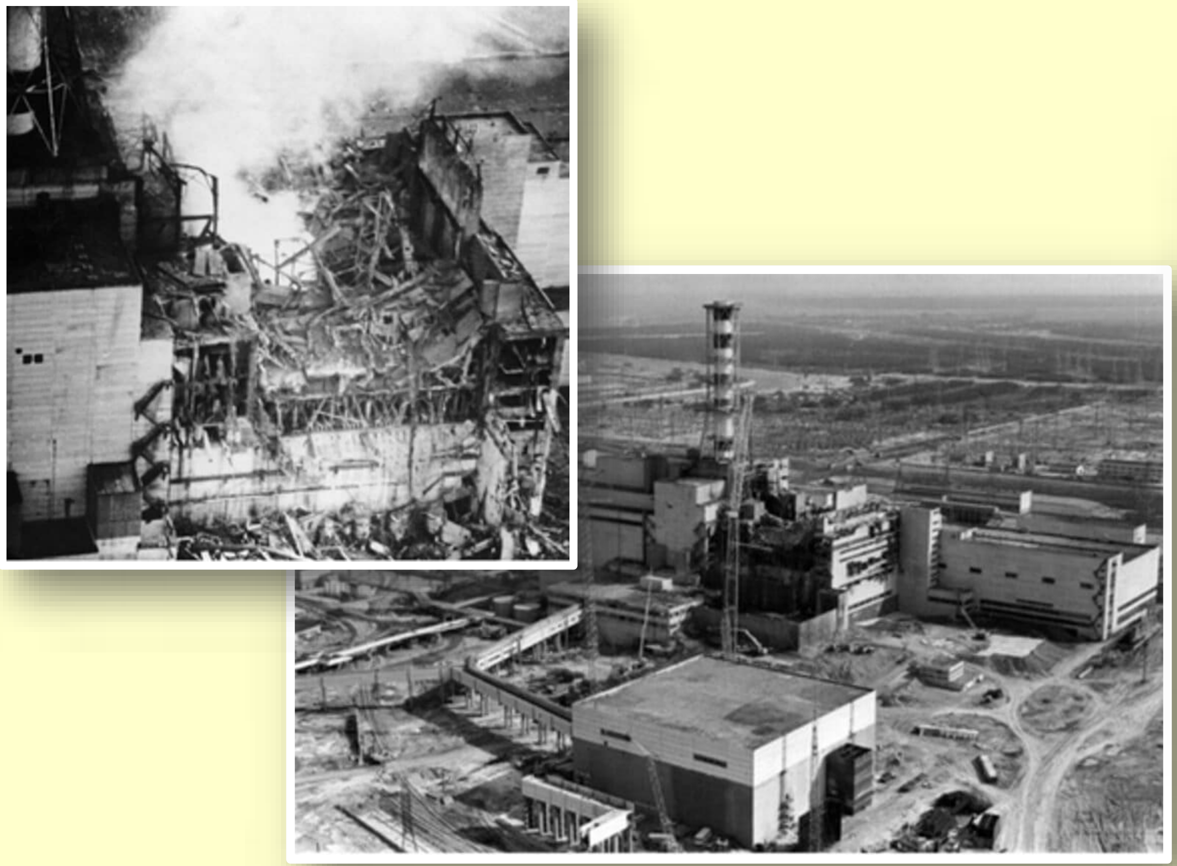


Image: David M. Bowers

Chernobyl nuclear reactor 4
26 April 1986

The Chernobyl accident awakened the most extreme environmental hazard: "*nuclear catastrophe*"!!!



Young victim

Far-reaching consequences

In October 1989, a local woman holds up a disabled newborn pig, victim of the radioactive fallout.

https://www.cbsnews.com/pictures/horrifying-photos-of-chernobyl-and-its-aftermath/13/

1986
WEGS Working Group on
"*Regional Geochemical Mapping*"

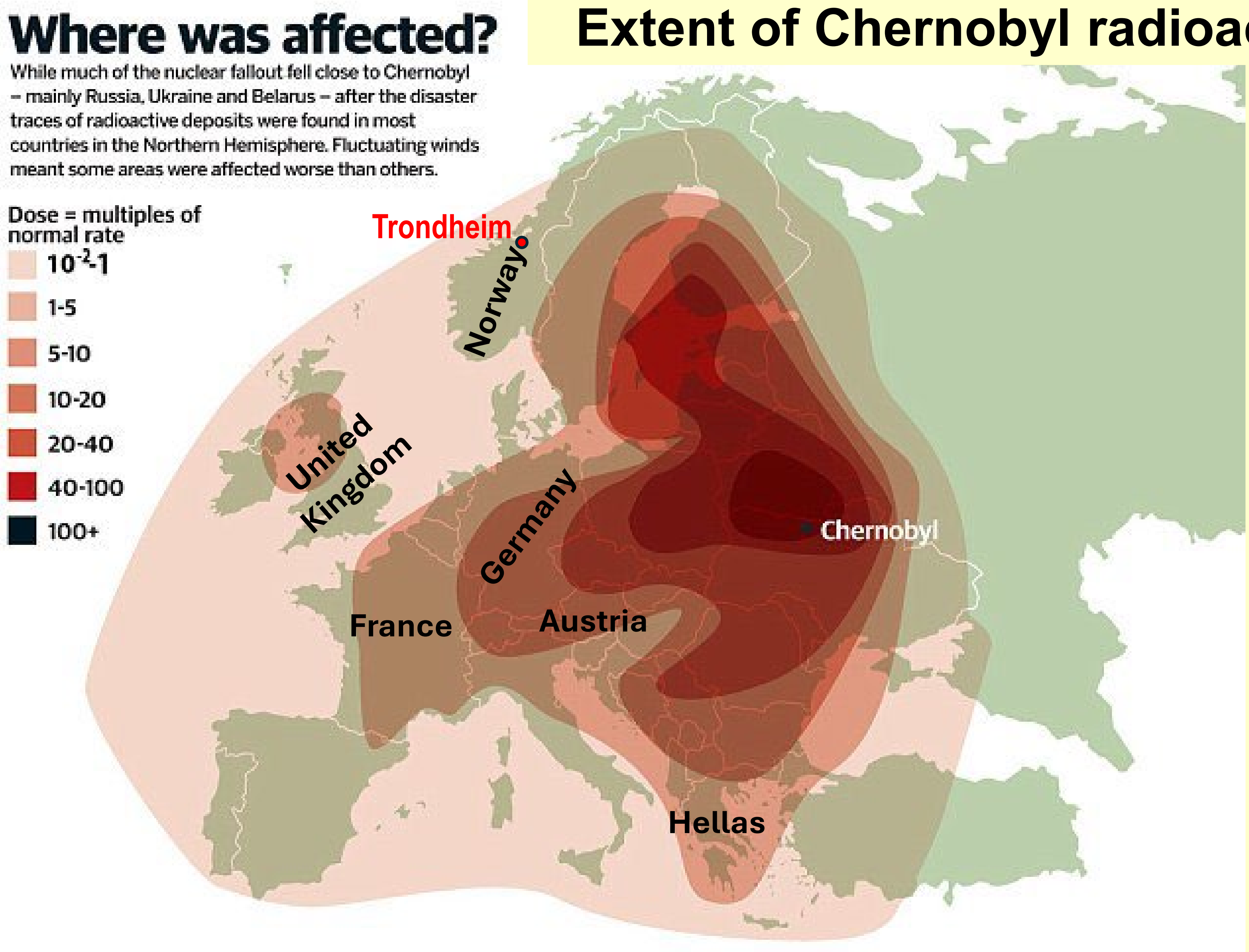
Members of the WEGS Working Group on "*Regional Geochemical Mapping*" from Norway, Austria, France, F.R. Germany, Hellenic Republic and United Kingdom met in Trondheim, Norway, on the 21-22 May 1986.

The Chernobyl accident was discussed, and it was concluded that geochemical data were not available in Europe to assess the impact on the surface environment caused by the Chernobyl accident.

Hence, a proposal was submitted to the WEGS Directors for the multi-media Geochemical Mapping of the then Western Europe.

It is very interesting to first see the Official State handling of the Chernobyl radioactive cloud.

Extent of Chernobyl radioactive fallout



https://www.reddit.com/r/MapPorn/comments/t68bdy/map_showing_how_a_cloud_of_radiation_engulfed/#lightbox

The stories regarding the Official State handling of the Chernobyl accident from the:

- **German,**
- **Austrian,**
- **French,**
- **British and**
- **Hellene**

participants are interesting.

1986 Trondheim meeting project proposal

The following sample types were proposed to be collected at a sampling density of 1 sample station per 500 km^2:

- Surface water
- Ground water
- Surface soil
- Soil C-horizon, and
- Overbank sediment.

The total area of the WEGS countries was 4,727,989 km^2, and the total number of samples for each type was 9,466.

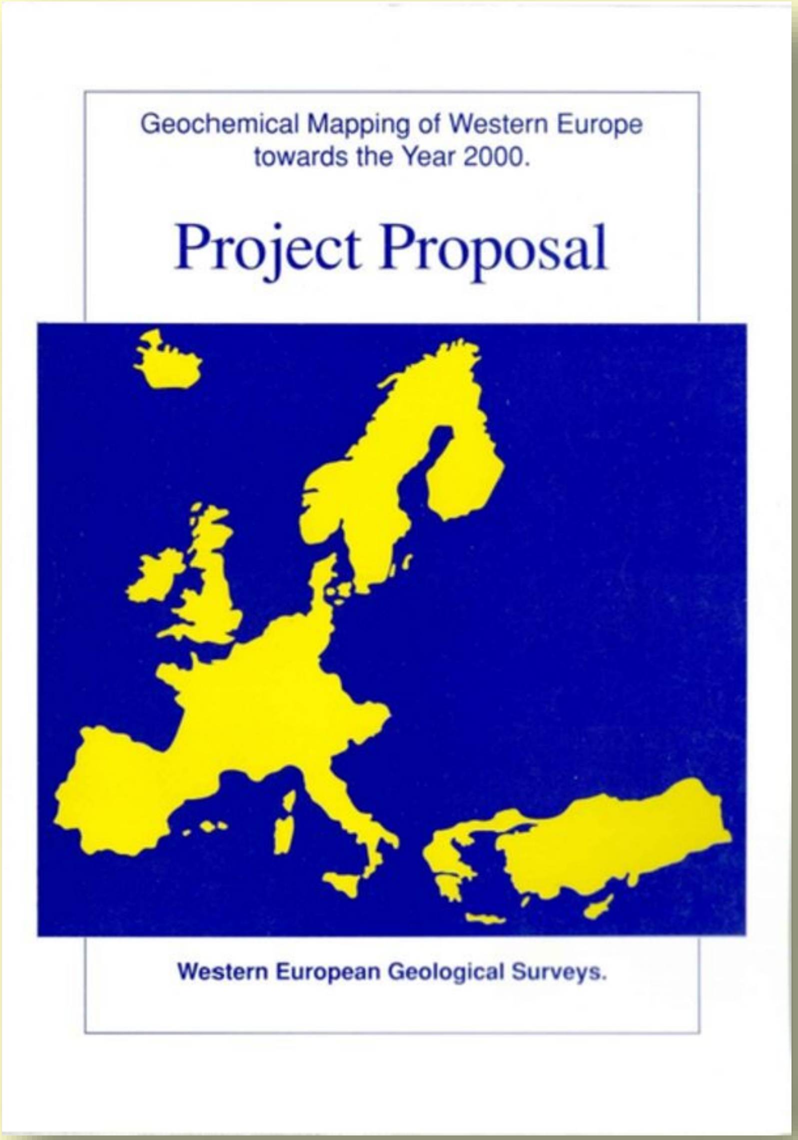
Bjørn Bølviken

Bjørn Bølviken, Chair of the WEGS Group, offered to analyse all collected samples free of charge and also to provide financial assistance to countries that had problems.

This was a ***one-of-a-lifetime offer***, which, unfortunately, the WEGS Directors did not take up.

1990 Pilot Project Report and Project Proposal

It is worth studying these two reports.



I.G.C.P. 259

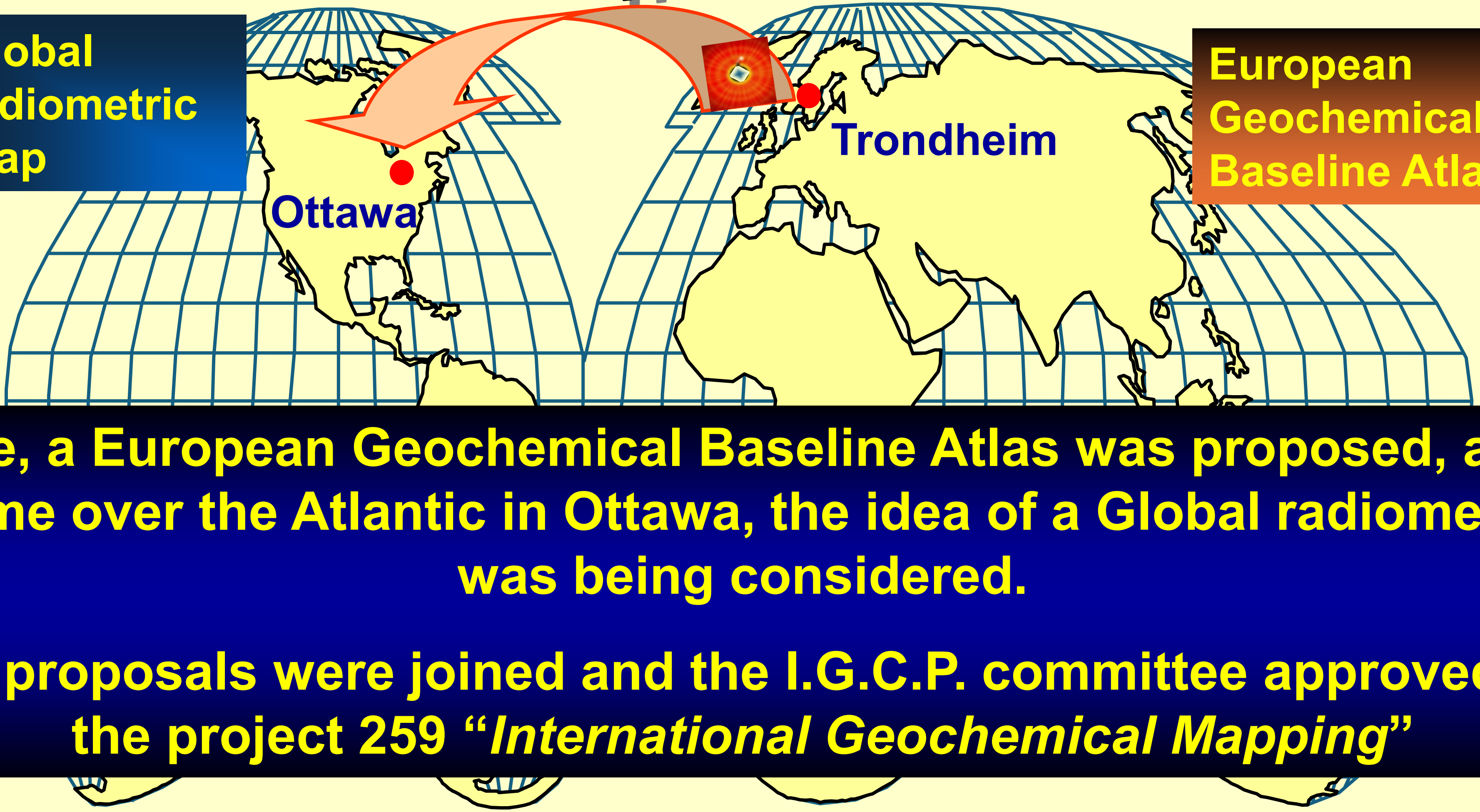
W.E.G.S.

1988 International Geochemical Mapping

1986 Geochemical Mapping of Europe

Arthur G. Darnley

Global radiometric map



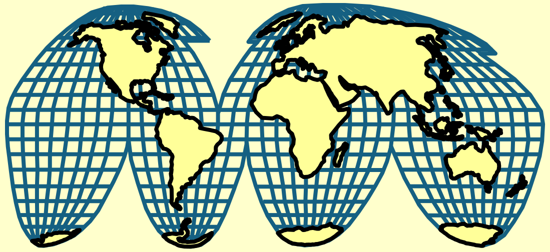
European Geochemical Baseline Atlas

Bjørn Bølviken

In Europe, a European Geochemical Baseline Atlas was proposed, and at the same time over the Atlantic in Ottawa, the idea of a Global radiometric map was being considered.

The two proposals were joined and the I.G.C.P. committee approved in 1988 the project 259 "*International Geochemical Mapping*"

Concise history of activities



in the development of methodology

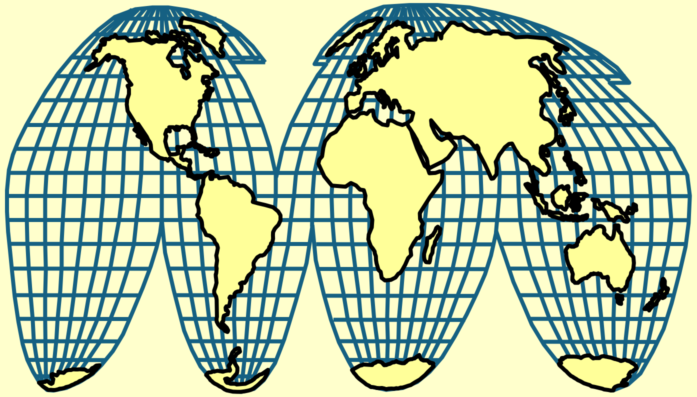
Geochemists map the globe

IGCP, IAGC, IUGS				
	Phase I:	IGCP 259	"International Geochemical Mapping"	1988-1992
	Phase II:	IGCP 360	"Global Geochemical Baselines"	1993-1997
	Phase III:	IUGS/IAGC	"Global Geochemical Baselines"	1998-2016
	Phase IV:	IUGS	"Global Geochemical Baselines"	2016-

WEGS, FOREGS, EGS		
	1986-1993:	Pilot & Research phases (WEGS-FOREGS)
	1994-1996:	Discussion and decision phase (FOREGS)
	1997-2006:	Planning, Training and Execution (FOREGS-EGS)

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

IUGS
International Union of Geological Sciences



IUGS Commission on
"Global Geochemical Baselines"

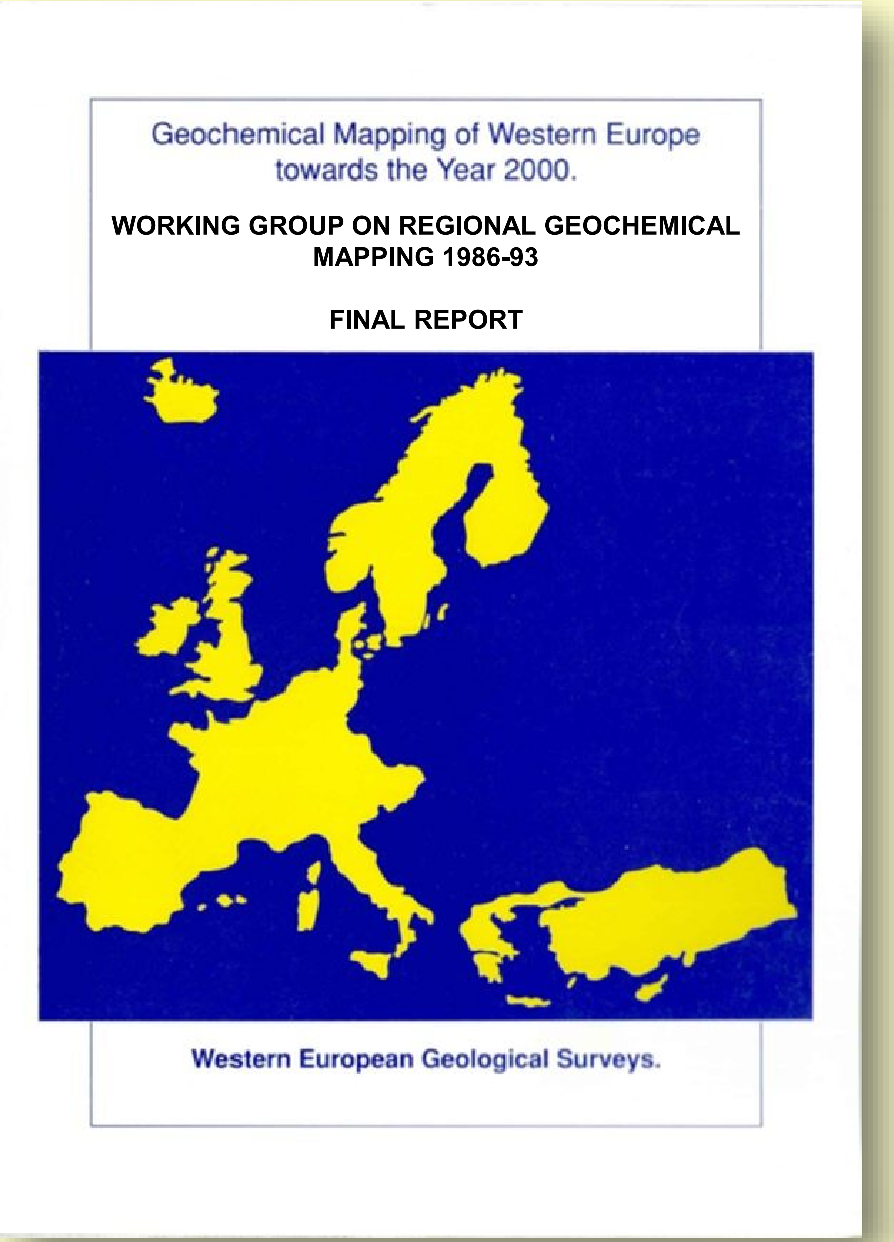
Mapping the Geochemistry of the Earth's Land Surface

Geochemists map the globe

Overall objective:

To establish a harmonised Global multi-purpose, multi-national applications primary multi-element & multi-sampling media geochemical database.

1993 Final Report and Project Proposal

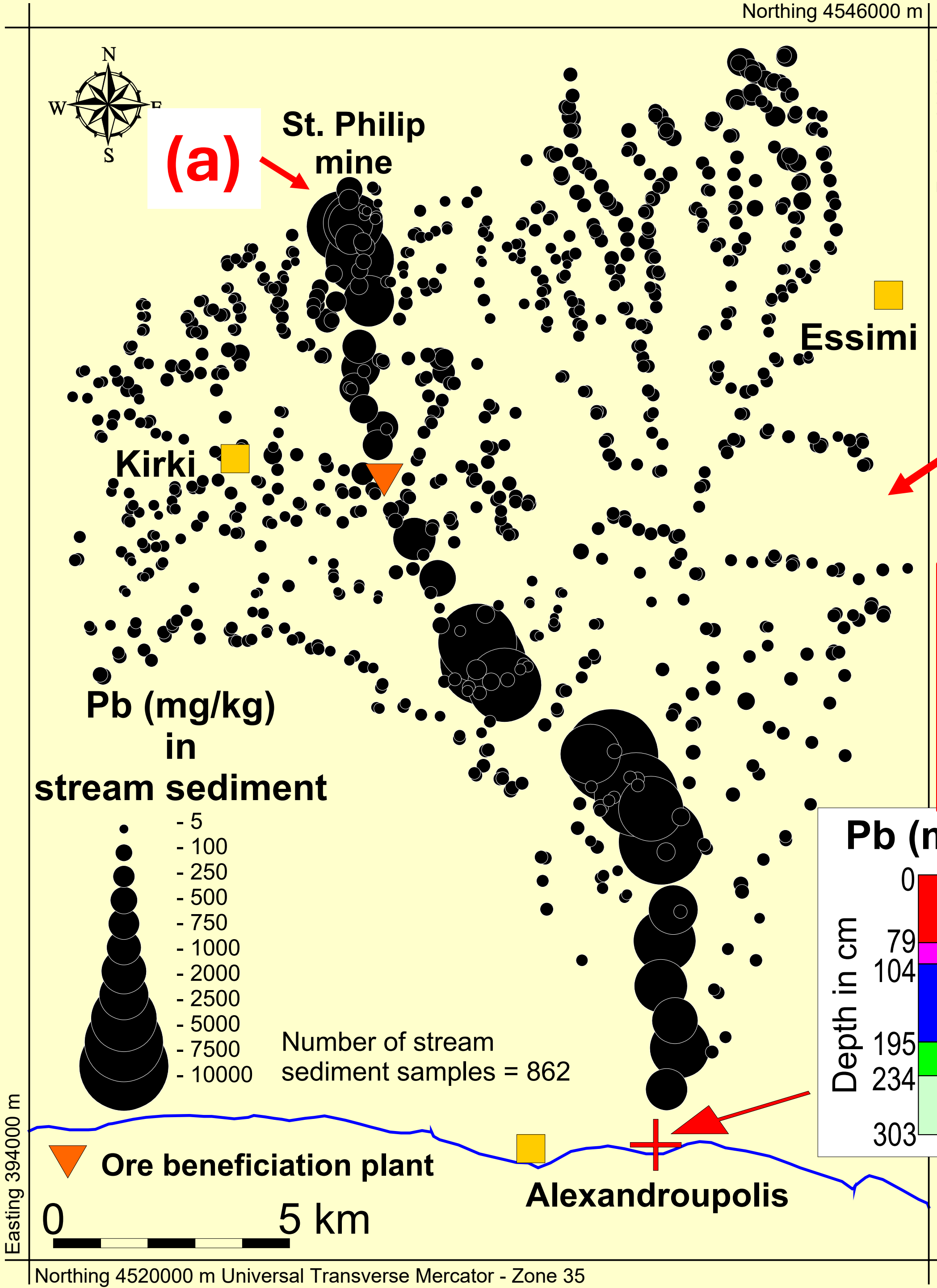


The WEGS Working Group on Regional Geochemical Mapping final proposal was the collection of the following sample types:

- An active stream sediment;
- A surficial overbank sediment, and
- A deep pre-industrial overbank sediment,

at an average density of 1 sample site per 500 km^2, each site representing a catchment area, the size of which should be between 60 to 600 km^2.

Why we proposed the sampling of overbank sediment?



Geochemical history of a drainage basin

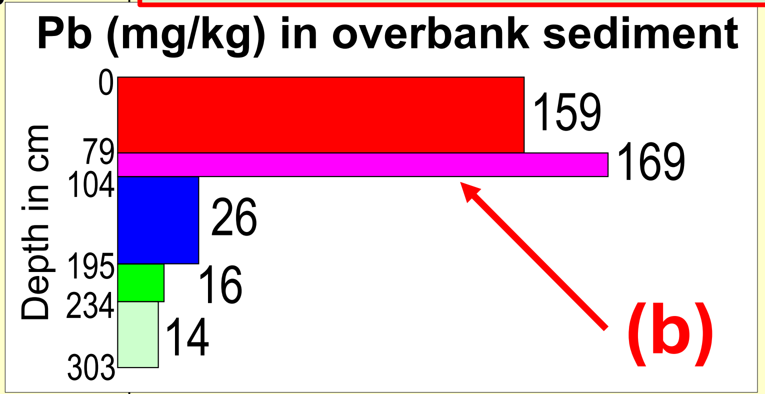


Figure 3.5.4 on page 264 of Manual. (Source: Demetriades, 2014, Fig. 8, p.14; WEGS Pilot project).

Distribution of Pb in the <0.180 mm reconnaissance stream sediment fraction, and the <0.063 mm fraction of overbank/floodplain sediment layers, Irene River, Thrace, N.E. Hellas (25.902°E, 40.848°N).

Observe:

(a) The contamination train in the stream sediment samples from the St. Philip mine and ore beneficiation plant, and

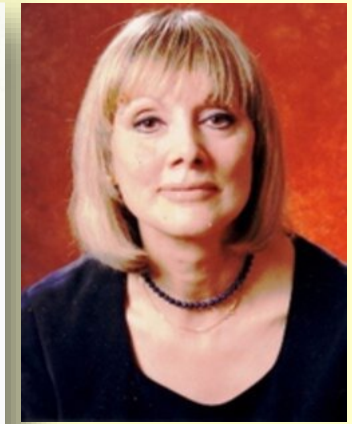
(b) The two surface layers of overbank sediment that show contamination, and the lower layers, which tend towards background conditions.

FOREGS Directors decision


Forum of European Geological Surveys
FOREGS
Geochemistry Task Group
1994–1996
Report

A contribution to IUGS Continental Geochemical Baselines

BGS Technical Report WP/95/14
British Geological Survey


Prof. Jane Plant

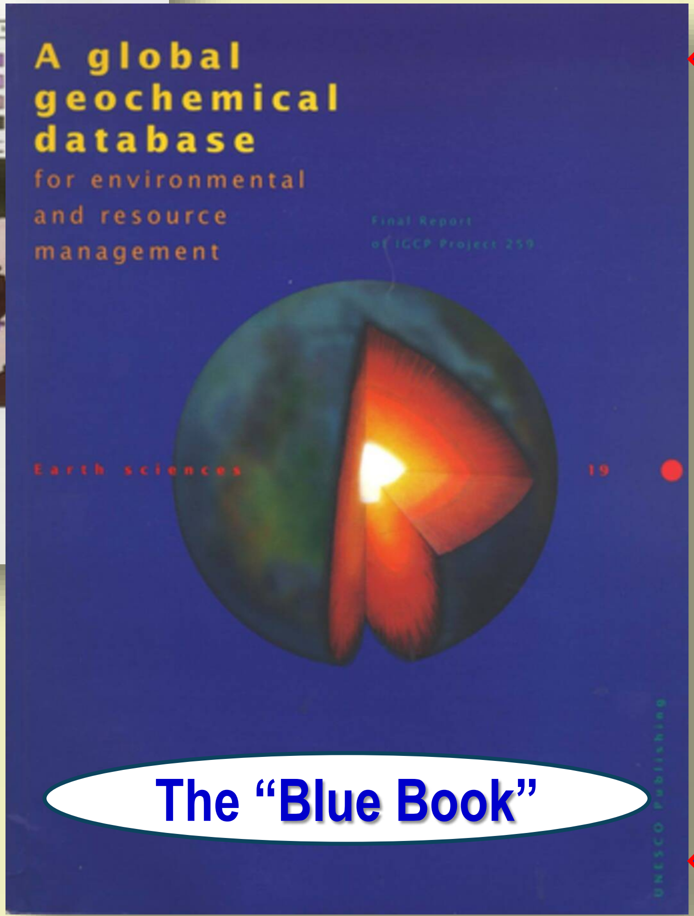
The FOREGS Directors established in 1994 a Geochemistry Task Group, chaired by Professor Jane Plant (British Geological Survey), with the mandate to compile an inventory of regional geochemical mapping projects in Europe and to submit its proposal.

It is noted that the WEGS Regional Geochemistry Working Group has already compiled such an inventory, and was presented as Appendix 10 in the Pilot Project Report.

So, what was the reason for repeating this exercise? **This is the one-million-euro question. The FOREGS Directors were stalling. Why? Answer: *Factual knowledge is difficult to handle in political decision-making.***

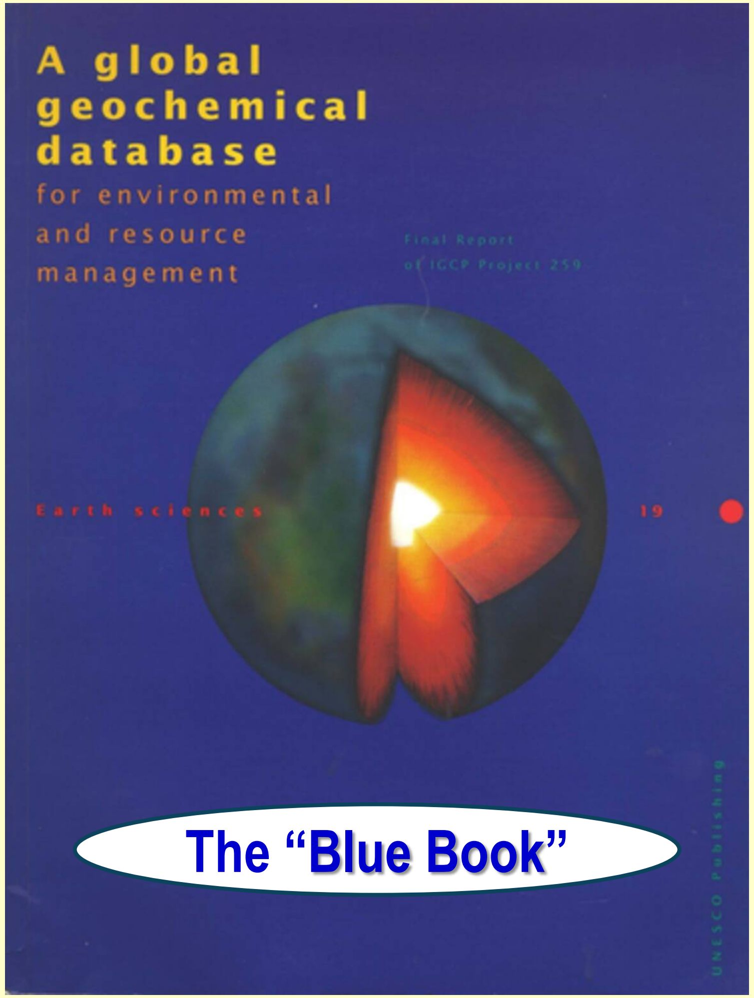
EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

The impetus for continental-scale geochemical mapping



Fortunately, the final report of the IGCP 259 project "*International Geochemical Mapping*" was published in 1995, and it has given all the necessary reasons supporting the ***compilation of a harmonised global geochemical database for environmental and resource management***.

The following timeless statements from Darnley *et al*. (1995, p.x) explain the reasons why the harmonised systematic geochemical mapping of our home planet Earth is absolutely necessary:



"*Everything in and on earth - mineral, animal and vegetable - is made from one, or generally some combination of, the 86 naturally occurring chemical elements. Everything that is grown, or made, depends upon the availability of the appropriate elements. The existence, quality and survival of life depends upon the availability of elements in the correct proportions and combinations. …….*

Because natural processes, and human activities, are continuously modifying the chemical composition of our environment, it is important to determine the present abundance, and spatial distribution, of the elements across the Earth's surface in a much more systematic manner that has hitherto been attempted."

FOREGS Directors decision

Prof. Reijo Salminen

The FOREGS Directors finally decided in 1996 to approve the continental-scale geochemical mapping of Europe, and to establish the FOREGS Geochemistry Working Group, chaired by Prof. Reijo Salminen from the Geological Survey of Finland.

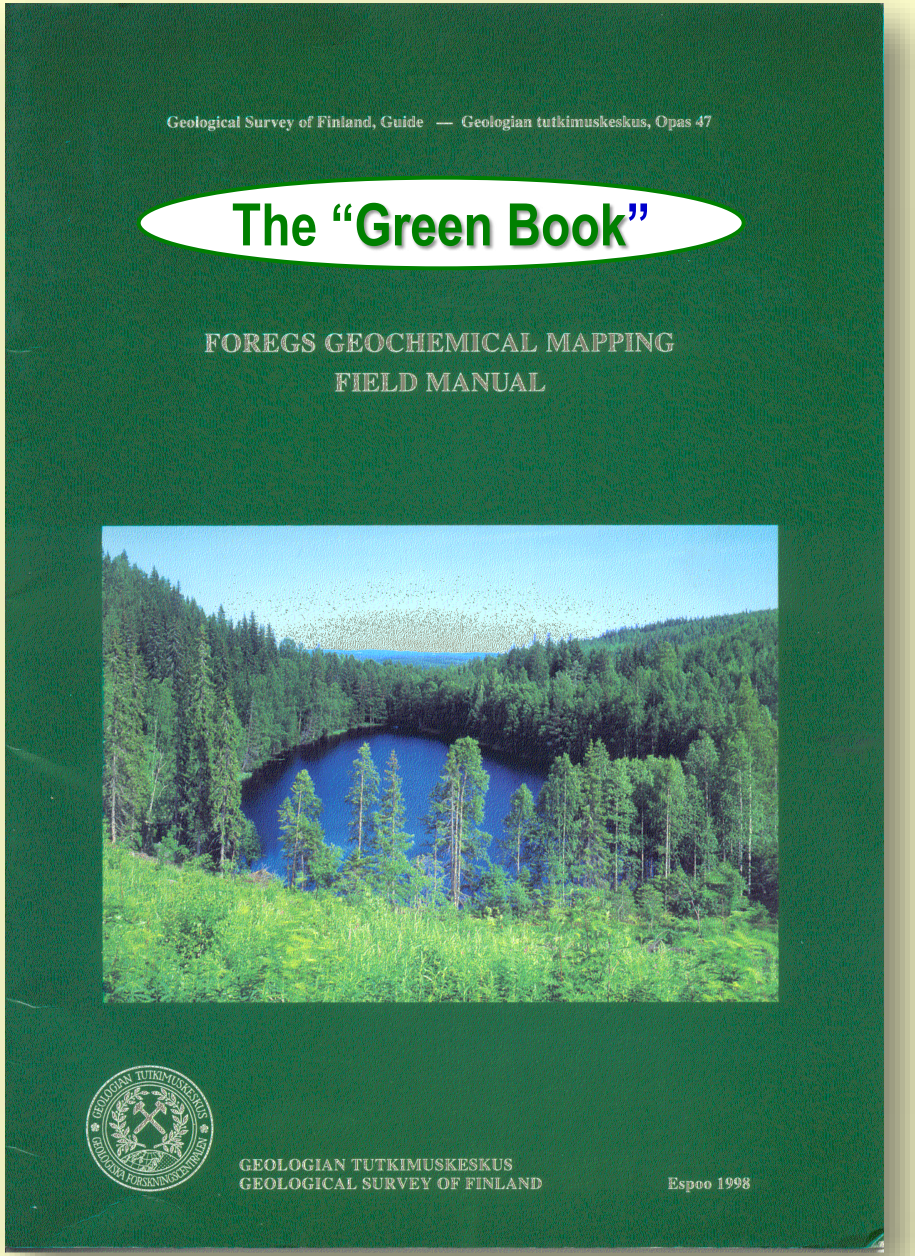
First action: Prof. Salminen sent a letter to the Directors of all the European Geological Surveys asking them to sign a declaration that their country will participate in the project of the FOREGS Geochemical Mapping of Europe, according to "Blue Book" recommendations. In total, 26 countries replied positively.

Second action: Compilation in the office of the first draft of the ***Field Sampling Manual***.

Kick-off meeting at Limbach (Slovakia) in June 1997

In total, 26 applied geochemists participated in the field testing of the **FOREGS Field Sampling Manual**:

Chair: Prof. Reijo Salminen	Finland	Dr. Maurizio Tarzia	Italy
Secretary: Ms. Fiona Fordyce	UK	Mr. Ricardas Budavicius	Lithuania
Dr. Peter Klein	Austria	Ms. Virgilija Gregorauskiene	Lithuania
Dr. Albert Schedl	Austria	Ms. Evelina Kliaugiene	Lithuania
Dr. Otmar Scherman	Austria	Dr. Öystein Jäger	Norway
Mr. Jan Van der Sluys	Belgium	Dr. Clemens Reimann	Norway
Dr. Miloslav Duris	Czech Republic	Dr. Anna Pasiecsna	Poland
Dr. Agnete Steenfelt	Denmark	Dr. Maria Joáo Batista	Portugal
Dr. Ignace Salpeteur	France	Dr. Karol Marsina	Slovak Republic
Mr. Alecos Demetriades	Greece	Dr. Hanna Mjartanova	Slovak Republic
Dr. László Odór	Hungary	Dr. Ján Curlik	Slovakia
Dr. Marco Canepa	Italy	Mr. Sten-Åke Ohlsson	Sweden
Dr. Pietro Frizzo	Italy		



At Limbach (Slovakia) all the sampling methods were tested in actual field conditions, and the descriptions refined.

The FOREGS Geochemical Mapping Field Manual

was published in 1998

Salminen, Tarvainen *et al*., 1998. *FOREGS Geochemical Mapping, Field Manual*. Geological Survey of Finland, Espoo. Guide Number 47.

It is mainly for temperate and Mediterranean terrains

URL: http://tupa.gtk.fi/julkaisu/opas/op_047.pdf

Overall objectives of the FOREGS Continental-scale Geochemical Mapping of Europe

- **Collect, store and analyse several sampling materials from the Global Terrestrial Network (GTN) cells.**
- **Standardise national geochemical mapping data sets across national boundaries.**
- **Show the actual situation of element concentrations - the geochemical baseline - within Europe, *i.e.*, the Geochemical Atlas of Europe.**
- **A common database available to every country.**
- **Promote follow-up work at the national and local level.**
- **A tool for European Union policy- and decision-making.**
- **European contribution to the work being carried out by the IUGS Commission on *Global Geochemical Baselines*.**

Production of High Quality Harmonised Geochemical Databases at any mapping scale

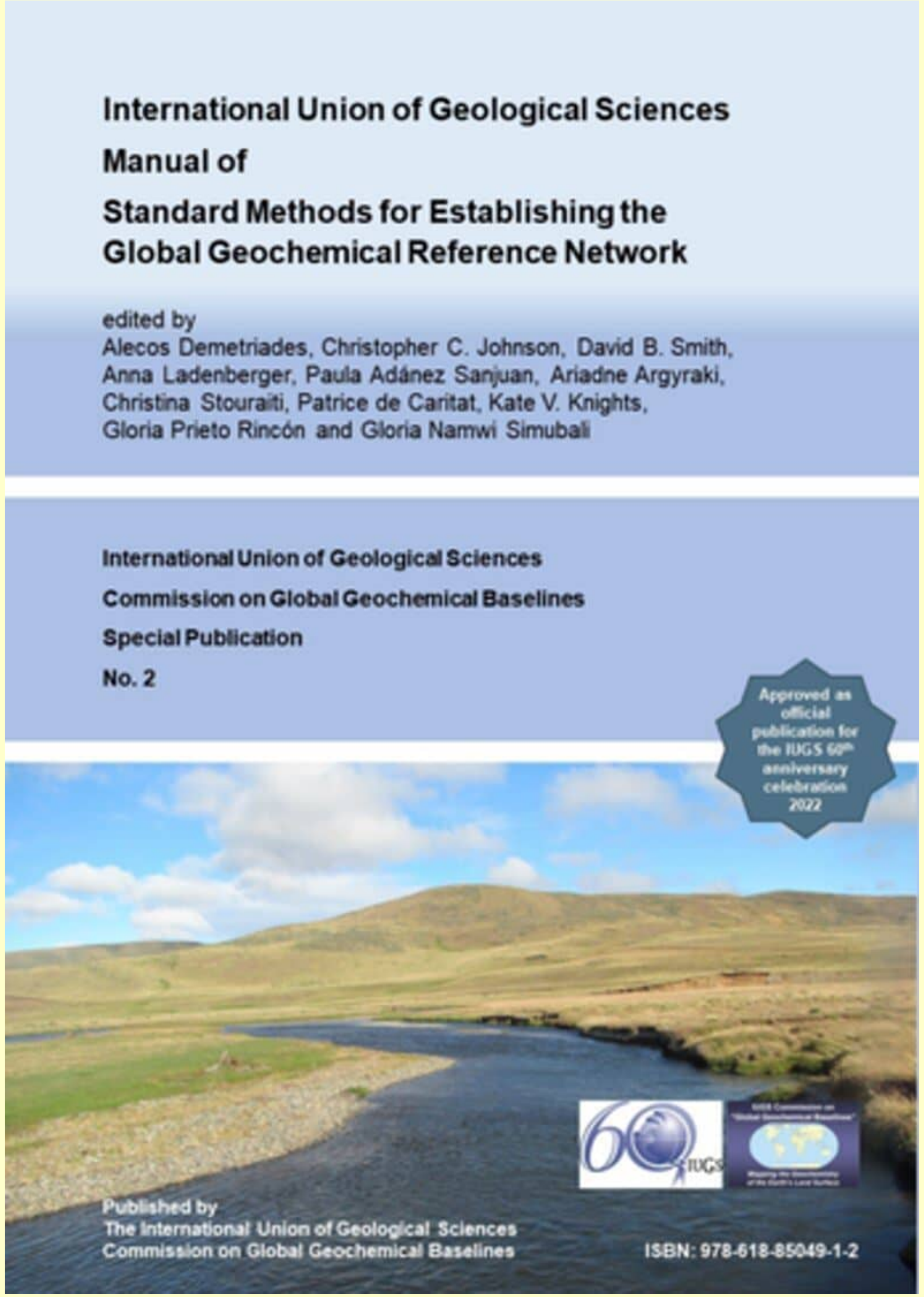
Sampling

Sample preparation

- These are the two most crucial stages of any geochemical survey.
- Any errors during these two stages is carried forward, and can result in the failure of the whole survey.

Laboratory analysis

- Errors can be corrected by re-analysis of samples, provided enough sample material is available.



The diagrams in the following slides come from:-

Demetriades, A., Johnson, C.C., Smith, D.B., Ladenberger, A., Adánez Sanjuan, P., Argyraki, A., Stouraiti, C., Caritat, P. de, Knights, K.V., Prieto Rincón, G. & Simubali, G.N. (Editors), 2022. *International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network*. IUGS Commission on Global Geochemical Baselines, Athens, Hellenic Republic, Special Publication, 2, xliv, 515 pages, 375 figures, 35 Tables, 5 Annexes and 1 Appendix, ISBN: 978-618-85049-1-2; https://doi.org/10.5281/zenodo.7307696. Further information about this Manual is available at the relevant web page: https://www.globalgeochemicalbaselines.eu/content/174/iugs-manual-of-standard-methods-for-establishing-the-global-geochemical-reference-network-/.

This publication replaced the **FOREGS Geochemical Mapping Field Manual.**

Global Reference Network (GRN) grid cells of 160x160 km = Global Terrestrial Network (GTN) + Global Marine Network (GMN)

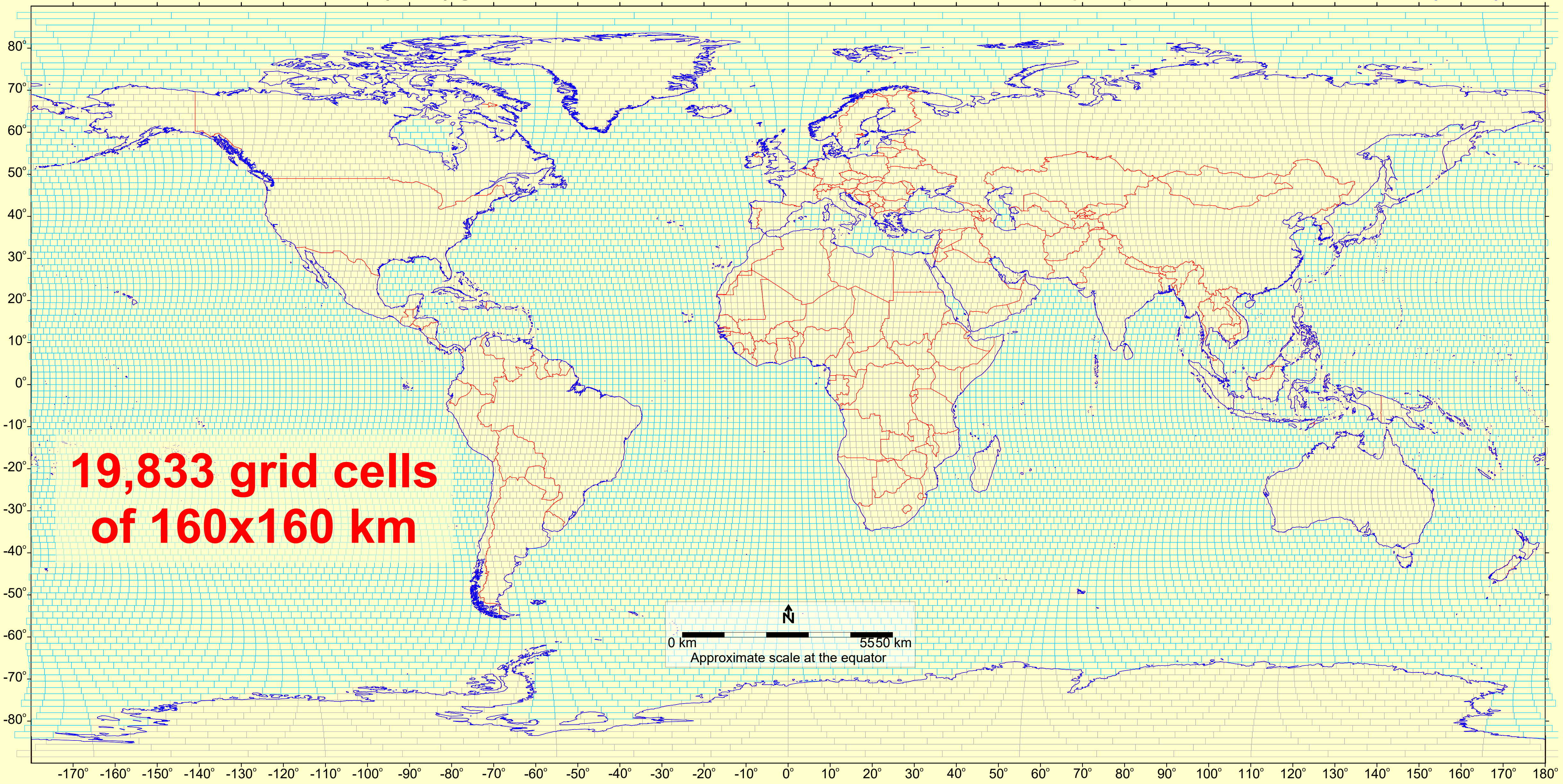


Figure 2.1 on page 16. The Global Reference Network (GRN) grid cells consist of the Global Terrestrial Network (GTN) and Global Marine Network (GMN) grid cells. The nominal size of each 160x160 km grid cell is defined by two parallels of latitude 1½° (approx. 166 km) apart, and two meridians. In order to retain a constant area, the grid cells are systematically displaced in longitude East and West in successive latitudinal bands. Drawn with Golden Software's Surfer™ v21 by Alecos Demetriades, Hellenic Institute of Geology and Mineral Exploration (IGME) & IUGS Commission on Global Geochemical Baselines (IUGS-CGGB).

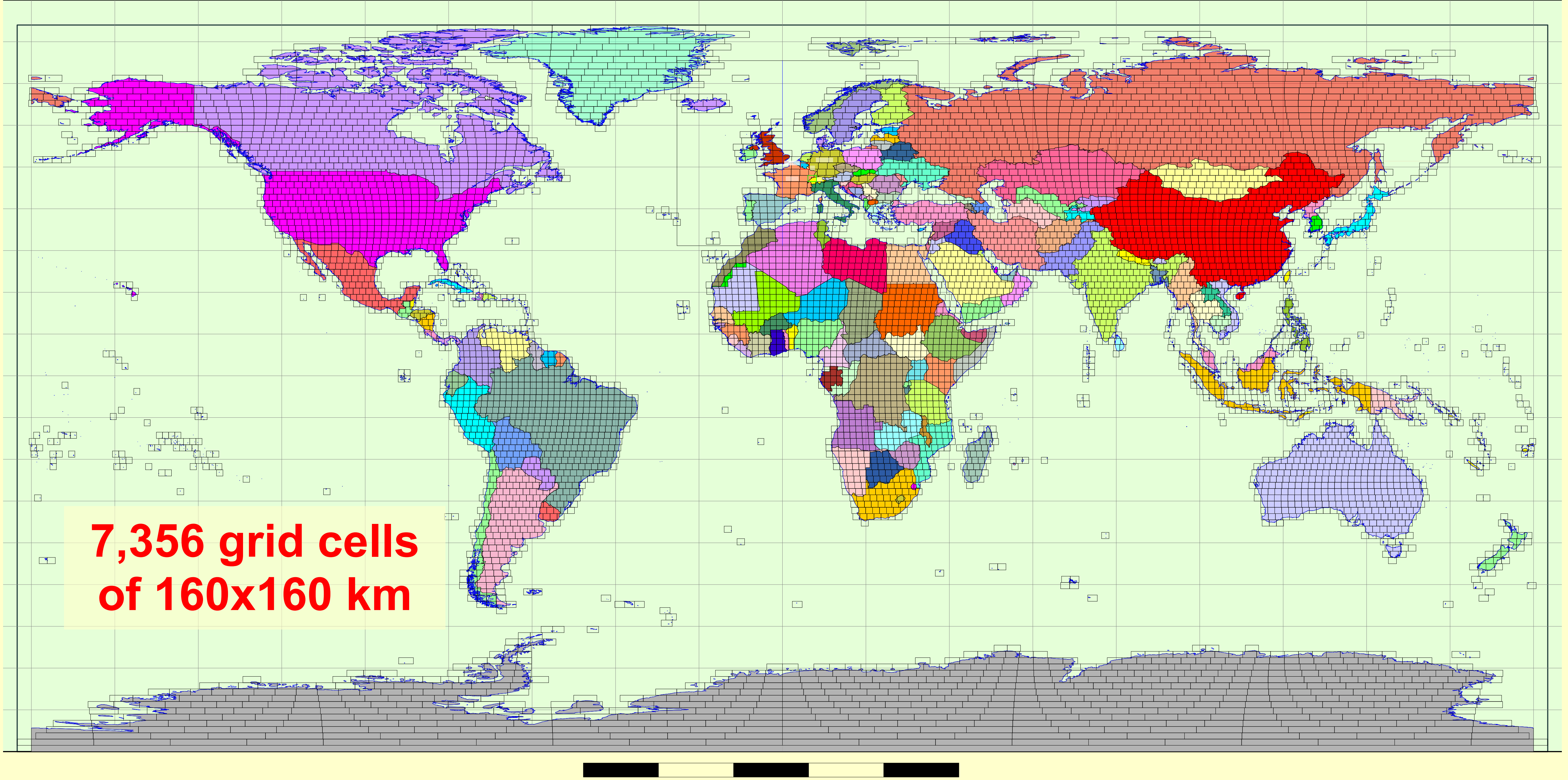
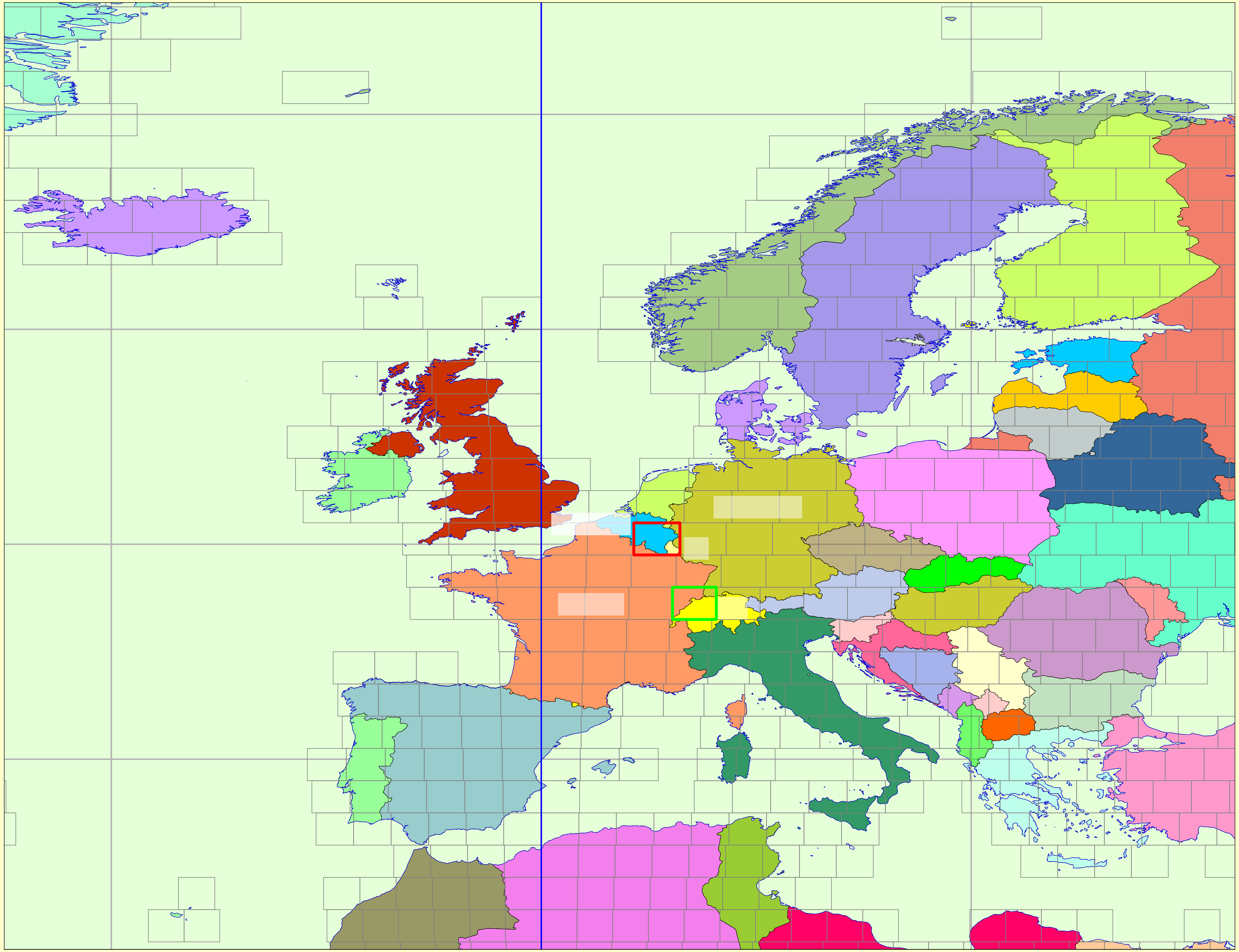


Figure 2.2 on page 17. The 7356 Global Terrestrial Network (GTN) grid cells cover the entire land surface of the Earth, including islands. The nominal size of each 160x160 km grid cell is defined by two parallels of latitude 1½º (approx. 166 km) apart, and two meridians. For keeping a constant area, the grid cells are systematically displaced in longitude East and West in successive latitudinal bands. Drawn by Alecos Demetriades (IGME/IUGS-CGGB) with Golden Software's MapViewer™ v8.



Map showing the FOREGS Geochemical Atlas of Europe area and adjacent countries.

The coded numbers indicate the North-South and East-West GTN grid cell numbering system used in the Global Geochemical Reference Network project. The red colour-lined GTN grid cell N34E03 covers Belgium, Luxembourg (Lx), France and Germany, and the green colour-lined GTN grid cell N32E04 covers Switzerland (Sw), France and Germany. In the former case, Belgium is the coordinating country, and in the latter case is Switzerland. Refer to the text for an explanation.

(Figure 2.3 on page 18. Drawn by Alecos Demetriades (IGME/IUGS-CGGB) with Golden Software's MapViewer™ v8).

Sample identifier codes, and an example using GTN grid cell N26E14 and random site number 3. In red colour text, the sample types collected in the FOREGS project

(Table 2.1 on page 20. See Section §2.6, where there is a detailed explanation).

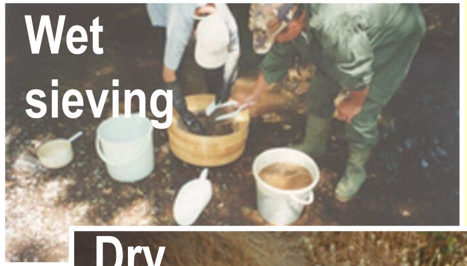
Catchment basin	Sample type	Code	Example
Second-order (<100 km²)	Rock (not collected in FOREGS pr.)	R	N26E14R3
	Residual soil – Top	T	N26E14T3
	Residual soil – Bottom	C	N26E14C3
	Humus (where present)	H	N26E14H3
	Stream water (where present)	W	N26E14W3
	Stream sediment (mineral sediment)	S	N26E14S3
	Overbank sediment – Top*	K	N26E14K3
	Overbank sediment – Bottom*	N	N26E14N3
Third-order (1000-6000 km²)	Floodplain sediment – Top	F	N26E14F3
	Floodplain sediment – Bottom*	L	N26E14L3

* Not collected in most of the FOREGS project countries

FOREGS sample types

Fieldwork was carried out from 1998 to 2002 as national projects

- **Stream water**
  - Unfiltered
  - Filtered

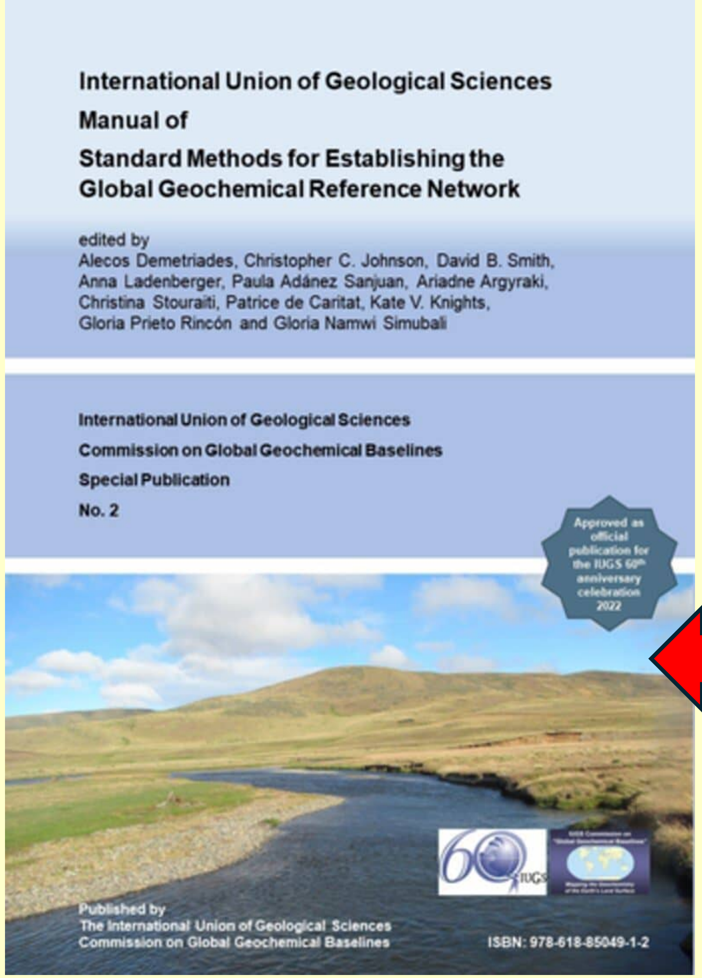


- **Stream sediment (minerogenic)**
  - Wet sieving
  - Dry sieving

- **Residual soil, top & bottom**

- **Humus**

- **Floodplain sediment**



International Union of Geological Sciences
Manual of
Standard Methods for Establishing the Global Geochemical Reference Network

edited by
Alecos Demetriades, Christopher C. Johnson, David B. Smith, Anna Ladenberger, Paula Adánez Sanjuan, Ariadne Argyraki, Christina Stouraiti, Patrice de Caritat, Kate V. Knights, Gloria Prieto Rincón and Gloria Namwi Simubali

International Union of Geological Sciences
Commission on Global Geochemical Baselines
Special Publication
No. 2

Approved as official publication for the IUGS 60th anniversary celebration 2022

Published by
The International Union of Geological Sciences
Commission on Global Geochemical Baselines

ISBN: 978-618-85049-1-2

For a detailed description of sampling methods consult the IUGS Manual of Standard Methods.

https://doi.org/10.5281/zenodo.7307696

For the generation of random sampling points consult the following publication:


R-scripts for Generation of 5, 8 and 16 Random Sampling Points Within Predefined Rectangles

Juanxia He and Xiaoyuan Geng

International Union of Geological Sciences
Commission on Global Geochemical Baselines
Special Publication
No. 3

Published by the International Union of Geological Sciences
Commission on Global Geochemical Baselines

ISBN: 978-618-85049-2-9

https://doi.org/10.5281/zenodo.7307202

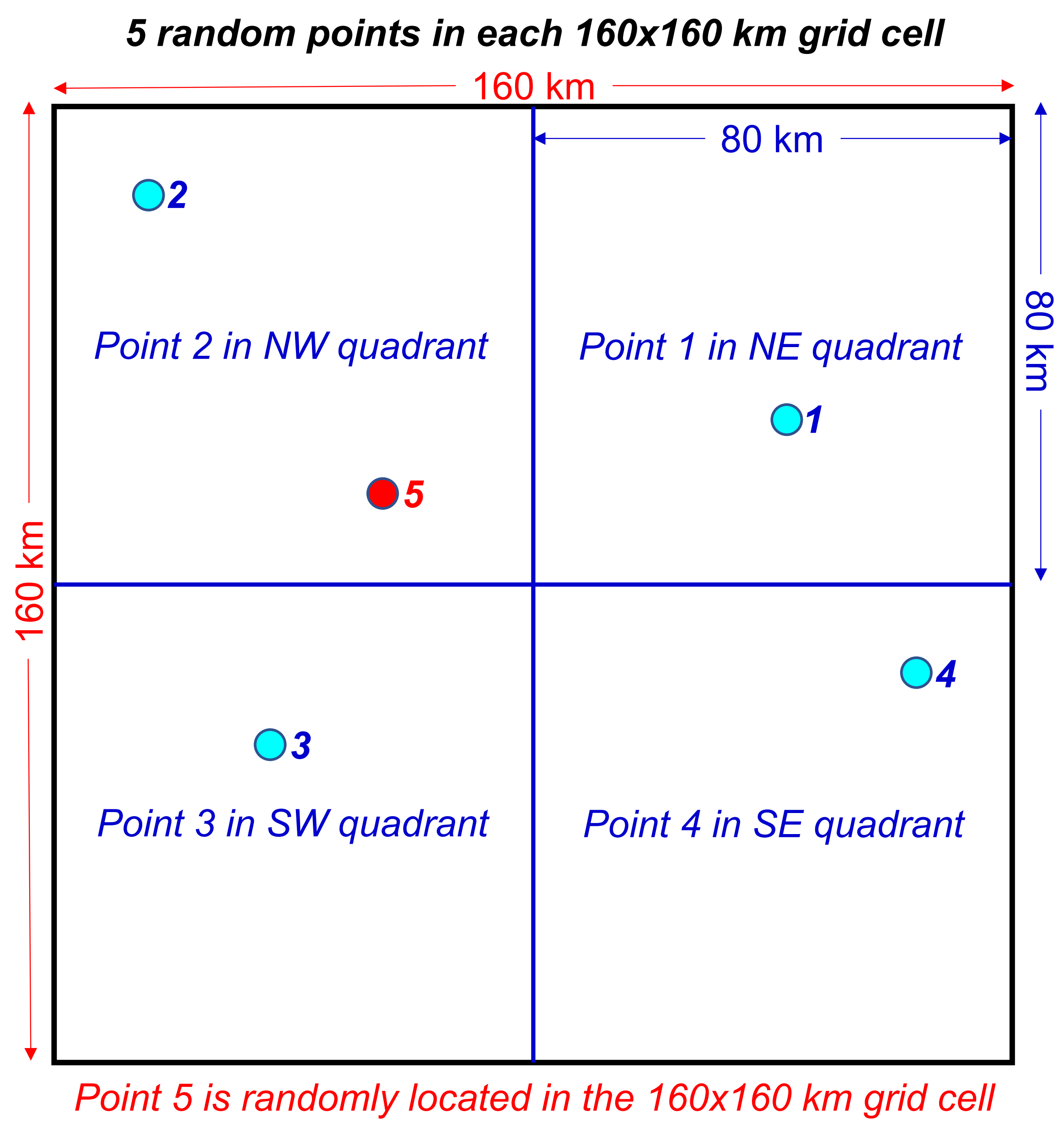
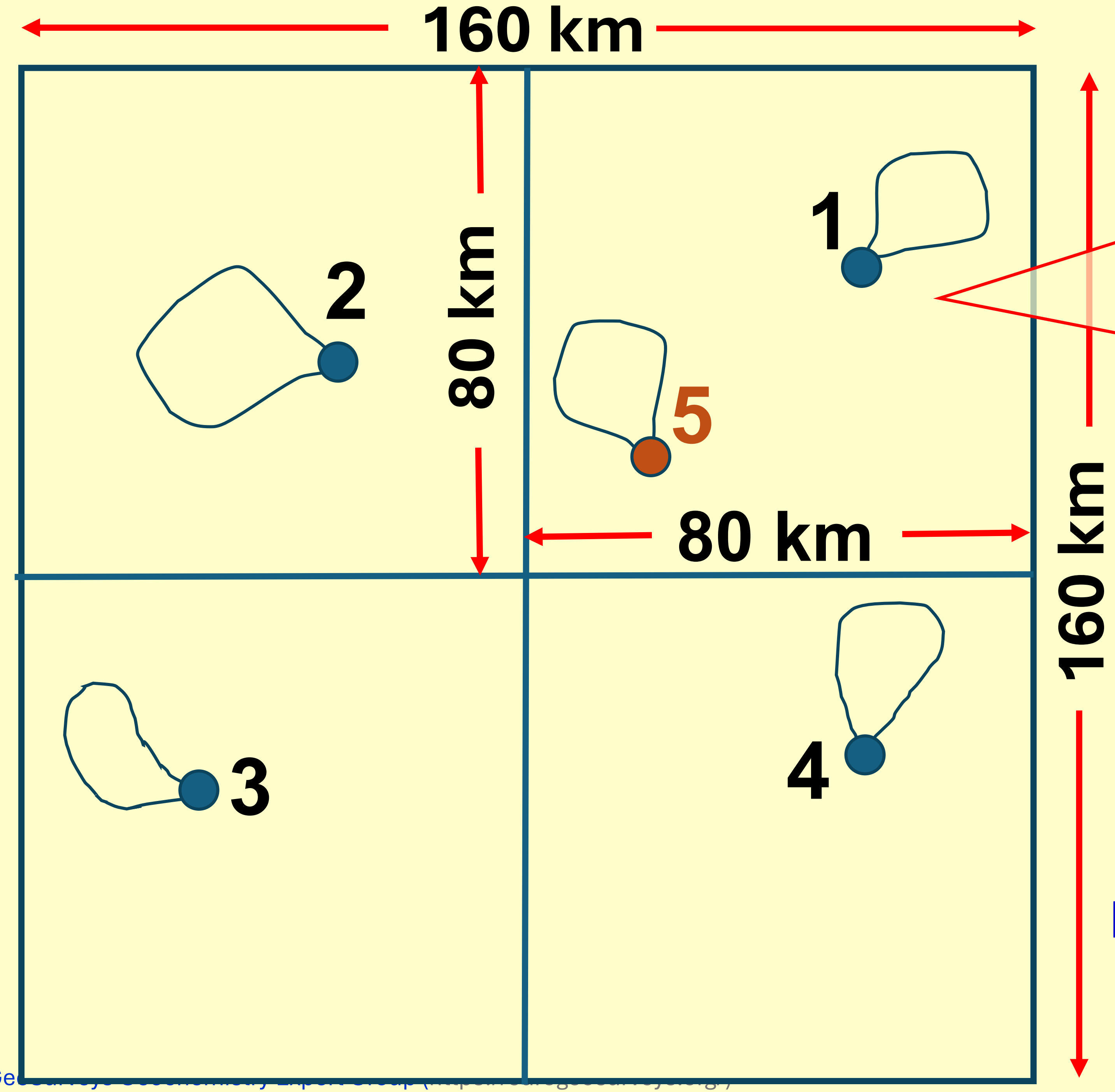
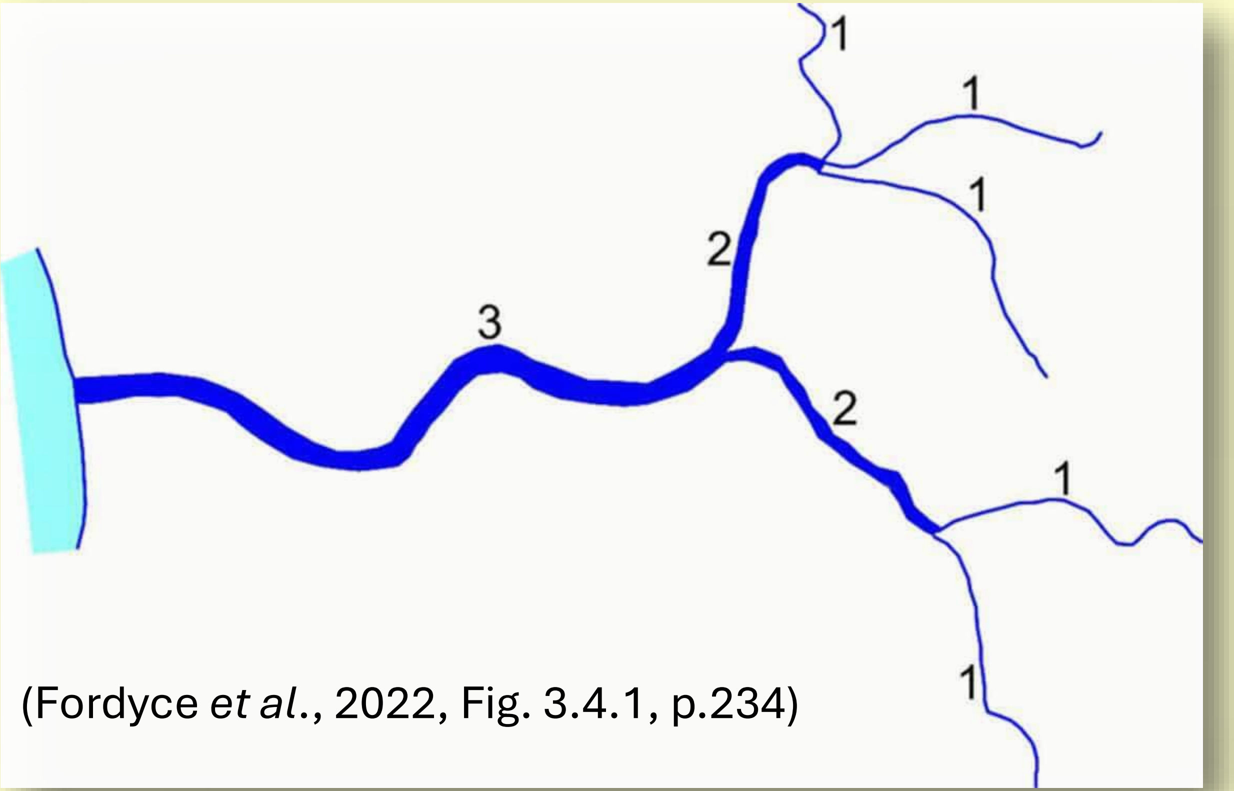


Figure 2.4 on page 20. Random sampling schemes in each 160x160 km GTN grid cell: (a) 5-random point sampling scheme.
Diagram plotted by Alecos Demetriades (IGME/IUGS-CGGB) with Microsoft™ PowerPoint.



Each 160x160 km grid cell is divided into 4 quadrants of 80x80 km

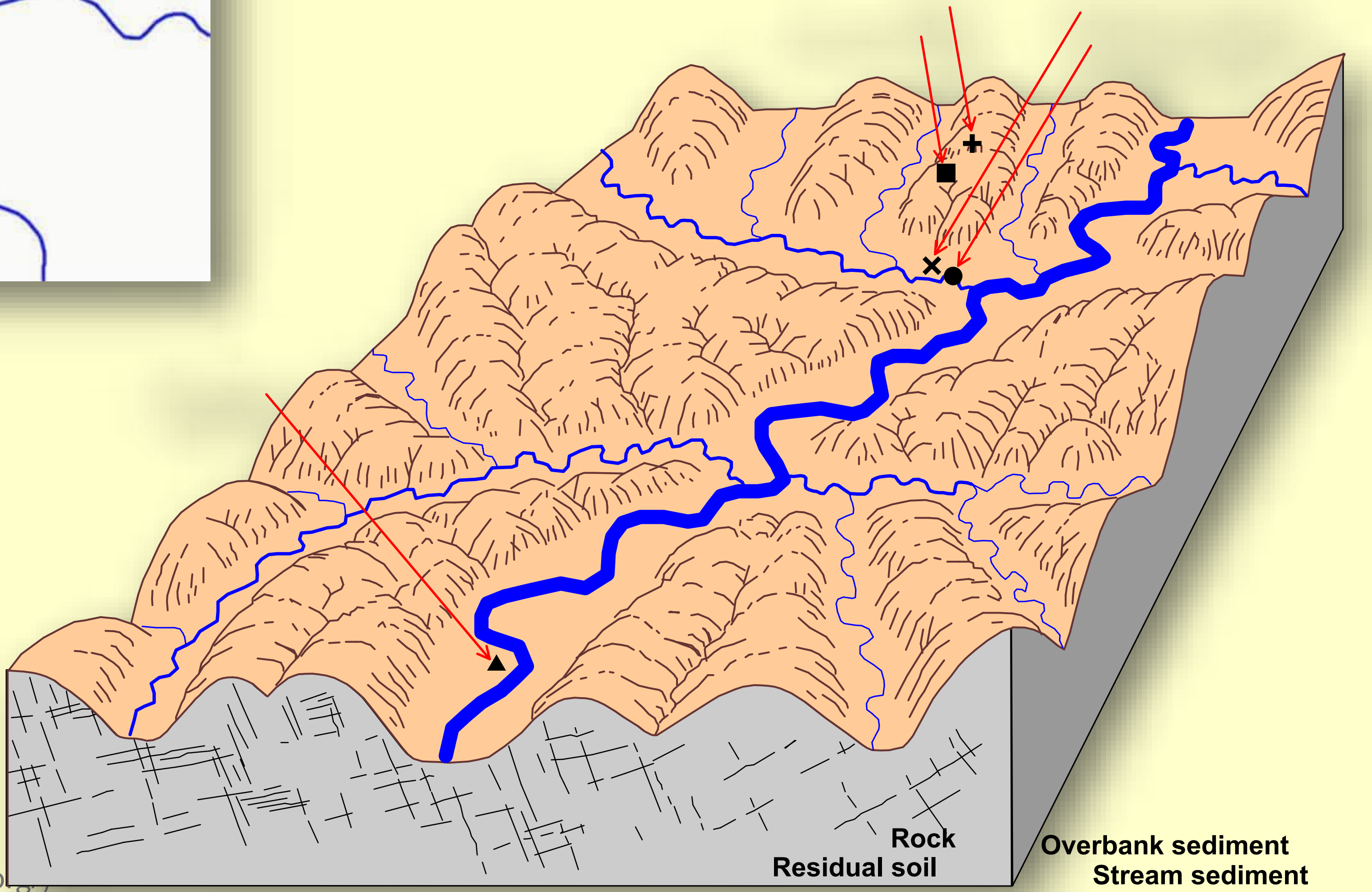
5 random points are used for the selection of the nearest 2nd order drainage basin in each quadrant



(Fordyce *et al*., 2022, Fig. 3.4.1, p.234)

On this slide the Strahler stream order classification system is explained

The mapping scale is 1:50,000



(Demetriades *et al*., 2022b, Fig. 2.5, p.21)

How are the random sites falling into the sea or ocean handled?

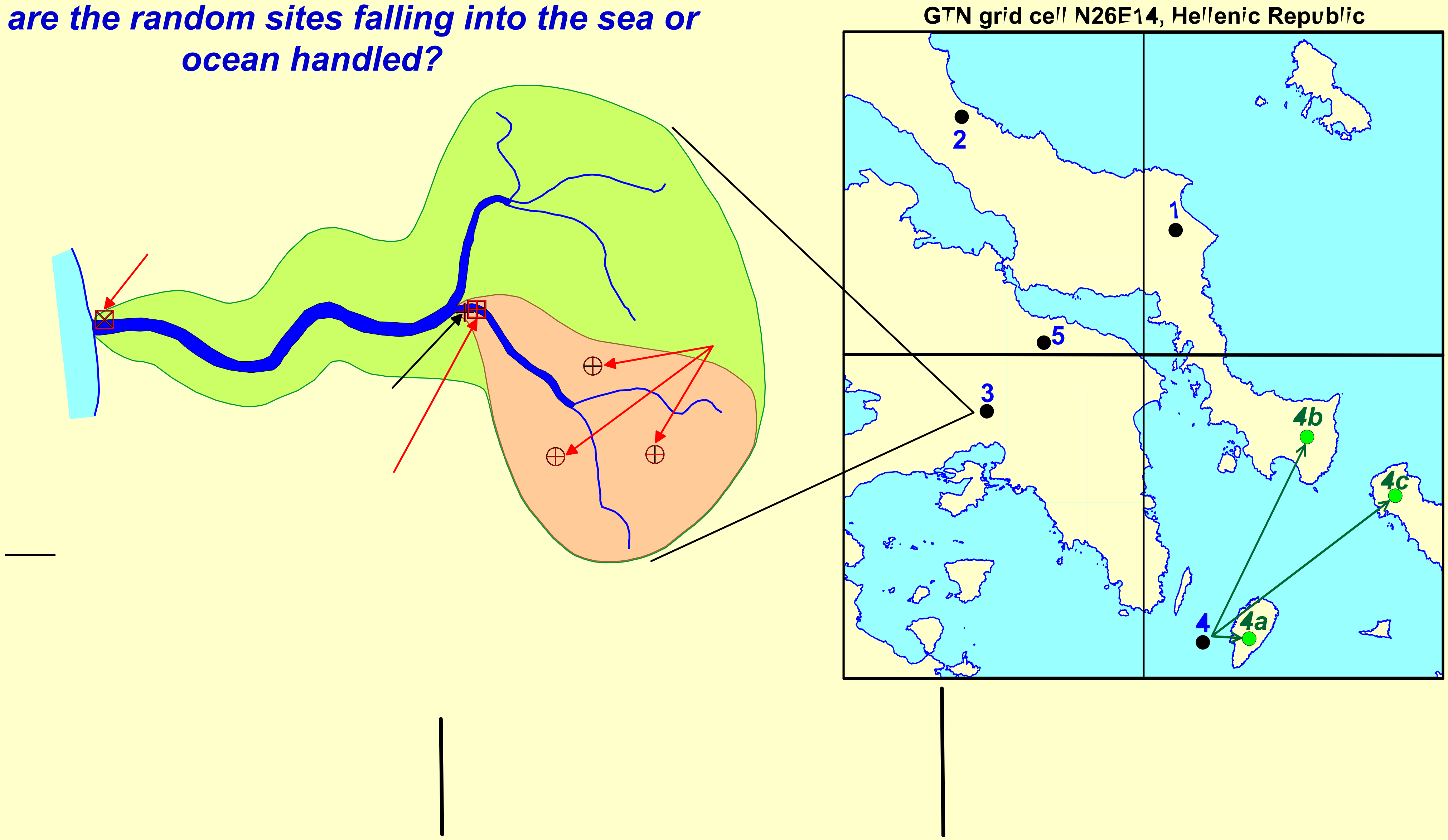


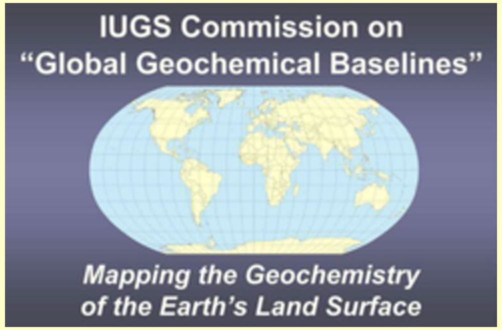
Figure 2.8 on page 23. Example of a GTN grid cell N26E14 with 5 random points, and a schematic diagram showing the possible sample sites of rock, residual soil, humus, stream water and sediment, overbank sediment, and floodplain sediment from the catchment basin representing random point number 3. Two random points fall on mainland Hellas (3 & 5), two on Euboea Island (1 & 2), and one in the sea (4), which should be moved to a land site. See text for explanation. Drawn by Alecos Demetriades (IGME/IUGS-CGGB) with Golden Software's MapViewer™ v8.

26 countries participated in the Geochemical Mapping of Europe

Area: 4,450,000 km^2
925 sample sites
≈1 site/4800 km^2

Each country used its own funding

A contribution to IUGS Commission on *Global Geochemical Baselines*



EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

http://weppi.gtk.fi/publ/foregsatlas/

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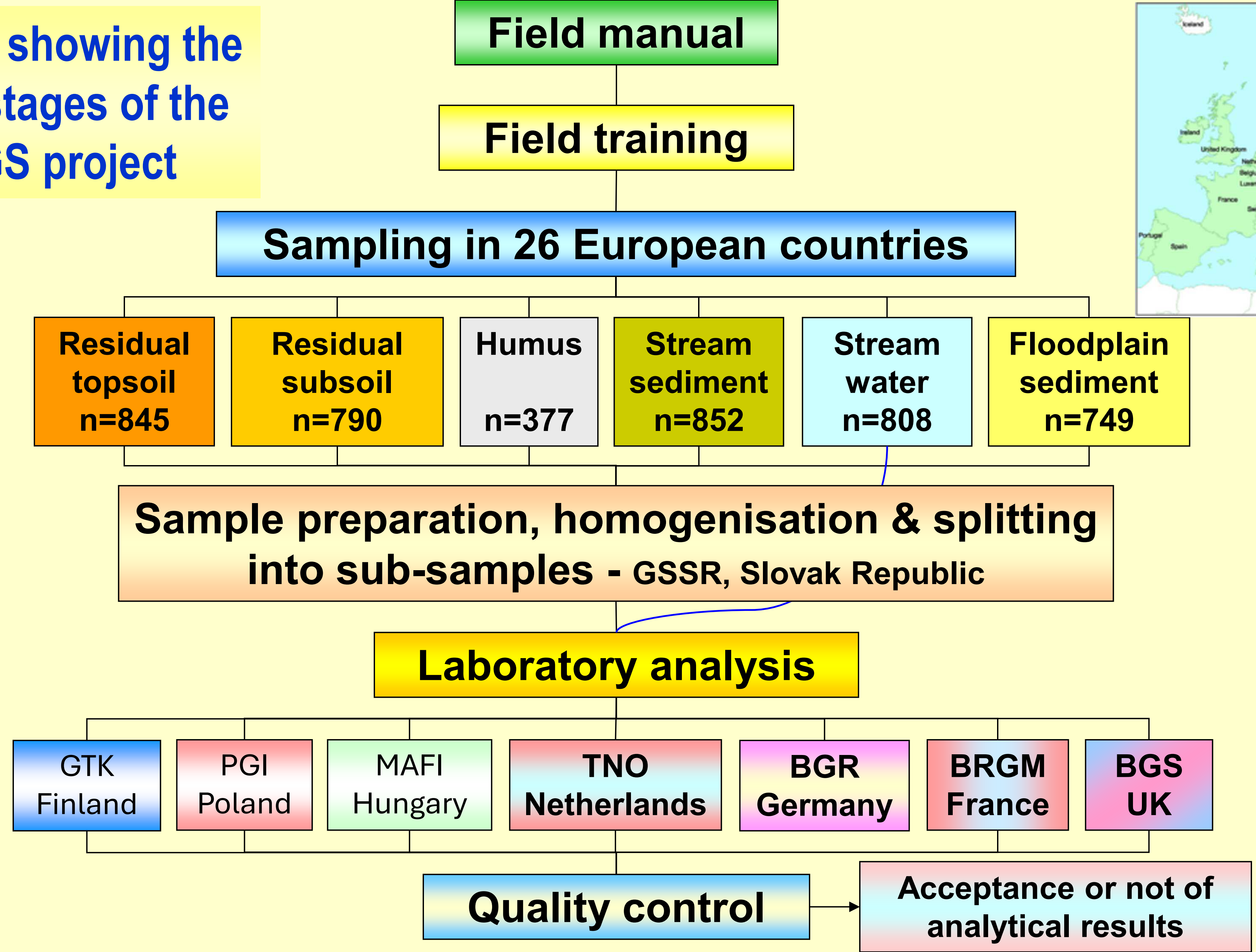
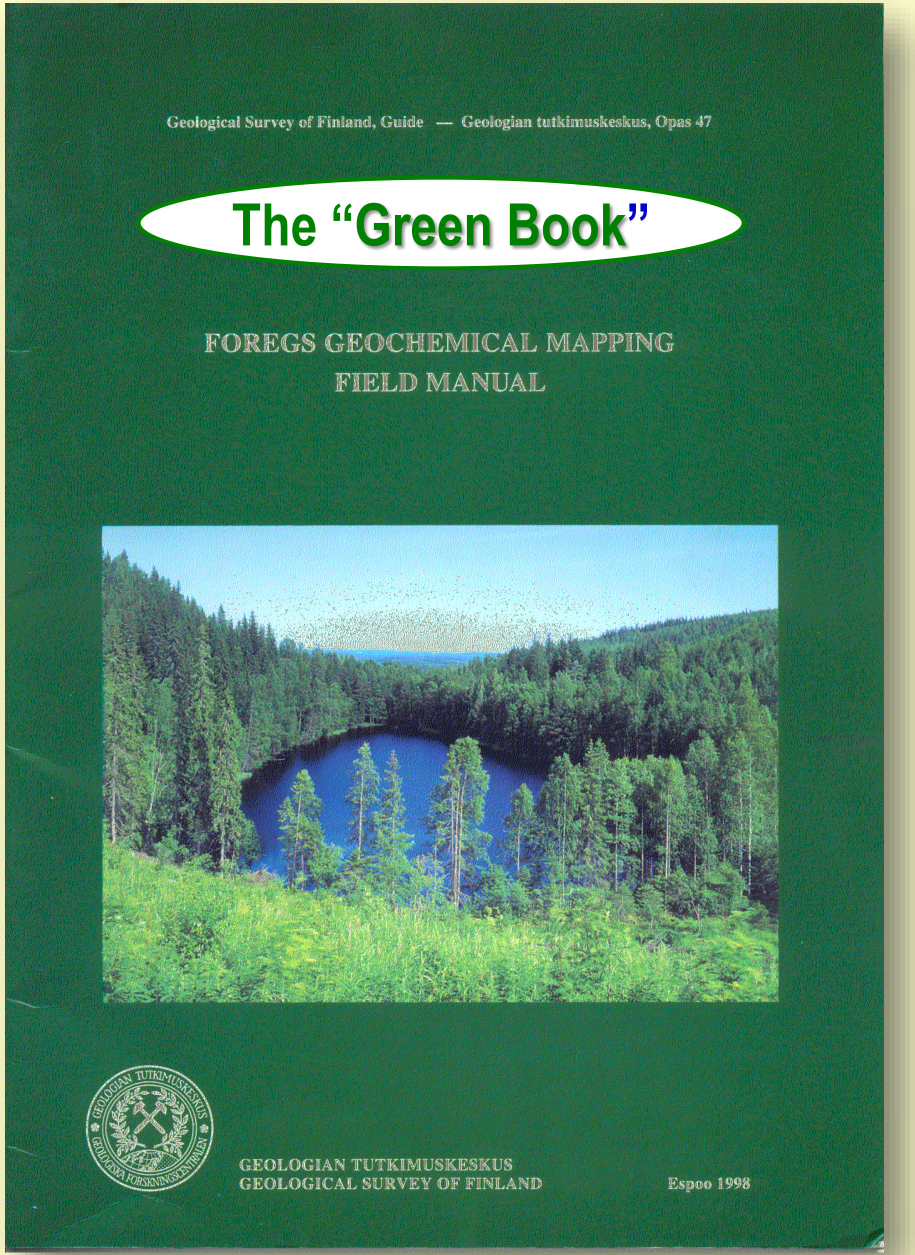
United Kingdom, British Geological Survey: J.A. Plant, S. Reeder, B. Smith, H. Taylor, R. Shaw, B. Breward, E.L. Ander.

Flow chart showing the different stages of the FOREGS project





http://tupa.gtk.fi/julkaisu/opas/op_047.pdf

Sampling chapter

Salminen, R., Batista, M.J., Demetriades, A., Lis, J. & Tarvainen, T., 2005. **Sampling**. In: R. Salminen (Chief-editor), M.J. Batista, M. Bidovec, A. Demetriades, B. De Vivo, W. De Vos, M. Duris, A. Gilucis, V. Gregorauskiene, J. Halamic, P. Heitzmann, A. Lima, G. Jordan, G. Klaver, P. Klein, J. Lis, J. Locutura, K. Marsina, A. Mazreku, P.J. O'Connor, S.Å. Olsson, R.T. Ottesen, V. Petersell, J.A. Plant, S. Reeder, I. Salpeteur, H. Sandström, U. Siewers, A. Steenfelt, & T. Tarvainen (Editors), FOREGS Geochemical Atlas of Europe, Part 1: Background Information, Methodology and Maps. Geological Survey of Finland, Espoo, 67-79 (in hardbound edition), http://weppi.gtk.fi/publ/foregsatlas/articles/Sampling.pdf.

Field observations are recorded at each sampling site

Stream water & Sediment

Soil

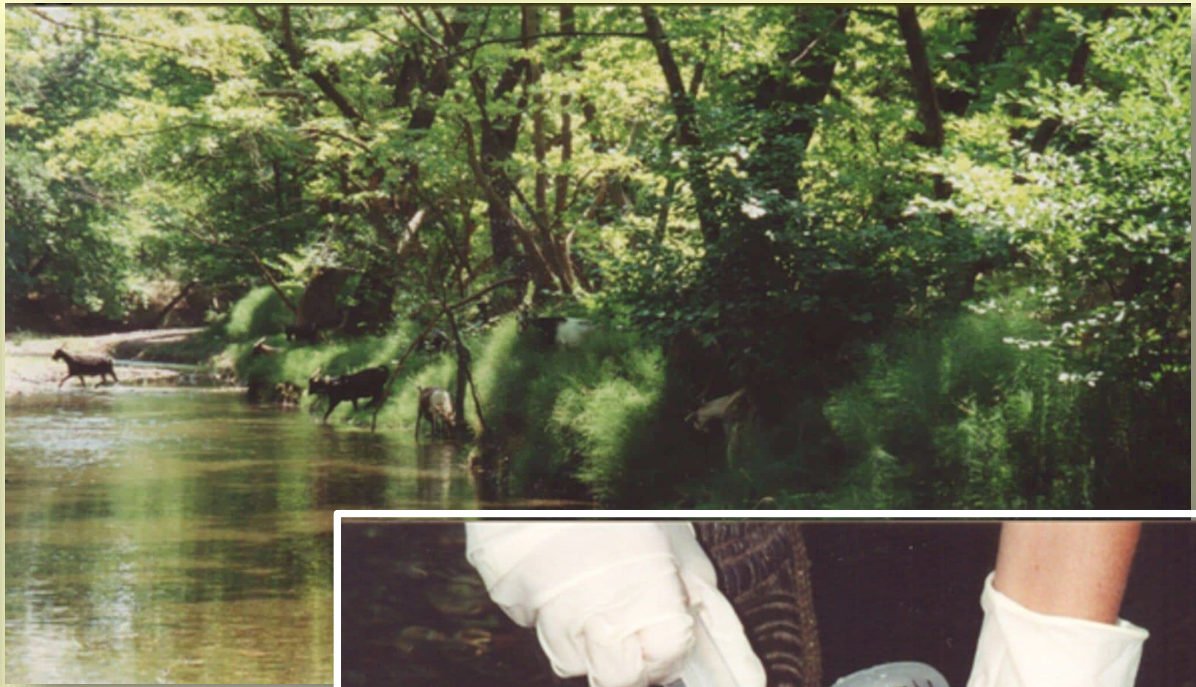
Humus

Floodplain sediment

Overbank sediment

Note: Overbank sediment was collected in countries that participated in the WEGS Pilot Project.

Photographs were taken at each sampling site



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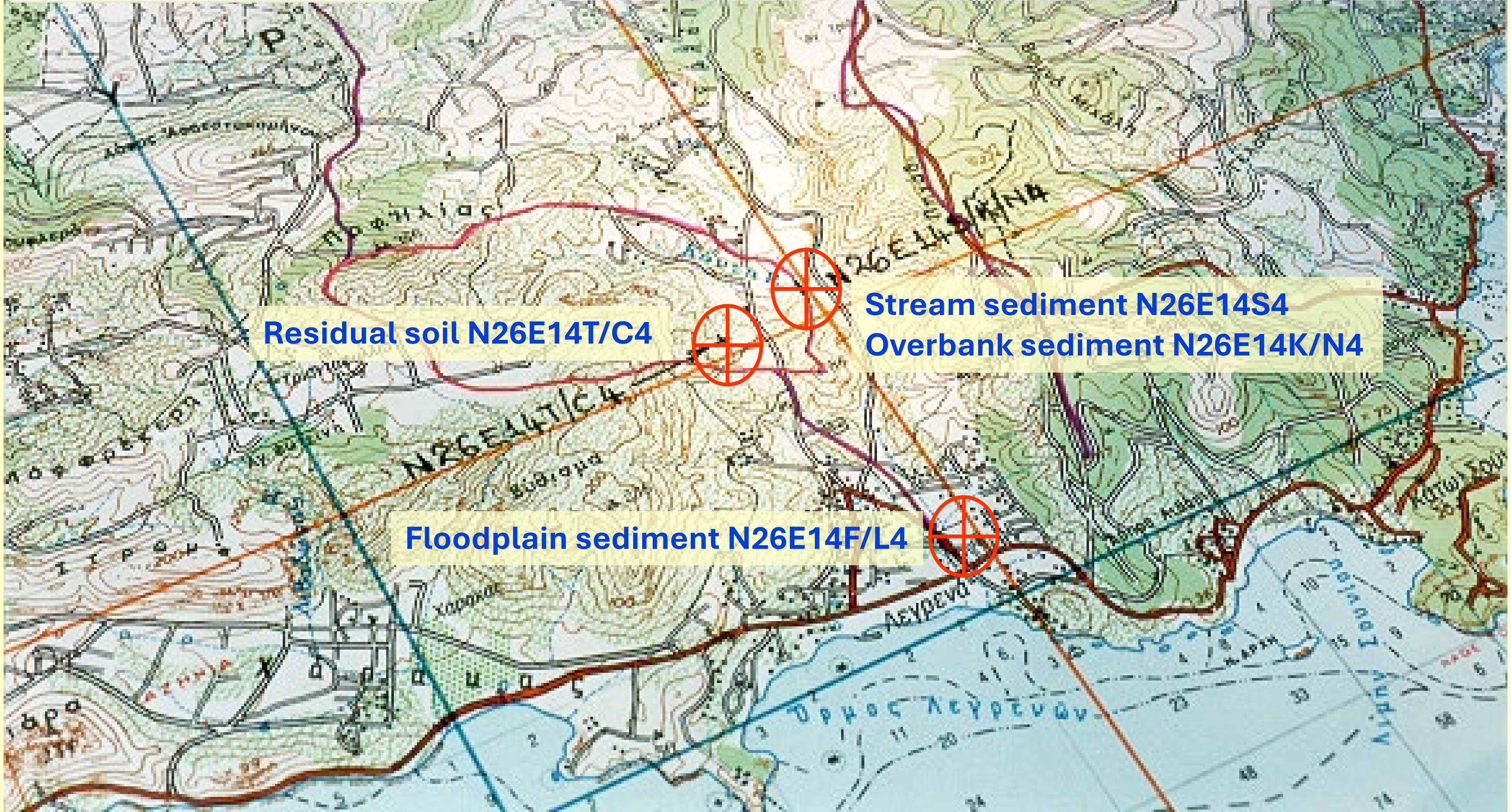
Marking the sampling sites on a 1:50,000 scale topographical map

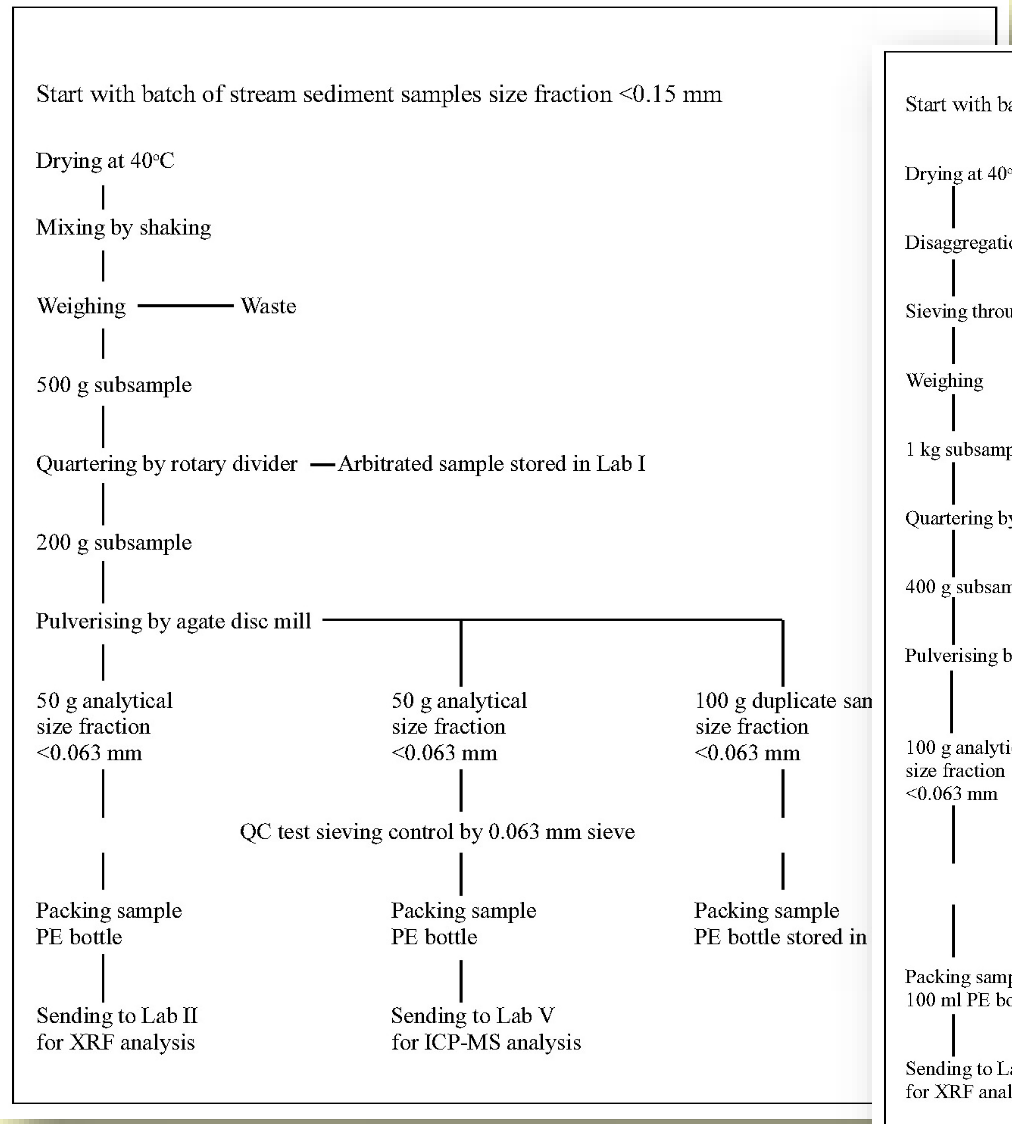
GTN cell N26E14

Sample sites recorded on 1:50,000 topographical map

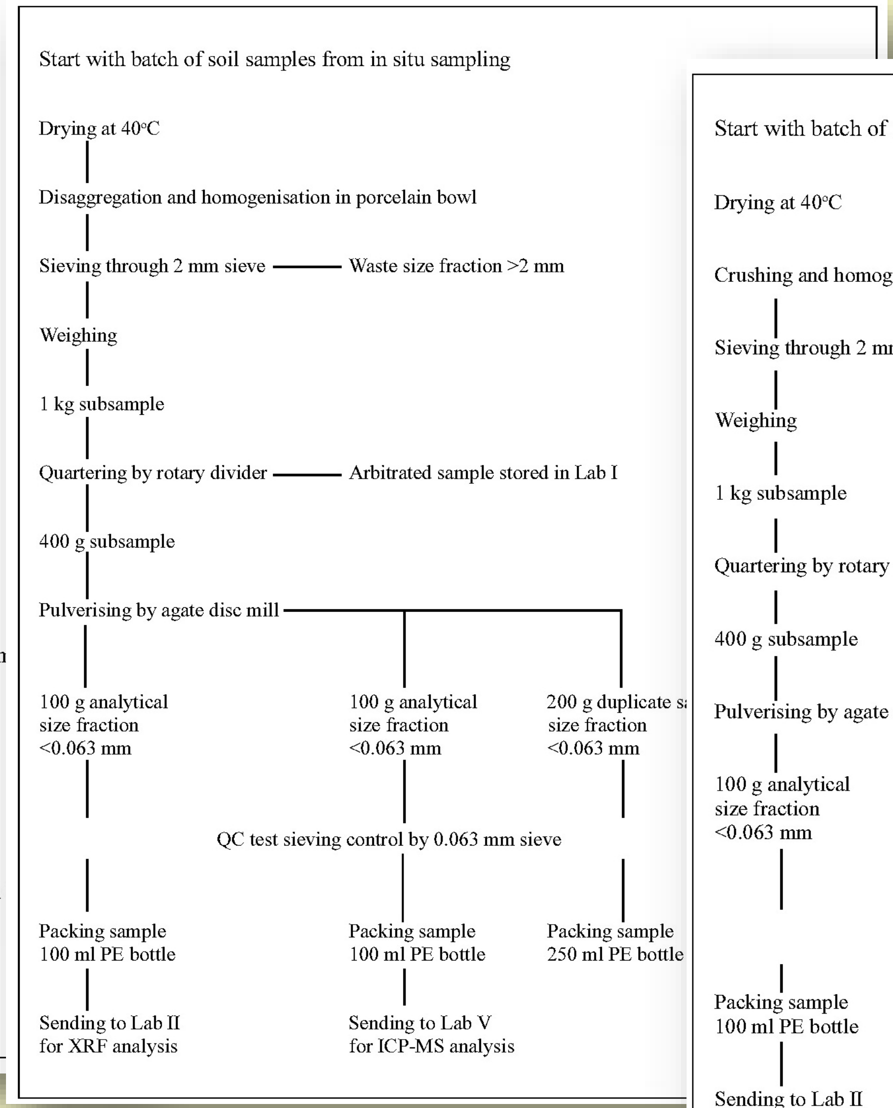


Sample preparation stages at a Slovakian laboratory

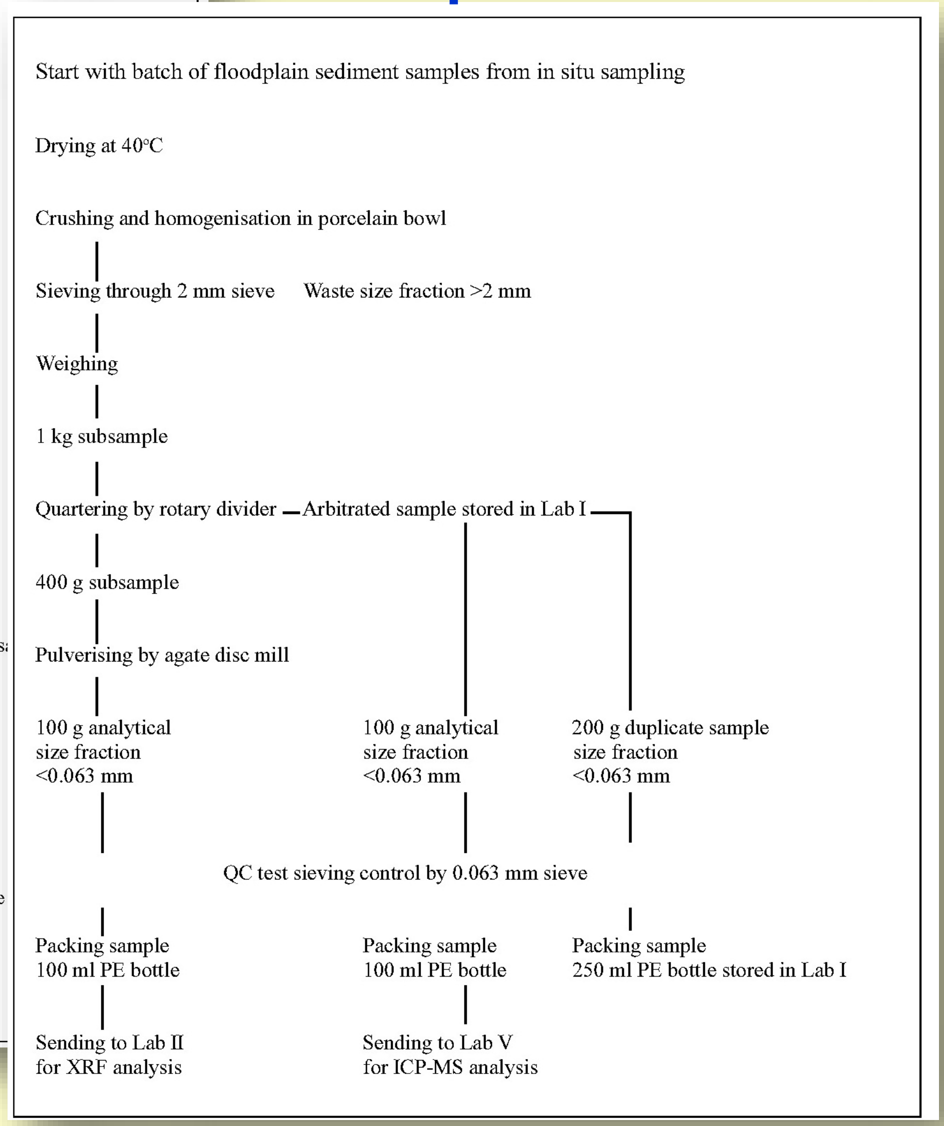
Stream sediment



Soil



Floodplain sediment



EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Laboratory analysis of collected samples

The collected samples were analysed in seven Geological Survey laboratories.

In order to achieve compatible analytical results, each laboratory analysed, by the same method, all samples for the same suite of elements.

In addition, a laborious quality control/quality assurance scheme was used to ensure results of high integrity.

Analytical methods & laboratories

- **Stream water**
  - ICP-QMS / ICP-AES — **BGR - Germany**
  - IC & DOC analyser — **BGS - UK**
- **Humus**
  - ICP-MS — **TNO - Netherlands**
  - Hg - analyser — MAFI - Hungary
- **Residual topsoil** / **Residual subsoil**
  - Hg - analyser — MAFI - Hungary
  - WD-XRF — **BGR - Germany**
  - ICP-MS — GTK - Finland
  - ICP-AES / AR — PGI - Poland
  - Granulometry / TOC — **TNO - Netherlands**
- **Stream sediment** / **Floodplain sediment**
  - TOC — **GSSR - Slovakia**
  - XRF — **BGS - UK**
  - ICP-MS — **BRGM - France**
  - ICP-AES / AR — GTK - Finland; PGI - Poland
  - Hg - analyser — MAFI - Hungary

Determinands analysed

Stream water (n=808): 66 determinands: Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, 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, Pr, Rb, Sb, Se, SiO_2, Sm, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr, pH, EC, HCO_3^-, Br^-, Cl^-, F^-, NO_3^-, SO_4^{2-}, DOC

Humus (n=377): 12 determinands (total extraction): Ba, Cd, Co, Cu, Ga, Hg, La, Ni, Pb, Rb, Sr, Zn

Residual topsoil (n=845) / **Residual subsoil (n=790)**:

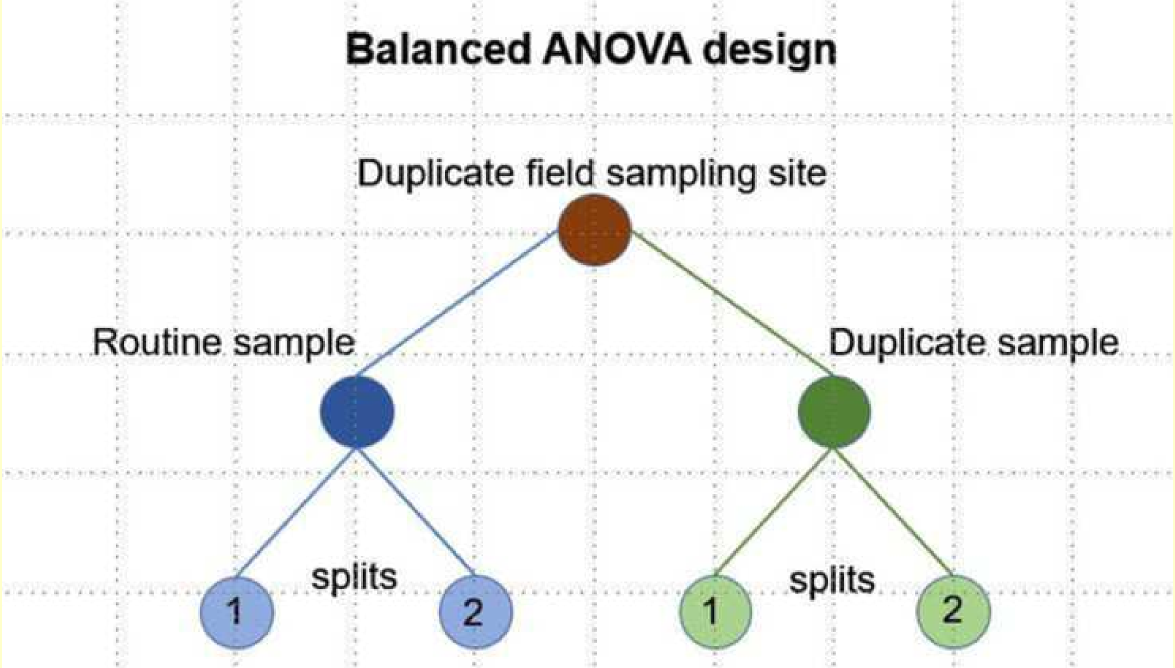
- 12 determinands (aqua regia extractable): As, Ba, Co, Cr, Cu, Fe, Mn, Ni, Pb, S, V, Zn
- 64 determinands (total extraction): Ag, Al_2O_3, As, Ba, Be, Bi, CaO, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe_2O_3, Ga, Gd, Hf, Hg, Ho, I, In, K_2O, La, Lu, MgO, MnO, Mo, Na_2O, Nb, Nd, Ni, P_2O_5, Pb, Pr, Rb, Sb, Sc, SiO_2, Sm, Sn, Sr, Ta, Tb, Te, Th, TiO_2, Tl, Tm, U, V, W, Y, Yb, Zn, Zr, TOC, pH, 4 grain-sizes

Stream sediment (n=852) / **Floodplain sediment (n=749)**:

- 12 determinands (aqua regia extractable): As, Ba, Co, Cr, Cu, Fe, Mn, Ni, Pb, S, V, Zn
- 54 determinands (total extraction): Al_2O_3, As, Ba, Be, CaO, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe_2O_3, Ga, Gd, Hf, Hg, Ho, K_2O, La, Li, Lu, MgO, MnO, Mo, Na_2O, Nb, Nd, Ni, P_2O_5, Pb, Pr, Rb, Sb, SiO_2, Sm, Sn, Sr, Ta, Tb, Th, TiO_2, Tl, Tm, U, V, W, Y, Yb, Zn, Zr, TOC

Quality Assurance
and
Quality Control
(QA-QC)

Quality Assurance and Quality Control (QA-QC) 1/2



$$X_{ijk} = a + b_i + c_{ij} + d_{ijk},$$ where

X_{ijk} = Value at site i, duplicate sample j, repeated analysis k

a = Total expectation

b_i = Regional effect at site i

c_{ij} = Local sampling effect at site i, duplicate sample j

d_{ijk} = Analytical effect at site i, repeated analysis j, duplicate sample k

Figure source: Salminen et al. (2005, Fig. 1, p.83 in hardbound edition)

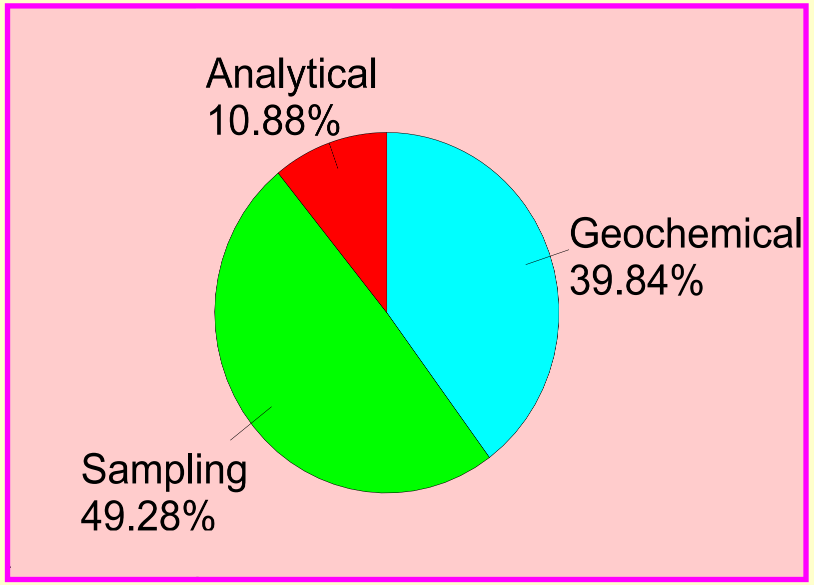
Approximately 5% of all sites were sampled in duplicate. The duplicate samples were prepared independently of each other and analysed randomly along with all other samples.

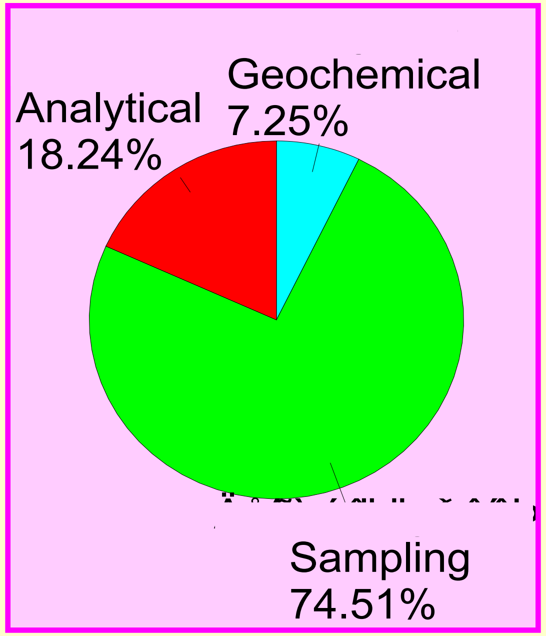
Each duplicate pair of samples was analysed in duplicate to allow estimation of sampling uncertainty by the balanced ANOVA statistical interpretation method.

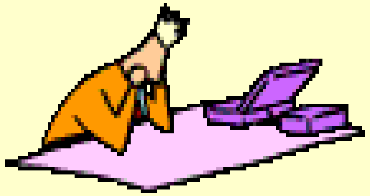
Sandström, H., Reeder, S., Bartha, A., Birke, M., Berge, F., Davidsen, B., Grimstvedt, A., Hagel-Brunnström, M-L., Kantor, W., Kallio, E., Klaver, G., Lucivjansky, P., Mackovych, D., Mjartanova, H., van Os, B., Paslawski, P., Popiolek, E., Siewers, U., Varga-Barna, Zs., van Vilsteren, E. & Ødegård, M., 2005. **Sample preparation and analysis**. In: R. Salminen (Chief-editor), M.J. Batista, M. Bidovec, A. Demetriades, B. De Vivo, W. De Vos, M. Duris, A. Gilucis, V. Gregorauskiene, J. Halamic, P. Heitzmann, A. Lima, G. Jordan, G. Klaver, P. Klein, J. Lis, J. Locutura, K. Marsina, A. Mazreku, P.J. O'Connor, S.Å. Olsson, R.T. Ottesen, V. Petersell, J.A. Plant, S. Reeder, I. Salpeteur, H. Sandström, U. Siewers, A. Steenfelt, & T. Tarvainen, FOREGS Geochemical Atlas of Europe, Part 1: Background Information, Methodology and Maps. Geological Survey of Finland, Espoo, 81-94, http://weppi.gtk.fi/publ/foregsatlas/articles/Analysis.pdf.

… Quantification of sources of variation …

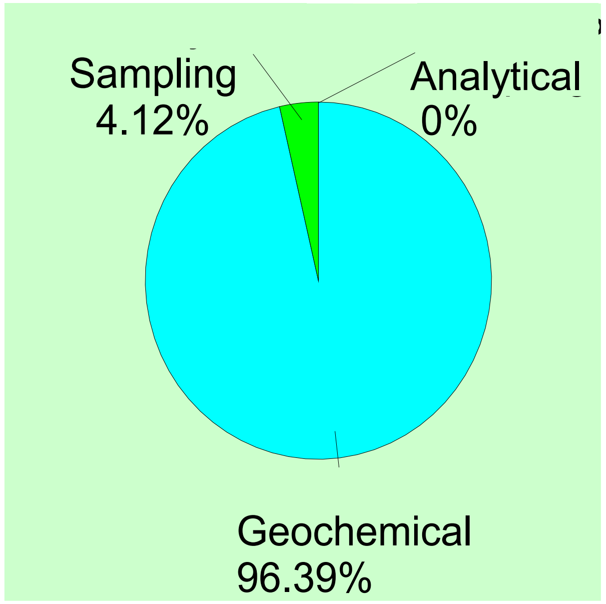
Unacceptable results

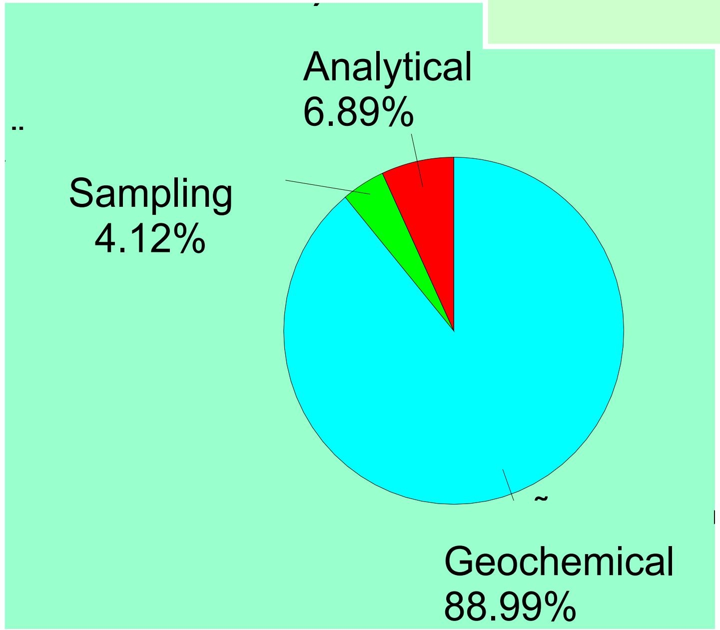






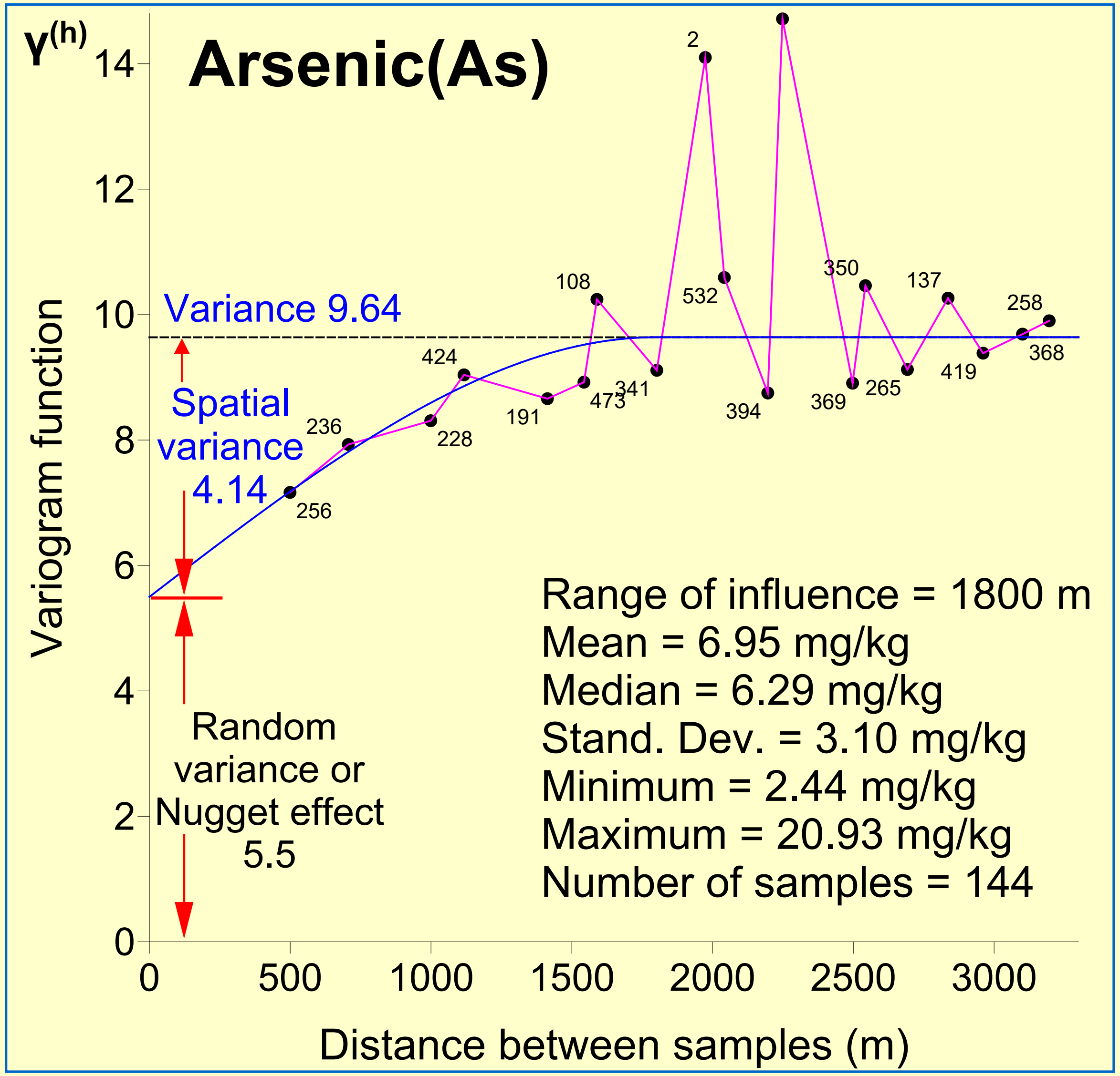
Acceptable results





https://upload.wikimedia.org/wikipedia/commons/e/ea/Emoji_u1f44c.svg

Variogram



Quantification of sources of variation using geostatistics

One must be very careful when using the variogram to estimate the sources of variation.

This diagram shows a well-structured variogram, and one may assume that the extracted information is satisfactory.

However, a closer examination shows the Random variance (nugget effect) at 5.5 $\gamma^{(h)}$ is greater than the Spatial variance at 4.14 $\gamma^{(h)}$, meaning that this particular As data set cannot be used for extrapolation into unsampled space.

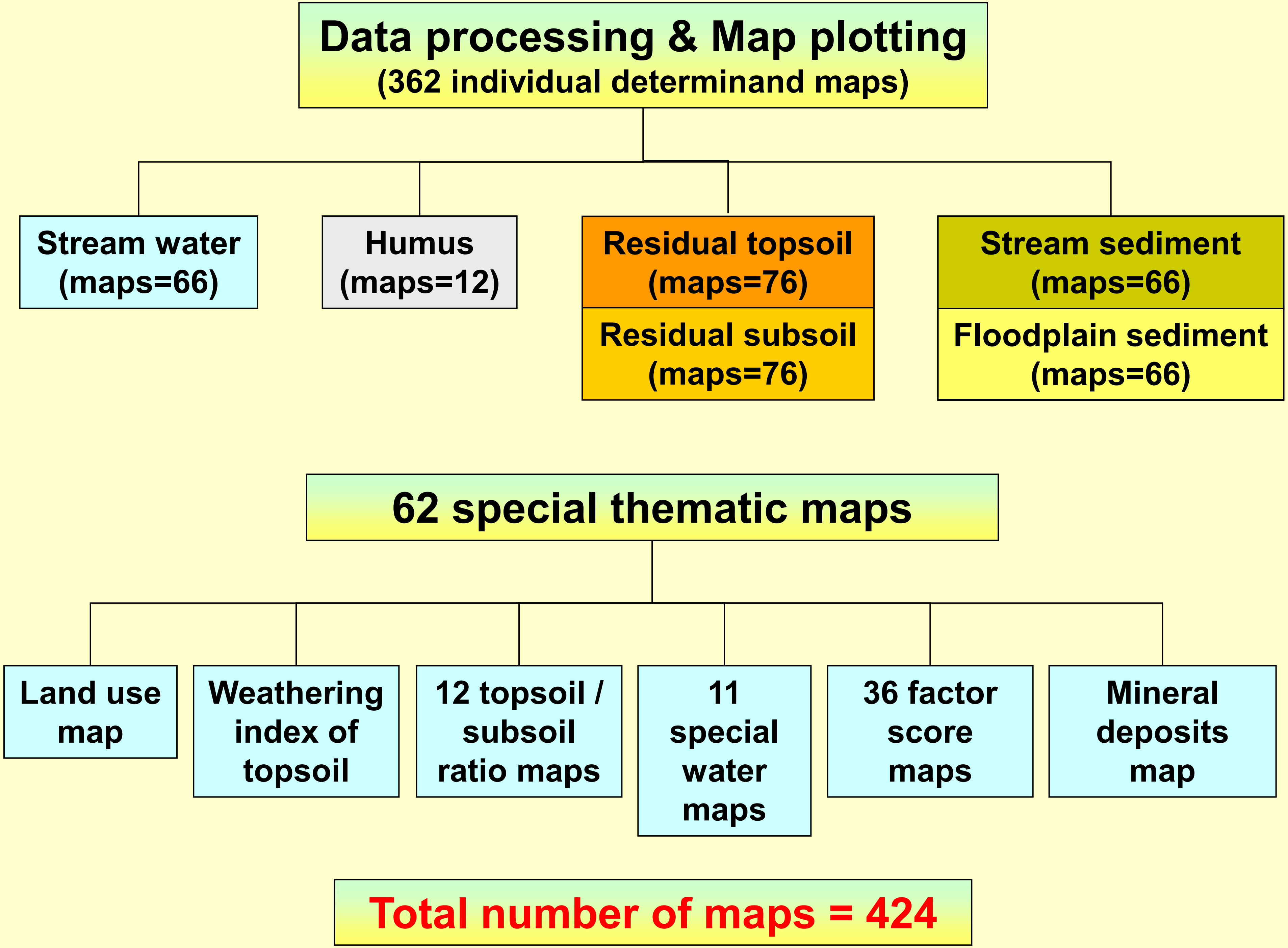
Quality Assurance and Quality Control (QA-QC) 2/2

- **For the project, additional quality measures were used to provide extra assurance that the overall quality of data was to the high standards required. For all solid sample analyses, two reference materials (ISE 921 and ISE 982) were analysed at regular intervals (between 1 and 2%, depending on the method) to monitor long-term stability and to enable comparison of data from different methods and different laboratories.**

- **About 8% of the solid samples were also used for inter-laboratory comparison, *e.g.*, about 50 soil samples were analysed by WD-XRF at BGS for comparison with the original BGR WD-XRF and GTK ICP-MS data.**

Before data processing, the quality of all data was checked thoroughly

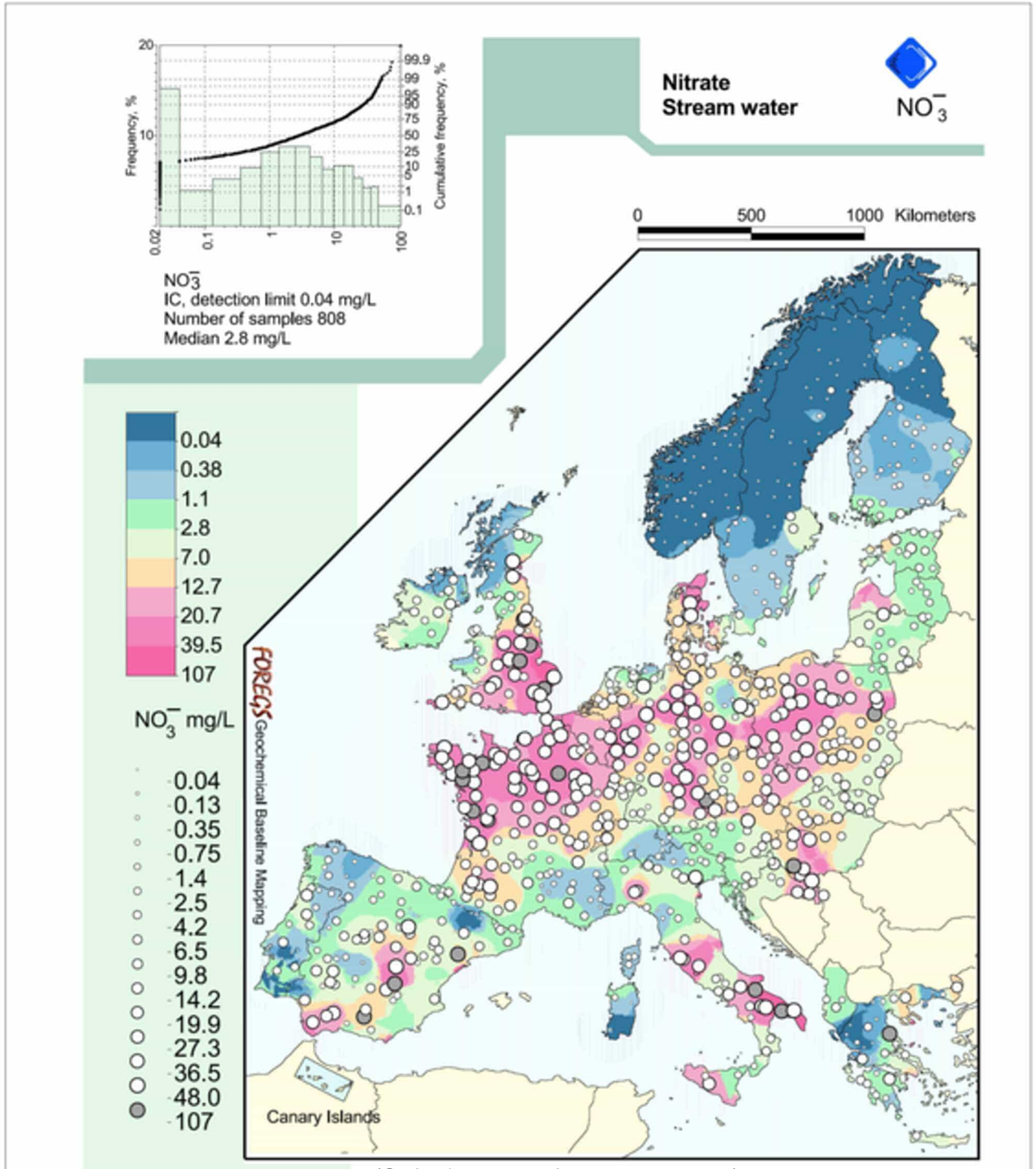
- **Separate Quality Control samples: ANOVA;**
- **Preliminary dot maps, basic statistical tables and element distribution plots;**
- **Corrected sample identifiers, coordinates, additional analysis to verify results, *etc*.;**
- **Analytical results below the detection limit were set to half their value, *e.g.*, Te <0.2 mg/kg → 0.1 mg/kg, and**
- **Final data set for map production.**



Data processing & Map plotting
(362 individual determinand maps)
Stream water (maps=66)
Humus (maps=12)
Residual topsoil (maps=76)
Residual subsoil (maps=76)
Stream sediment (maps=66)
Floodplain sediment (maps=66)
62 special thematic maps
Land use map
Weathering index of topsoil
12 topsoil / subsoil ratio maps
11 special water maps
36 factor score maps
Mineral deposits map
Total number of maps = 424

Interpolation

- **The data were interpolated to generate a regular grid with a 6 x 6 km output cell size;**
- **Method Alkemia Smooth (software module of the Geological Survey of Finland):**
  - **a moving weighted median in a circular window with a fixed radius of 150 km;**
  - **Weight: Butterworth function from distance, stronger weight to nearby samples than Inverse Distance Weighting (IDW);**
- **Alkemia Smooth format → ArcView GRID, and**
- **Final maps made with ArcView.**

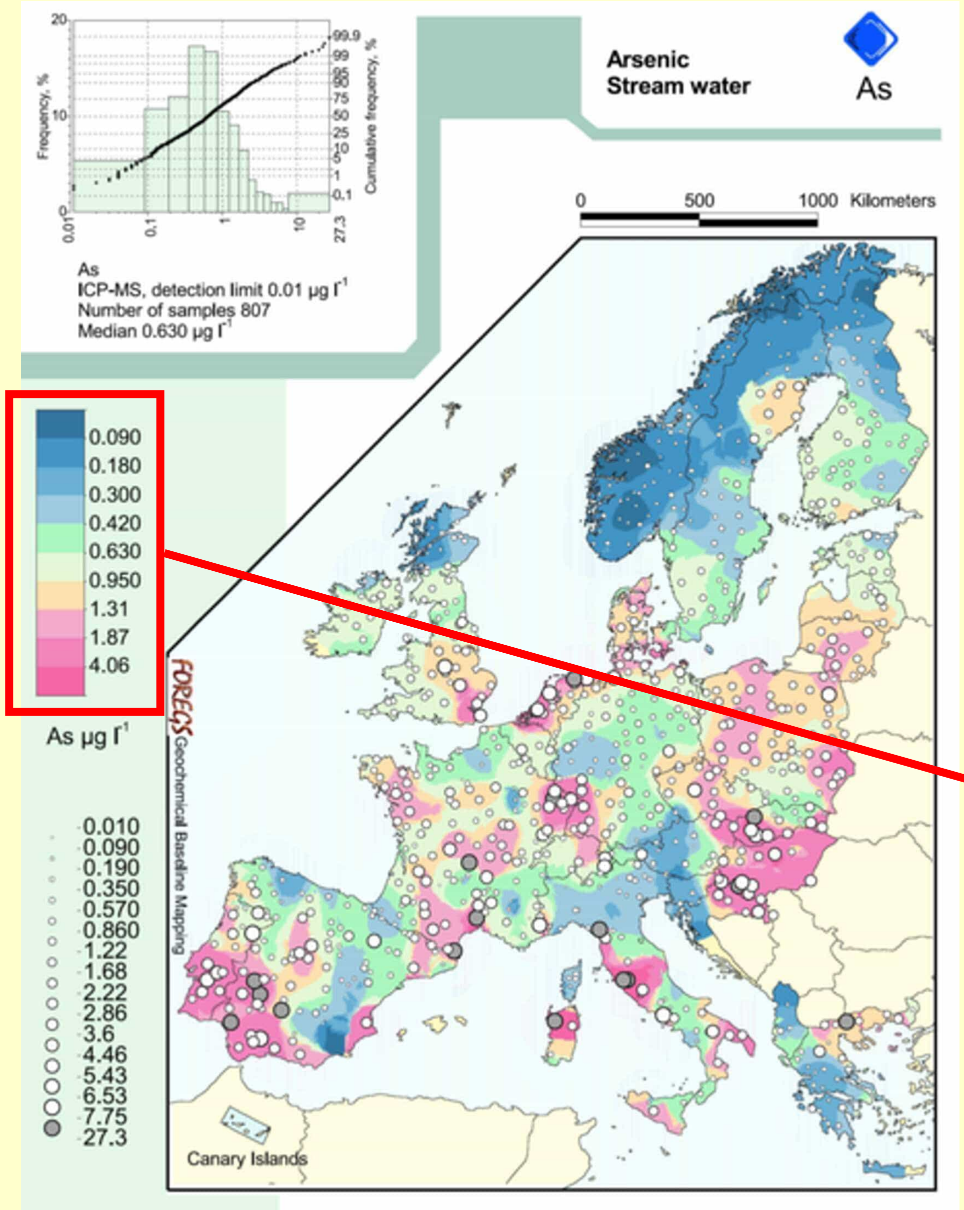


(Salminen et al., 2005, p.367)

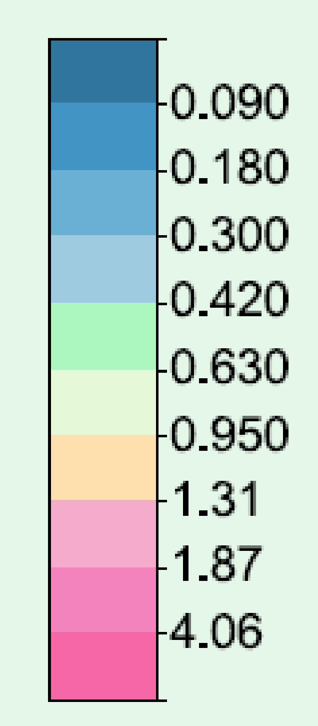
Example of a final map generated with ArcView

- **The interpolated GRID is presented using a 10-grade colour scale;**
- **Percentiles at: 5, 15, 25, 35, 50, 65, 75, 85 and 95**

Colour scale:

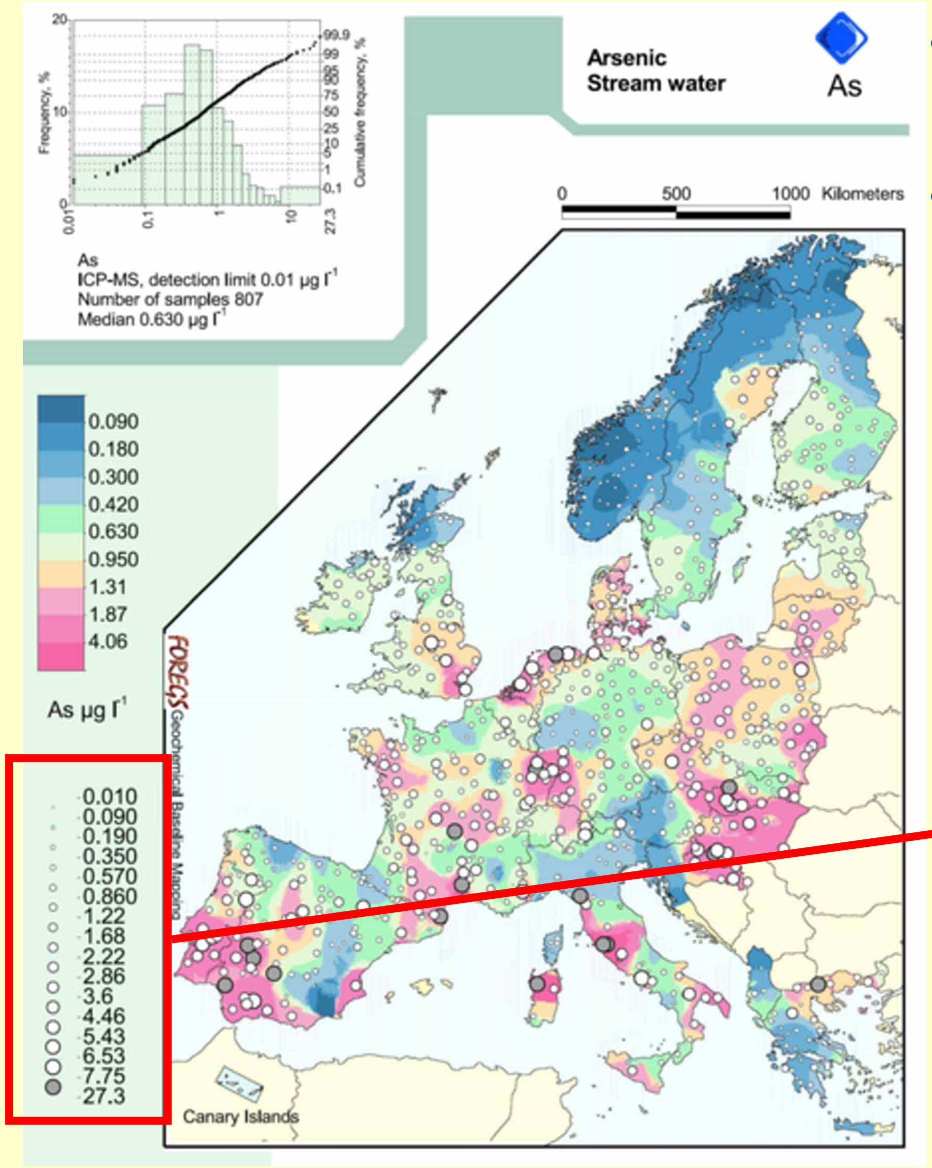


(Salminen et al., 2005, p.121)

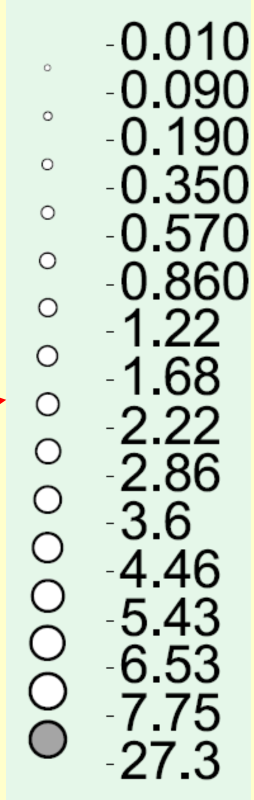


- **10% of the lowest values are presented with the smallest symbol size;**
- **2% of the highest concentrations with the largest symbol size (grey), and**
- **The rest of the distribution is divided into 14 symbol size categories using a logarithmic scale.**

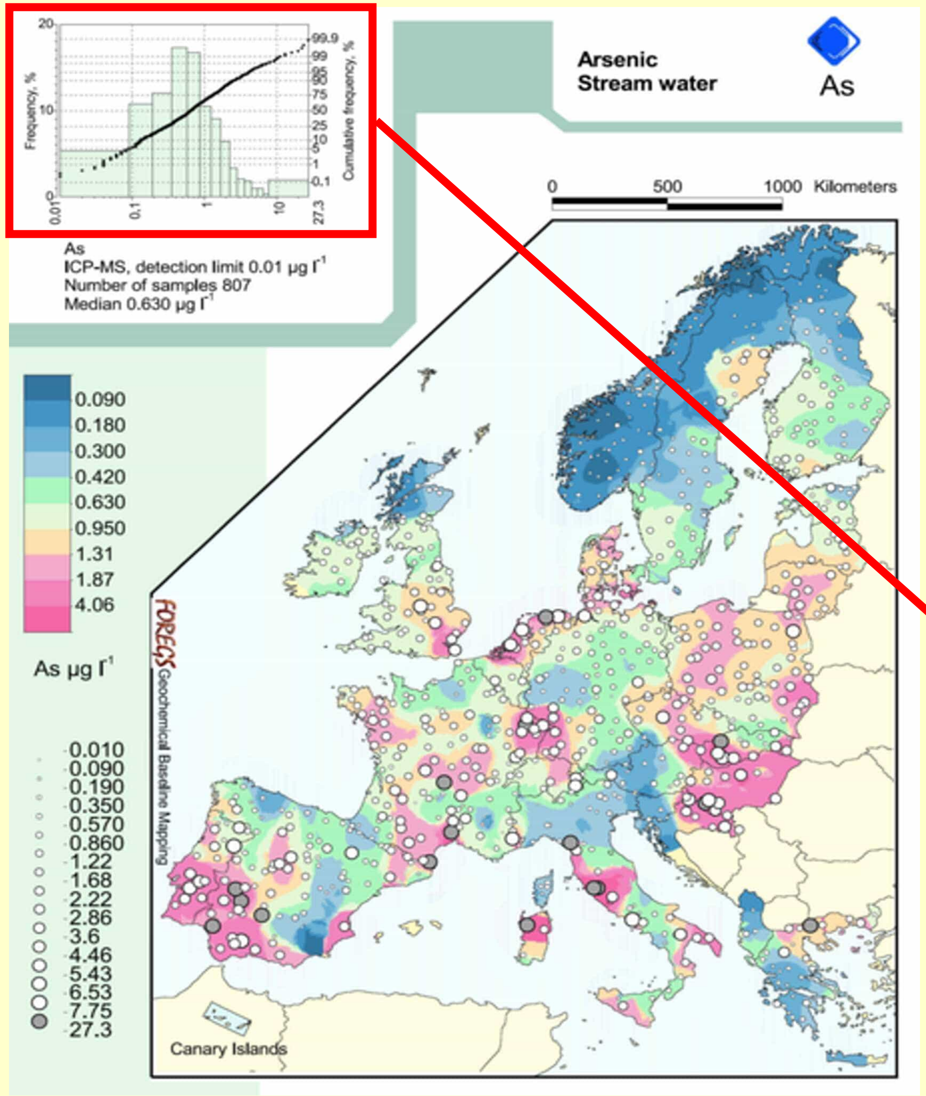
Gradual variable size symbols:



(Salminen et al., 2005, p.121)

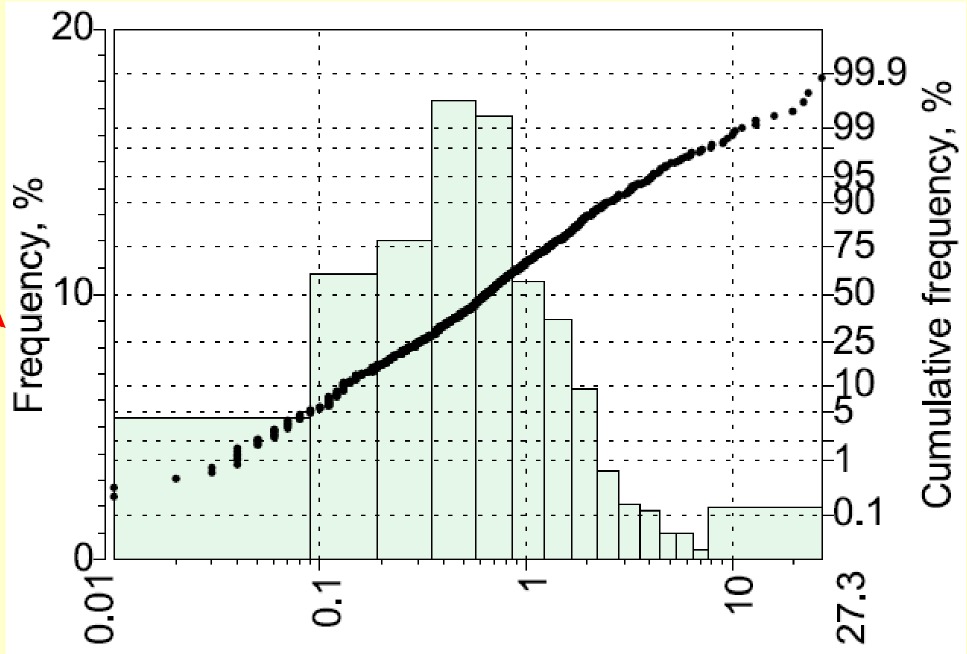


Histogram based on symbol size



(Salminen et al., 2005, p.121)

Made with an Avenue script



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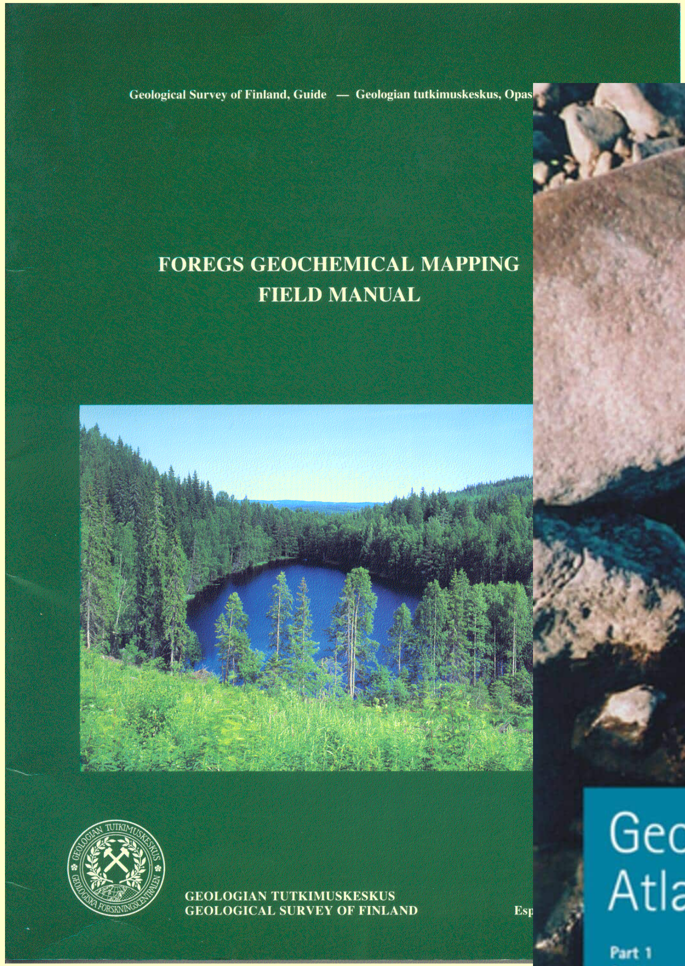
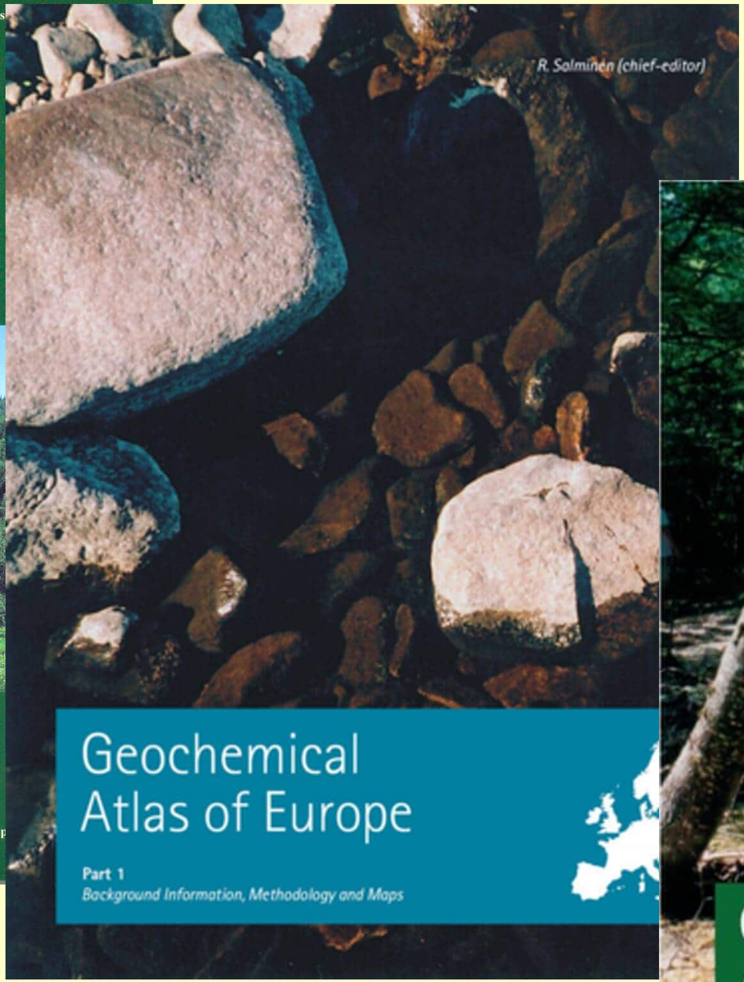
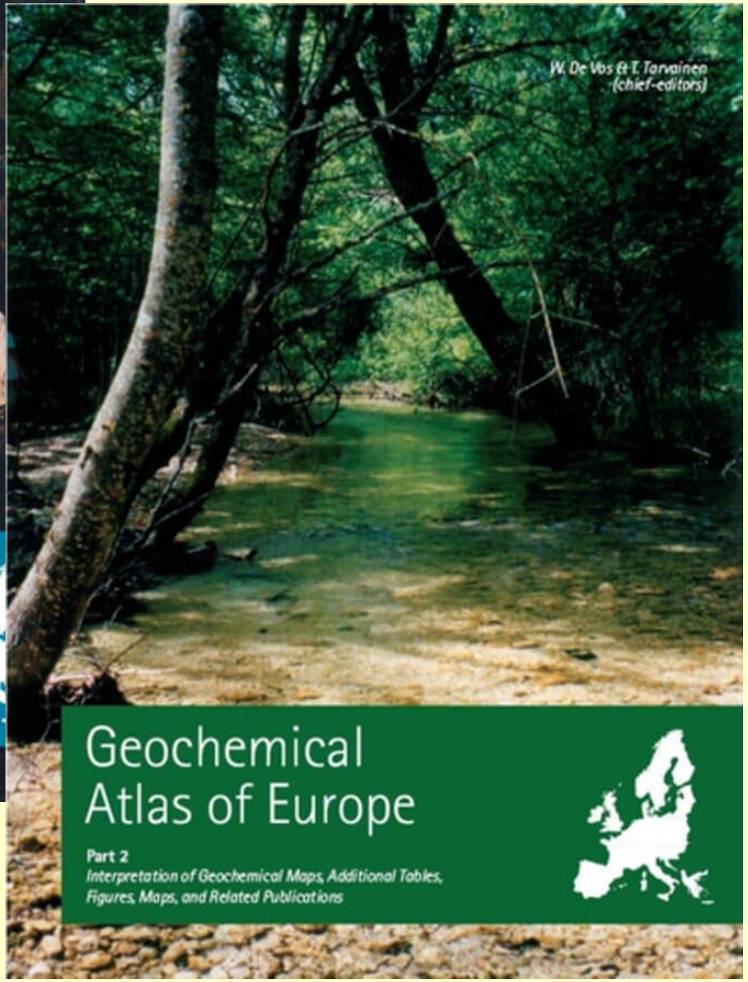
Printed Publications







Also, freely available electronically:

http://tupa.gtk.fi/julkaisu/opas/op_047.pdf

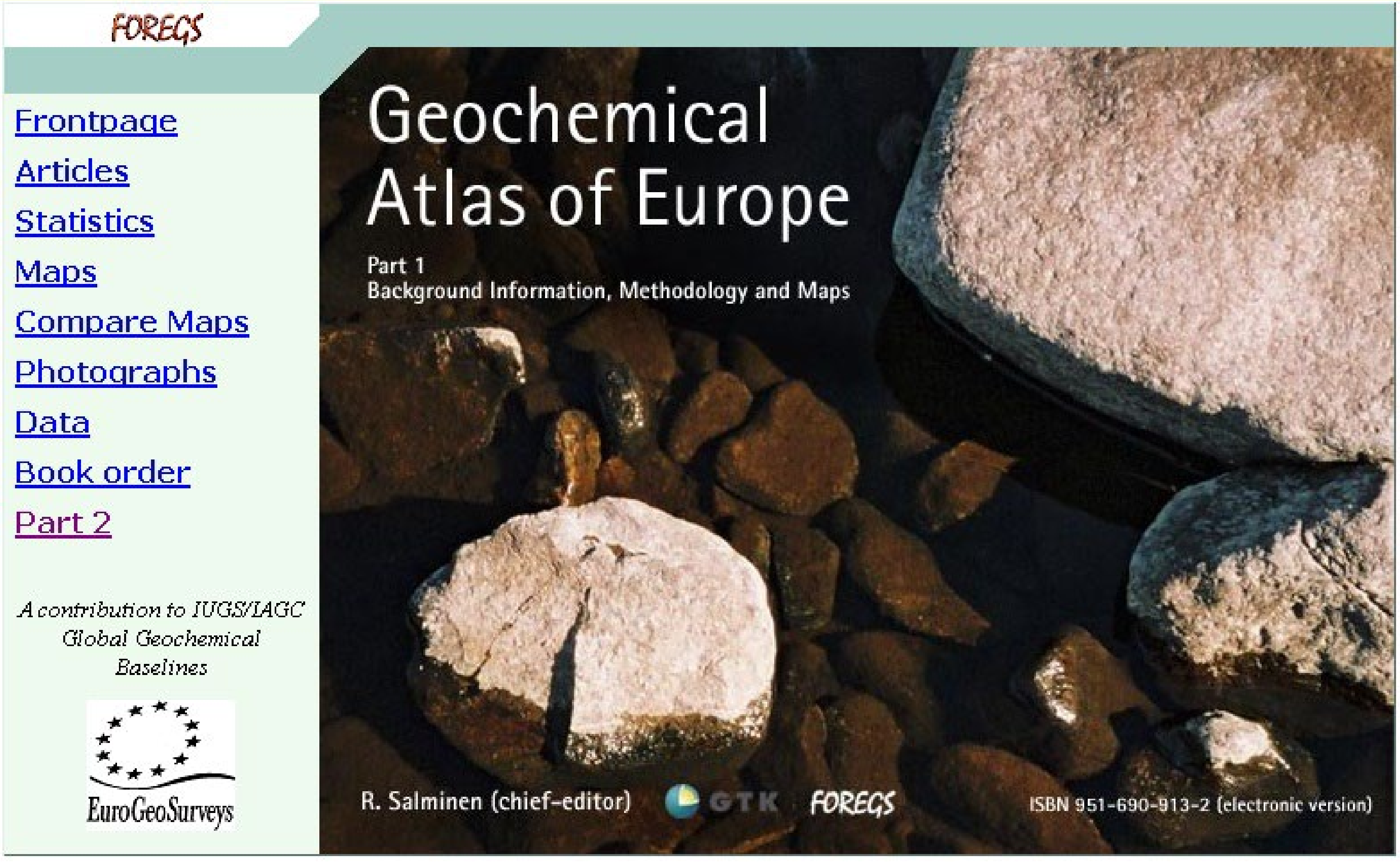
http://weppi.gtk.fi/publ/foregsatlas/

http://weppi.gtk.fi/publ/foregsatlas/part2.php

Databases and material archives comprise:

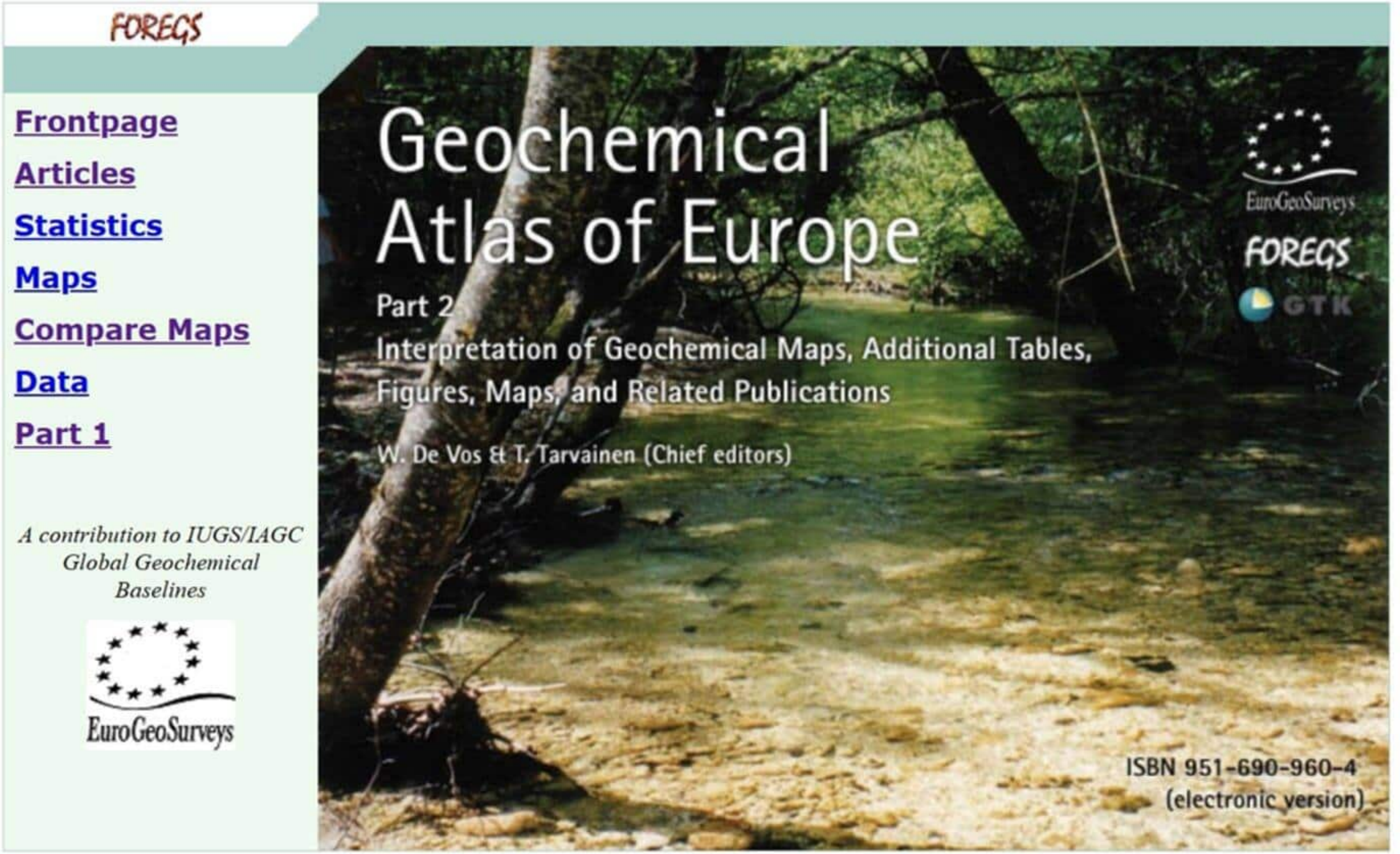
- Archived sample materials;
- Field observation sheets and field maps;
- MS Access databases for field observations of all sample types;
- Analytical data files (Excel);
- Databases of combined field and analytical data and related coverages, and
- Digital photo archive of individual sample sites.

Geochemical Atlas of Europe on-line: Internet publication features: an ArcIMS application



http://weppi.gtk.fi/publ/foregsatlas/

Geochemical Atlas of Europe on-line: Internet publication features: an ArcIMS application



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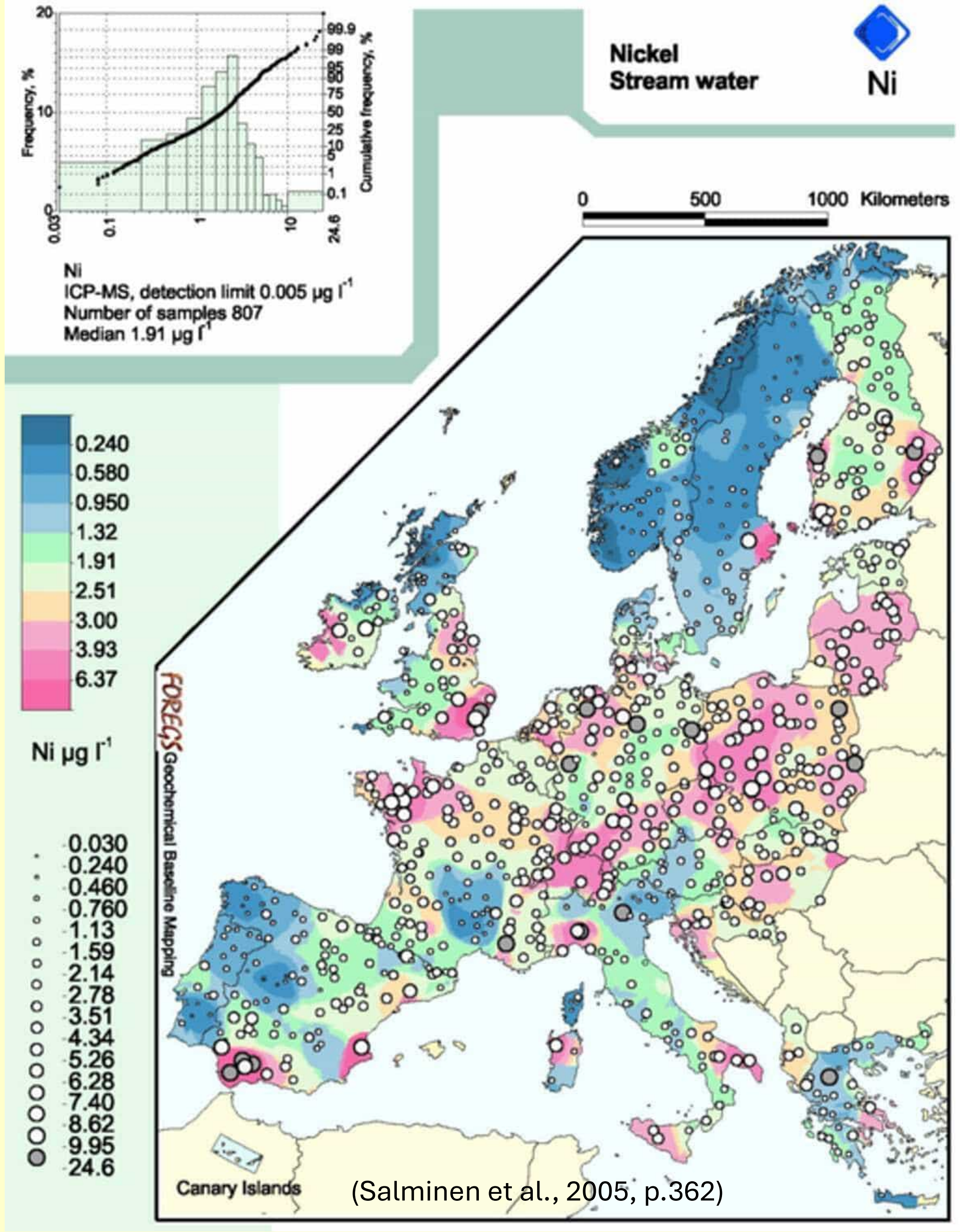


Geochemical baseline concentrations of elements in soil, sediment and water

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

EXISTENCE OF TWO SOURCES OF ABOVE NORMAL CONCENTRATIONS OF ELEMENTS

Baseline

Natural geogenic variation of element ≡ Natural variation of element

Lithology
«Background»

\+ Abnormal concentration of element

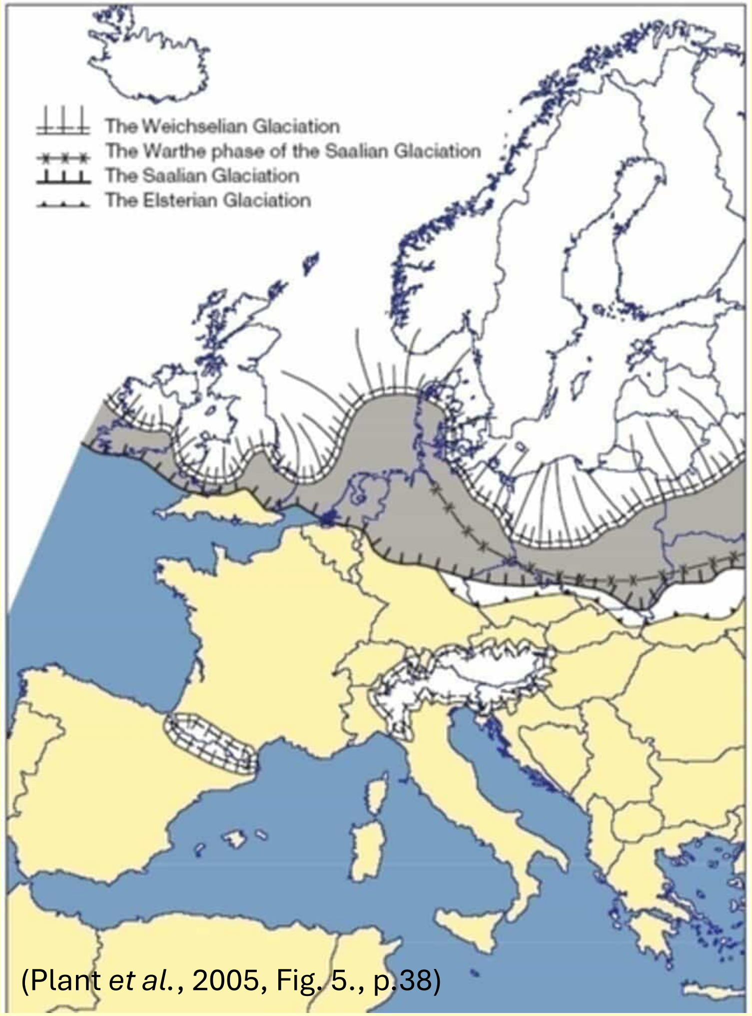
Mineralisation &
Lithology

ANTHROPOGENIC CONTAMINATION ≡ Natural geogenic variation of element + Concentration of element from anthropogenic activities

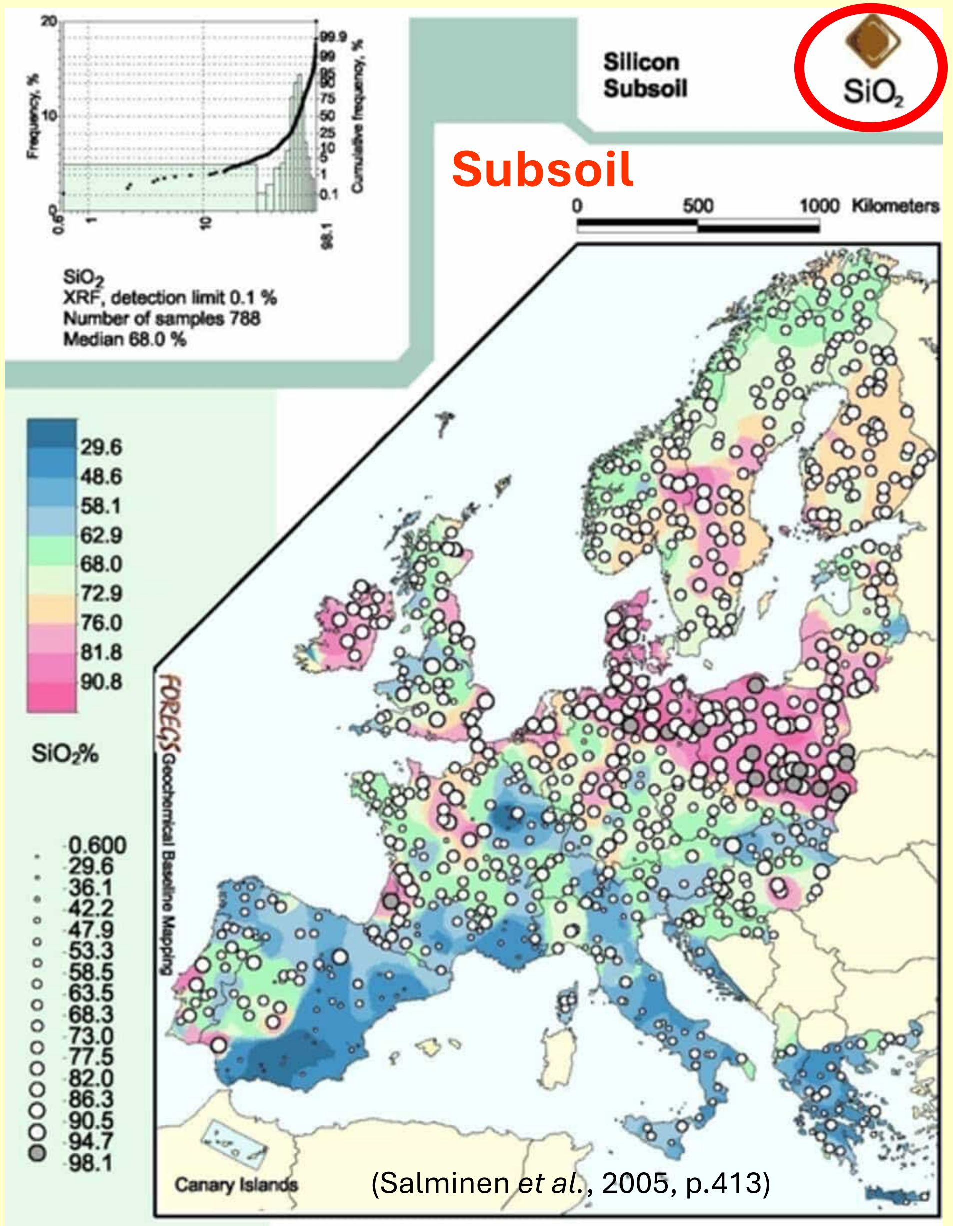
This concept is not understood or unknown to decision makers and the general public

Geochemical Atlas of Europe: Subsoil

Glacial sands are enriched in SiO_2



(Plant *et al.*, 2005, Fig. 5., p.38)



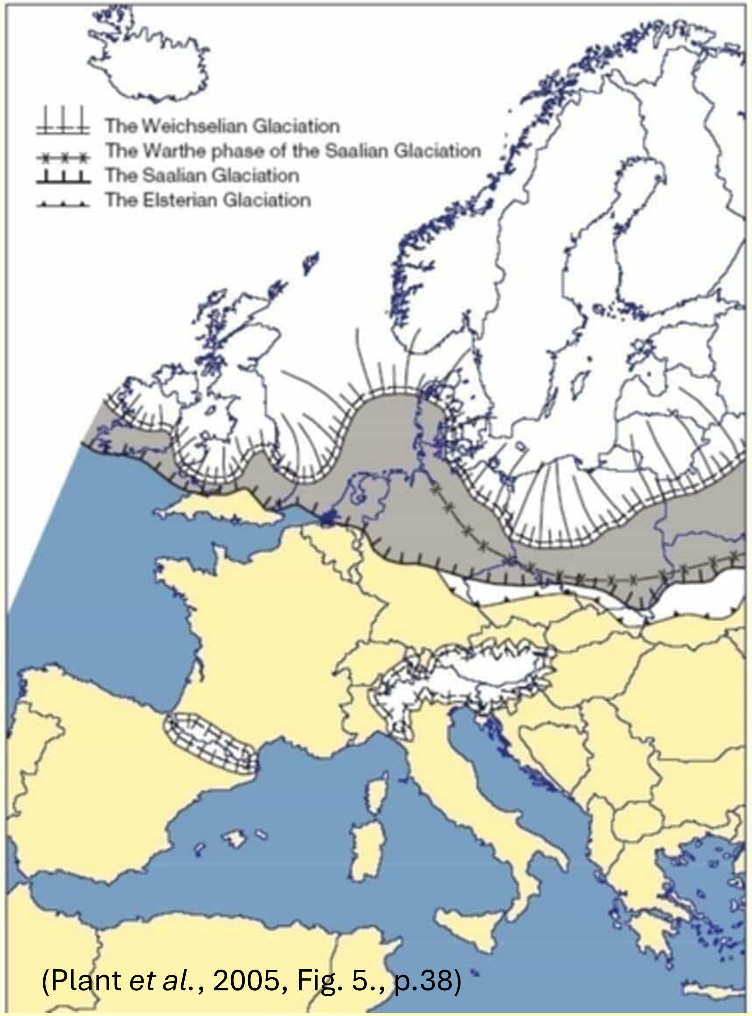
(Salminen *et al.*, 2005, p.413)

Mapping the limit of the last glaciation

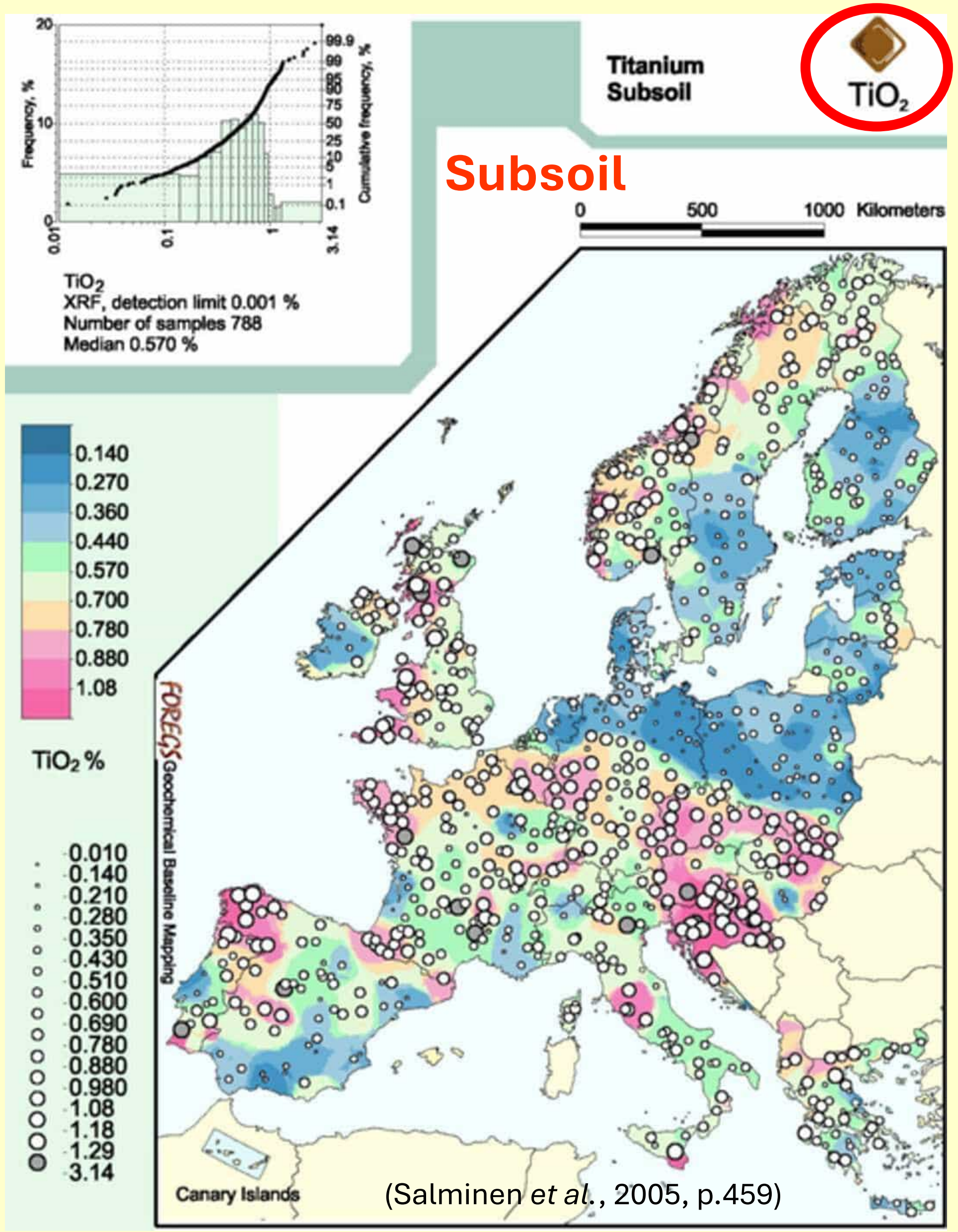
EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Geochemical Atlas of Europe: Subsoil

Glacial sands are depleted in TiO_2



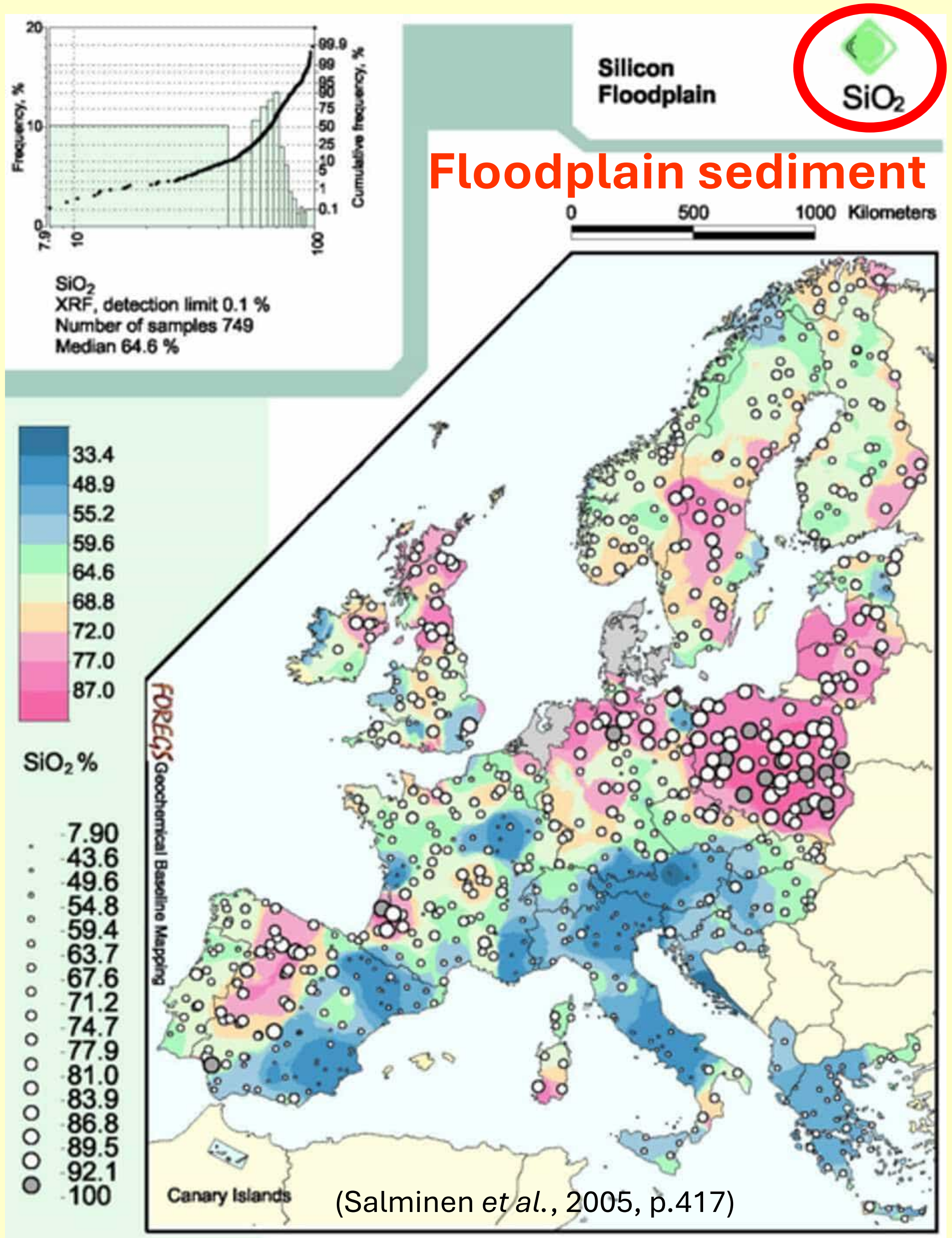
(Plant *et al.*, 2005, Fig. 5., p.38)

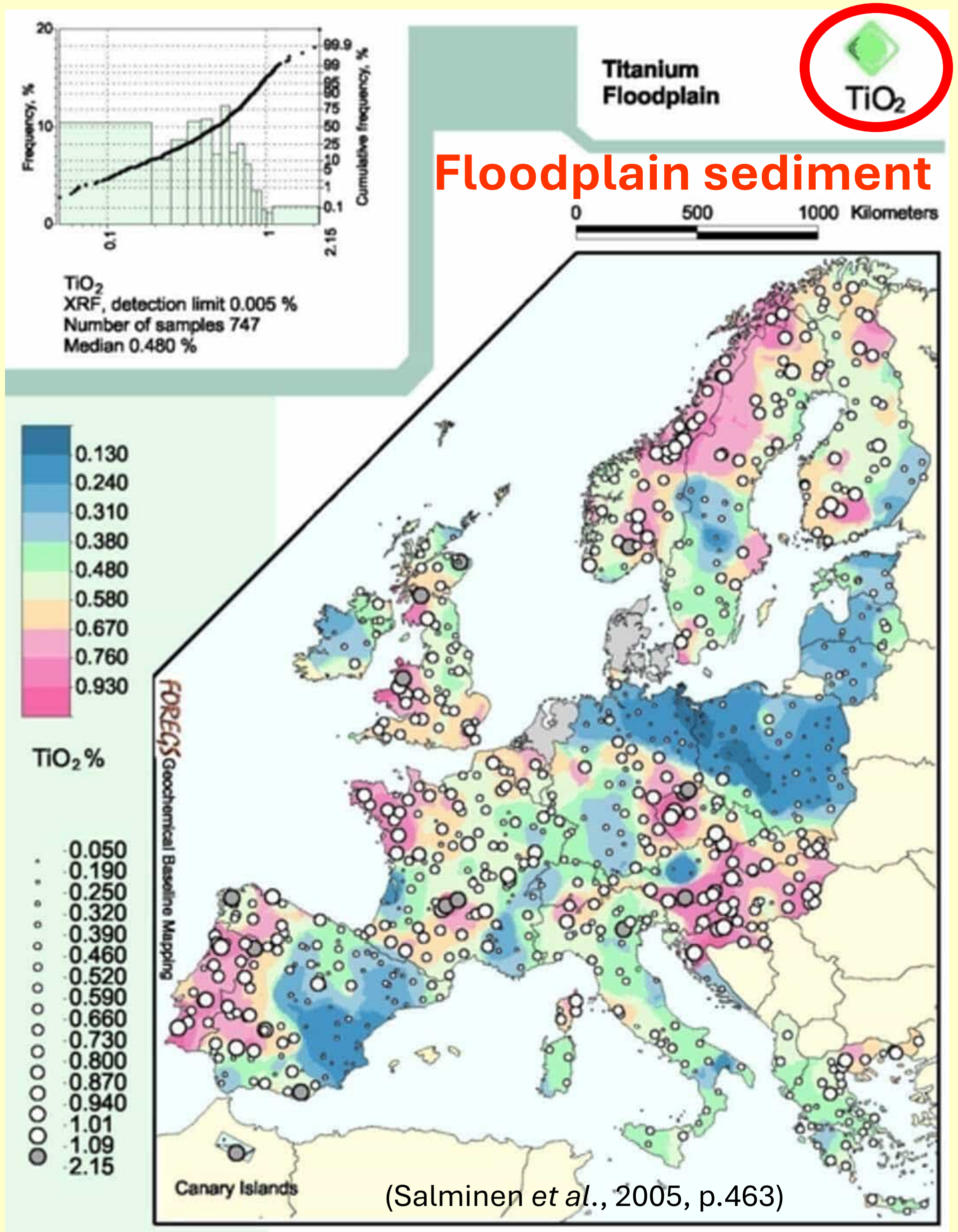


(Salminen *et al.*, 2005, p.459)

Mapping the limit of the last glaciation

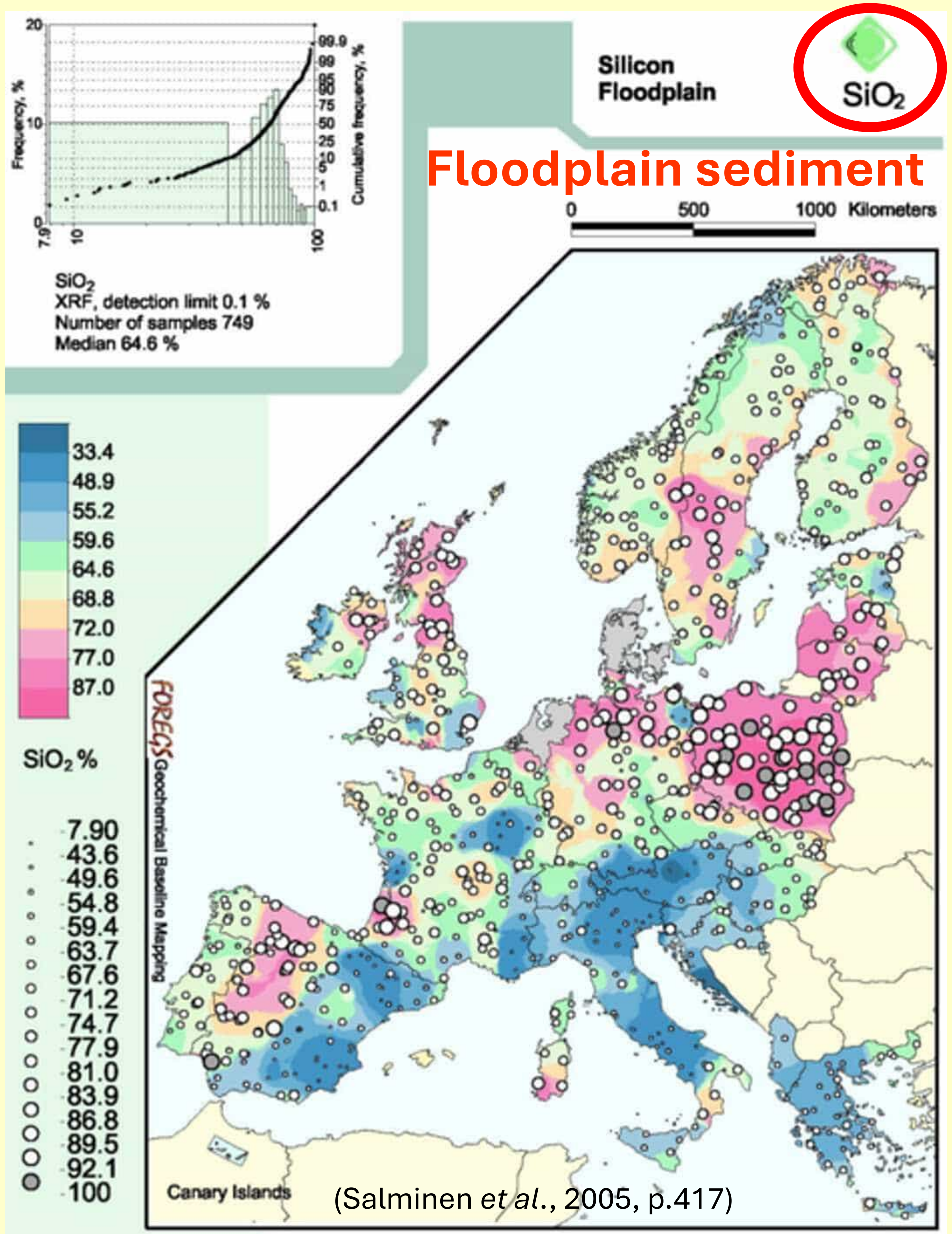
EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

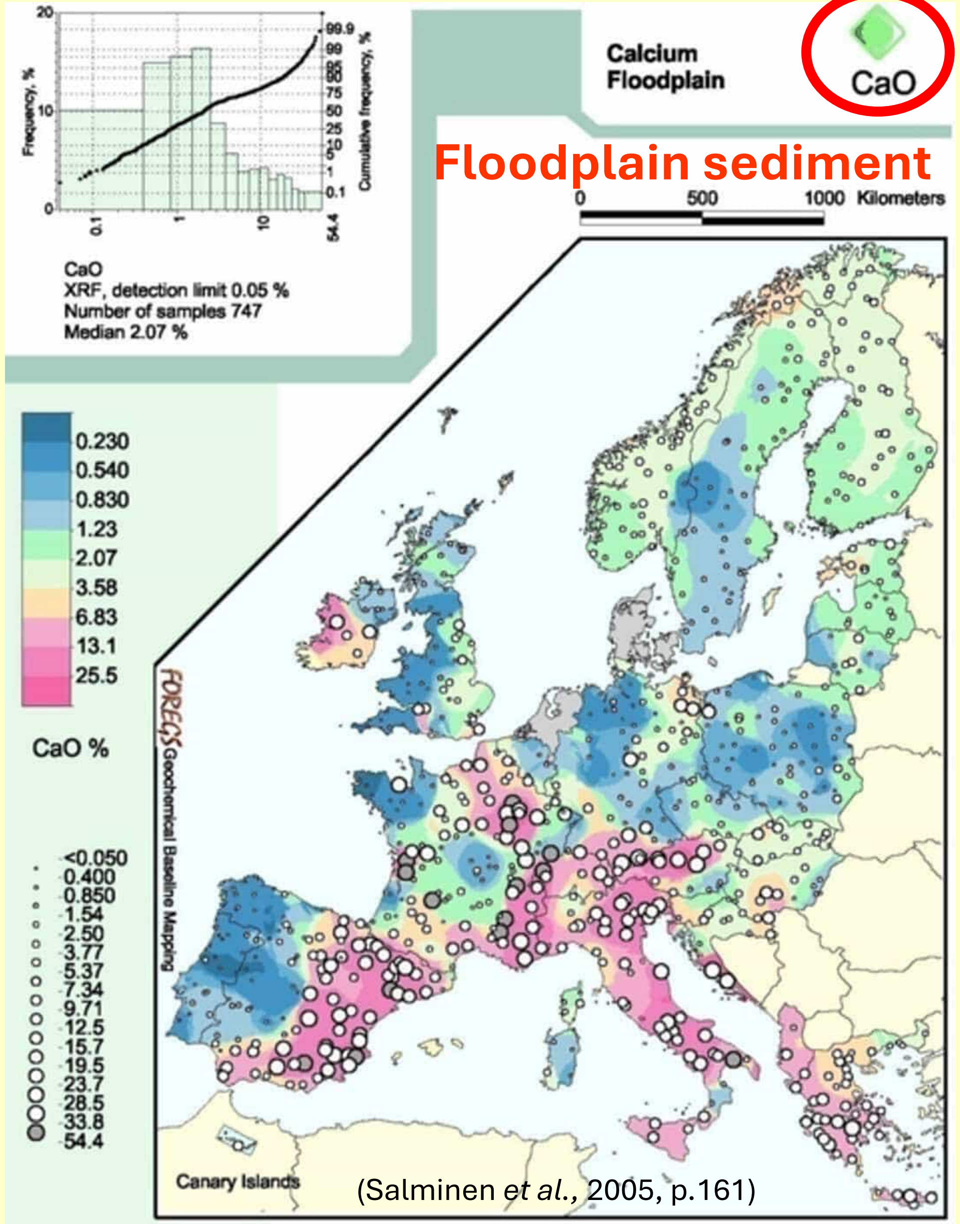




Mapping the limit of the last glaciation

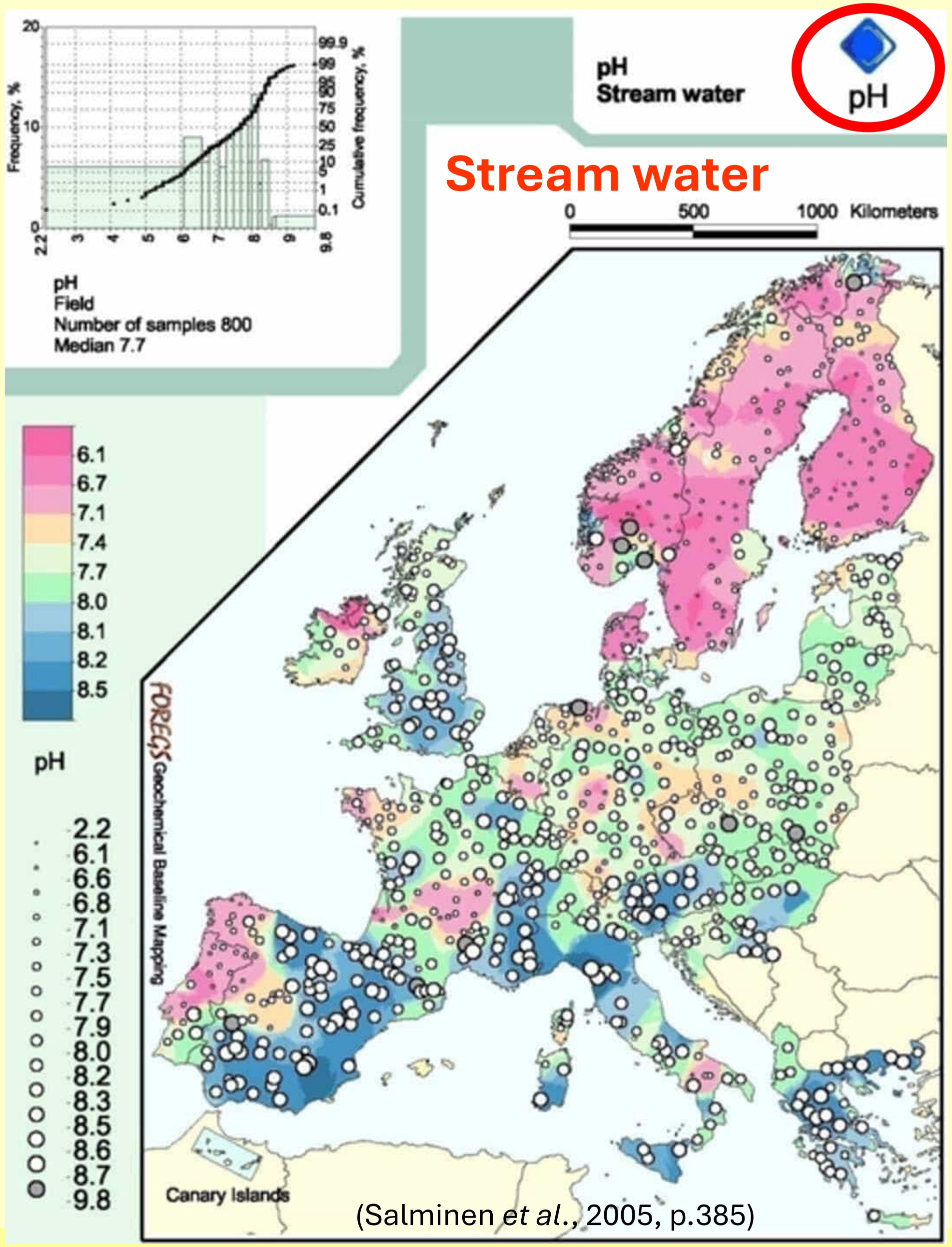
EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)



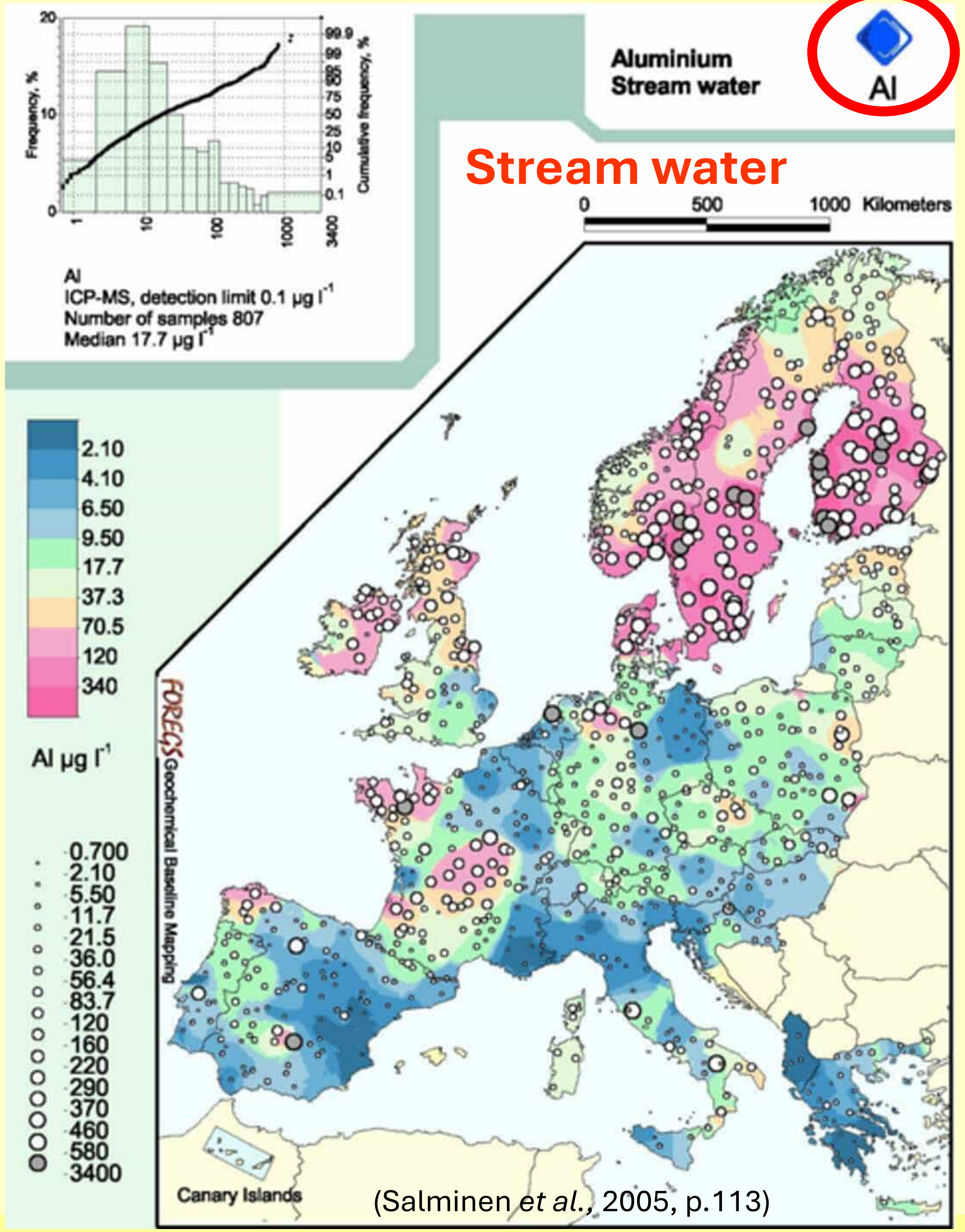


Mapping Felsic or Silica rich rocks, and Carbonate rocks

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

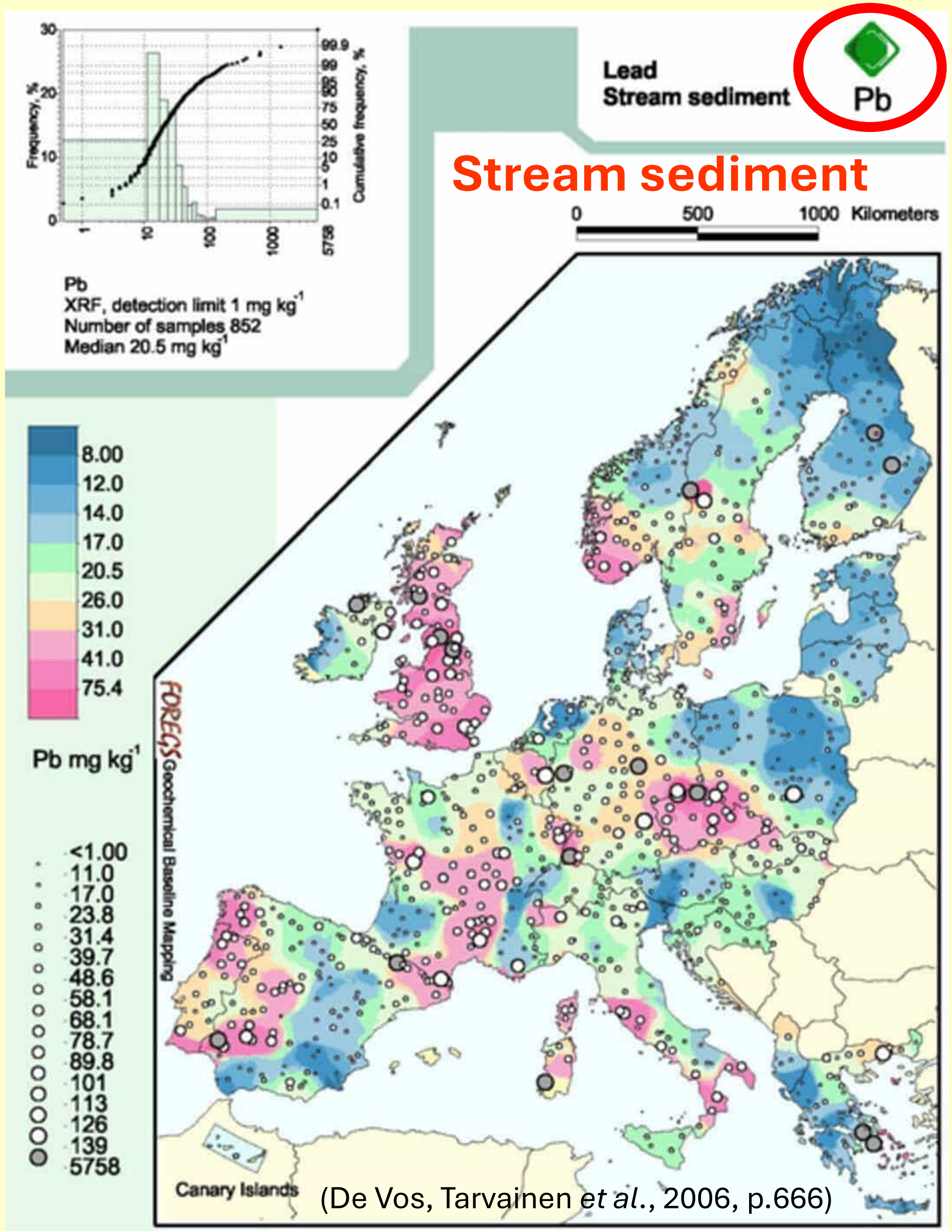


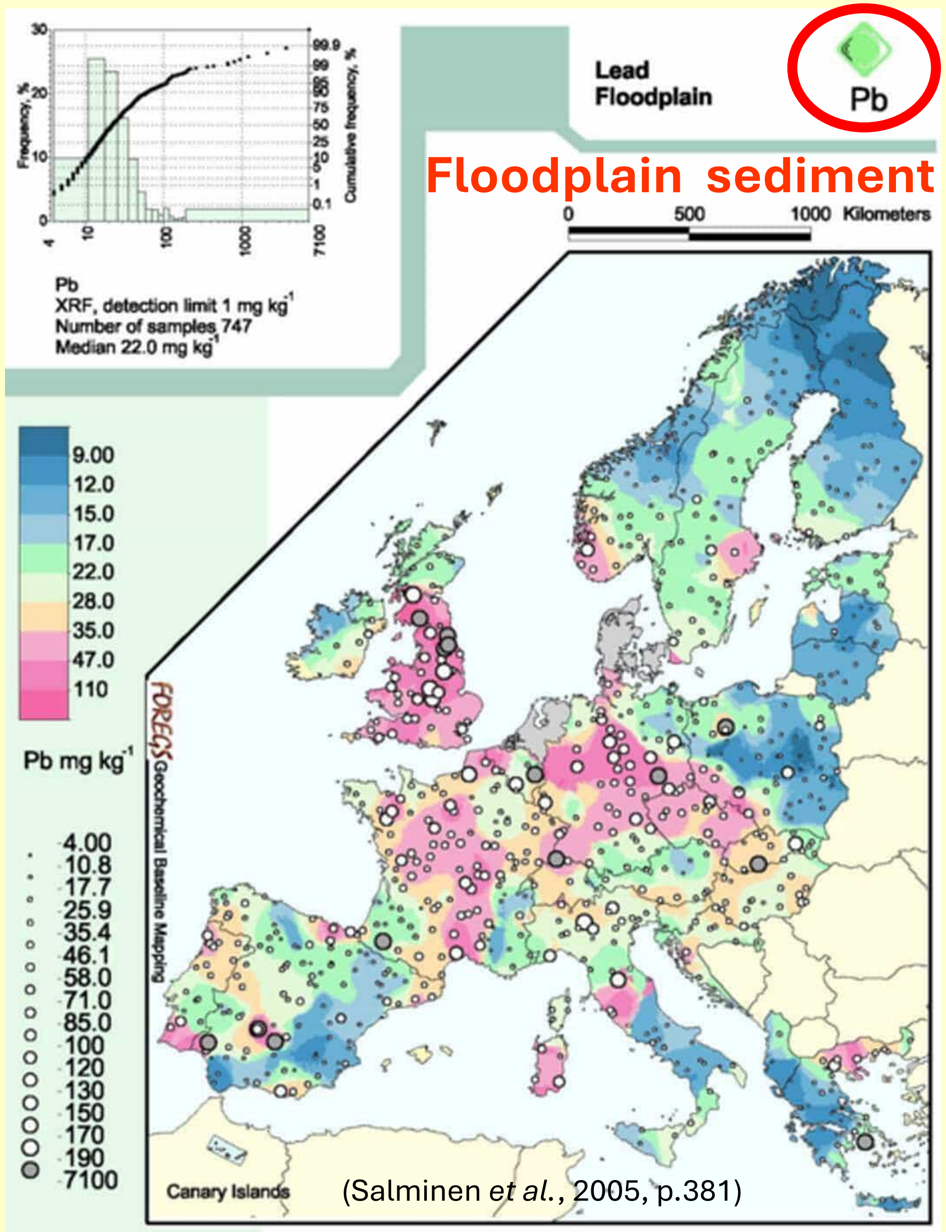
(Salminen *et al.*, 2005, p.385)



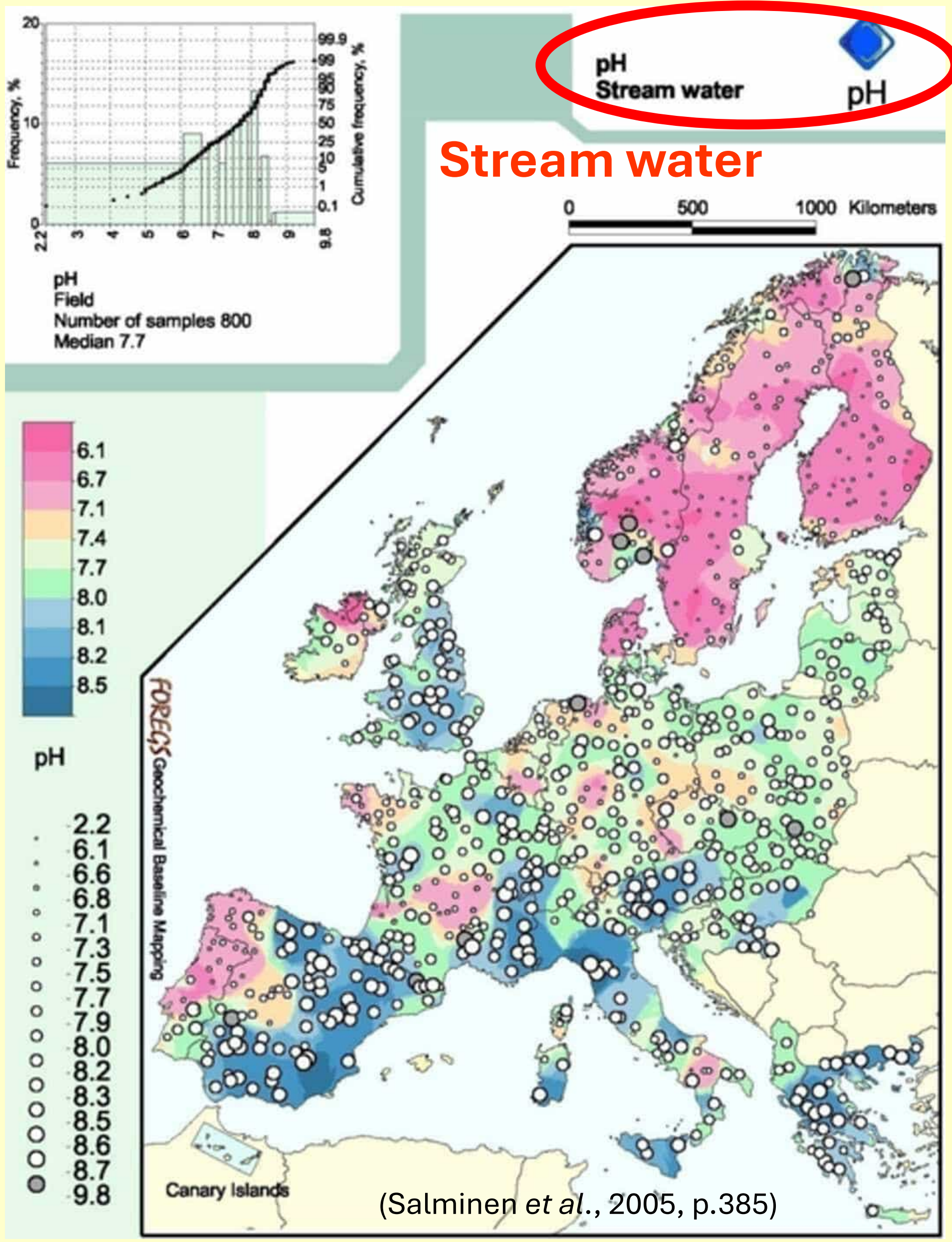
(Salminen *et al.*, 2005, p.113)

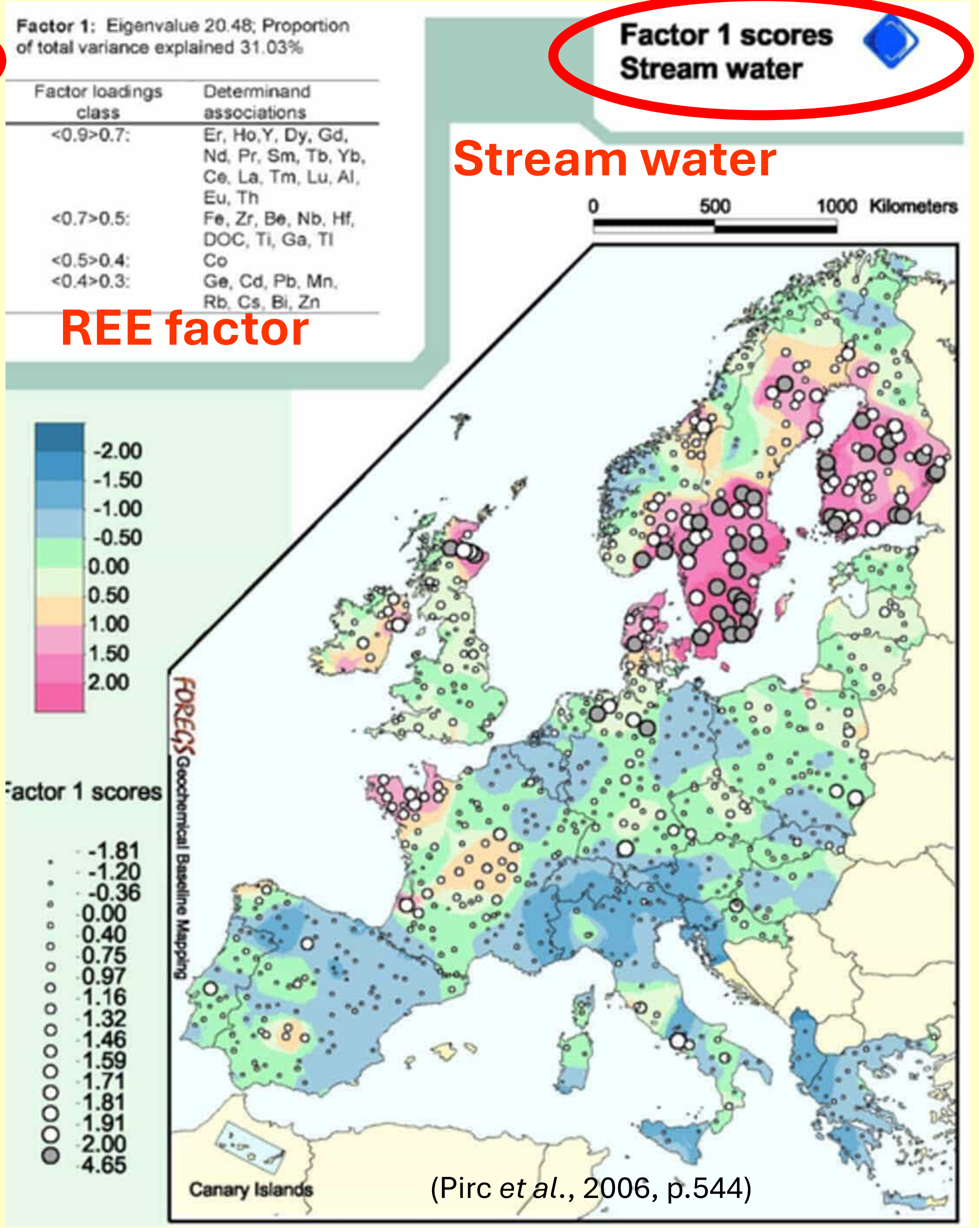
Stream water is more acid in Scandinavian countries, due to the low base cation capacity of metamorphic basement rocks and high concentration of humic and fulvic acids, typical of boreal climate. Low pH values result in higher solubility of aluminium and some metals.



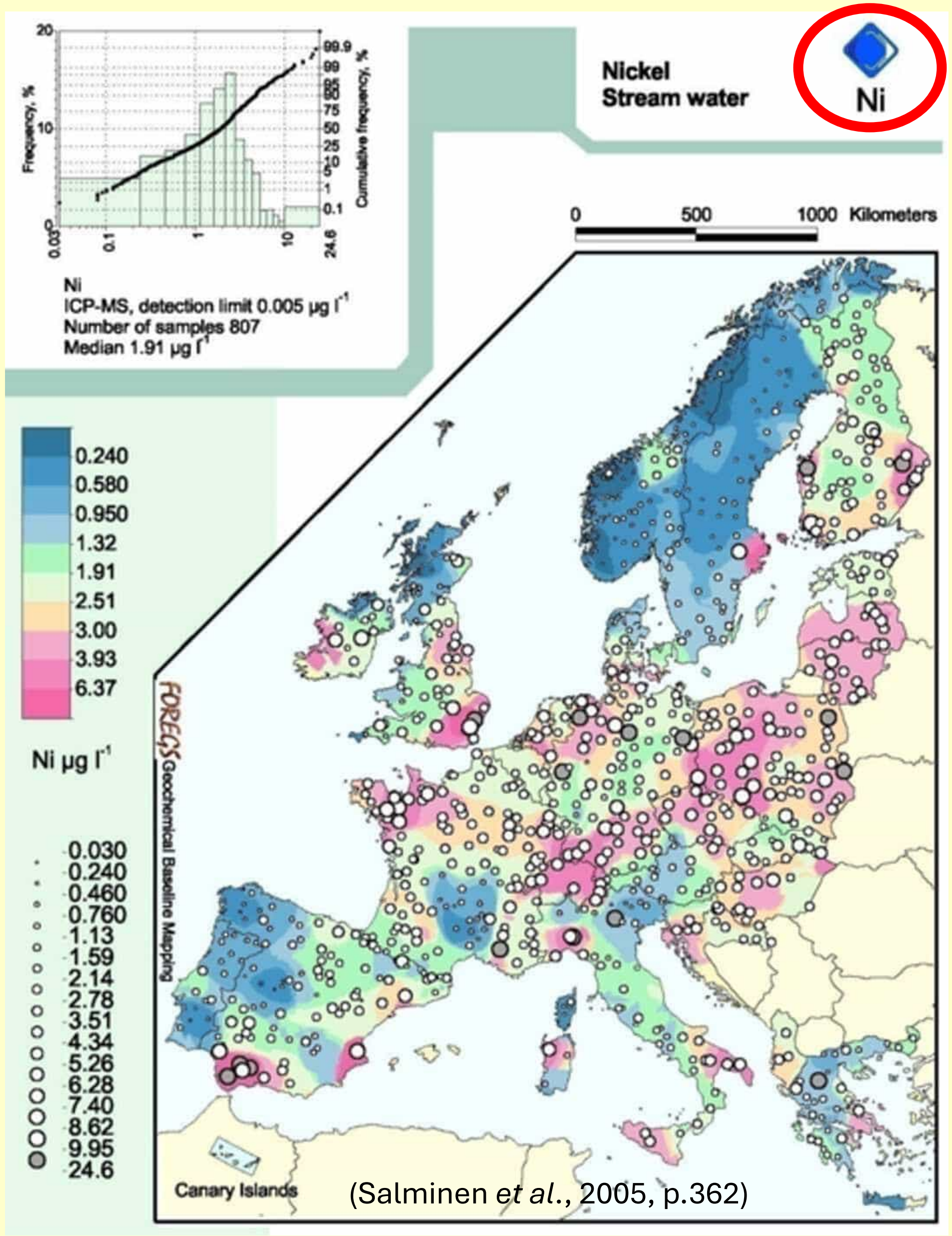


Surprisingly, almost similar patterns, although sample types & sites are different

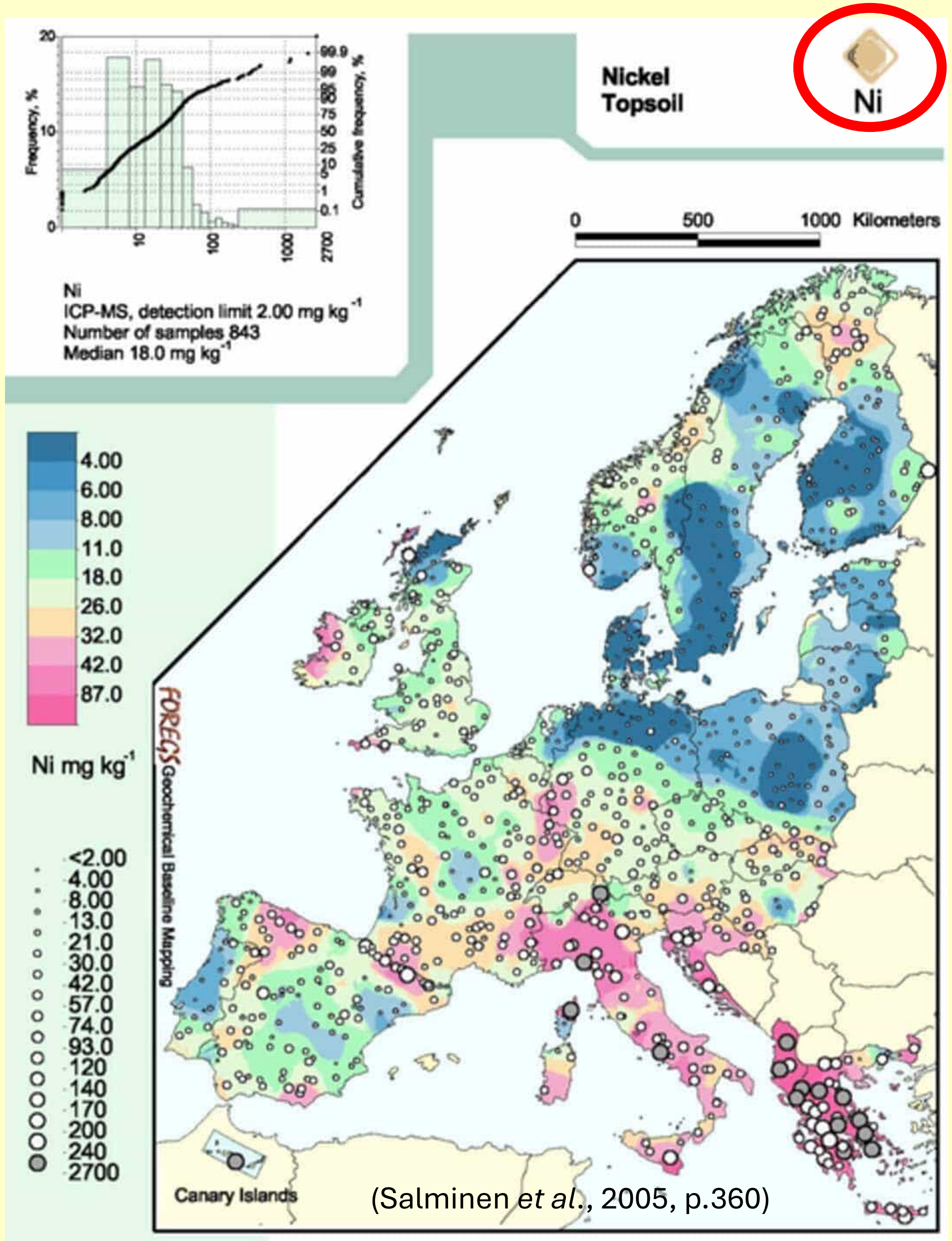




Factor 1 scores: Rare earth elements (REEs). Their anomalies in southern Fennoscandia are related to acid pH and high levels of dissolved organic carbon.



Stream water



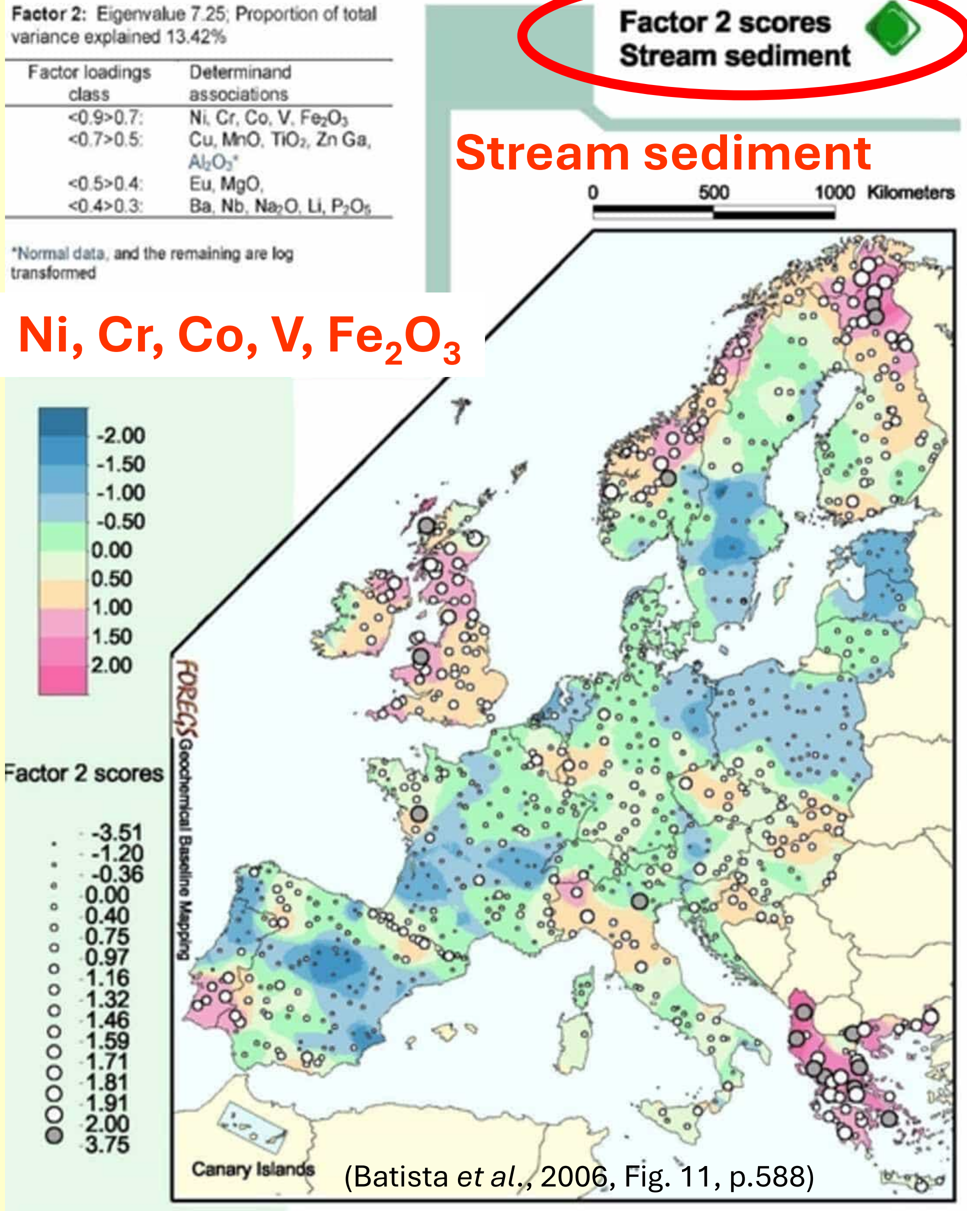
Topsoil (0-25 cm)

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Factor 2: Eigenvalue 7.25; Proportion of total variance explained 13.42%

Factor loadings class	Determinand associations
<0.9>0.7:	Ni, Cr, Co, V, Fe_2O_3
<0.7>0.5:	Cu, MnO, TiO_2, Zn Ga, Al_2O_3*
<0.5>0.4:	Eu, MgO,
<0.4>0.3:	Ba, Nb, Na_2O, Li, P_2O_5

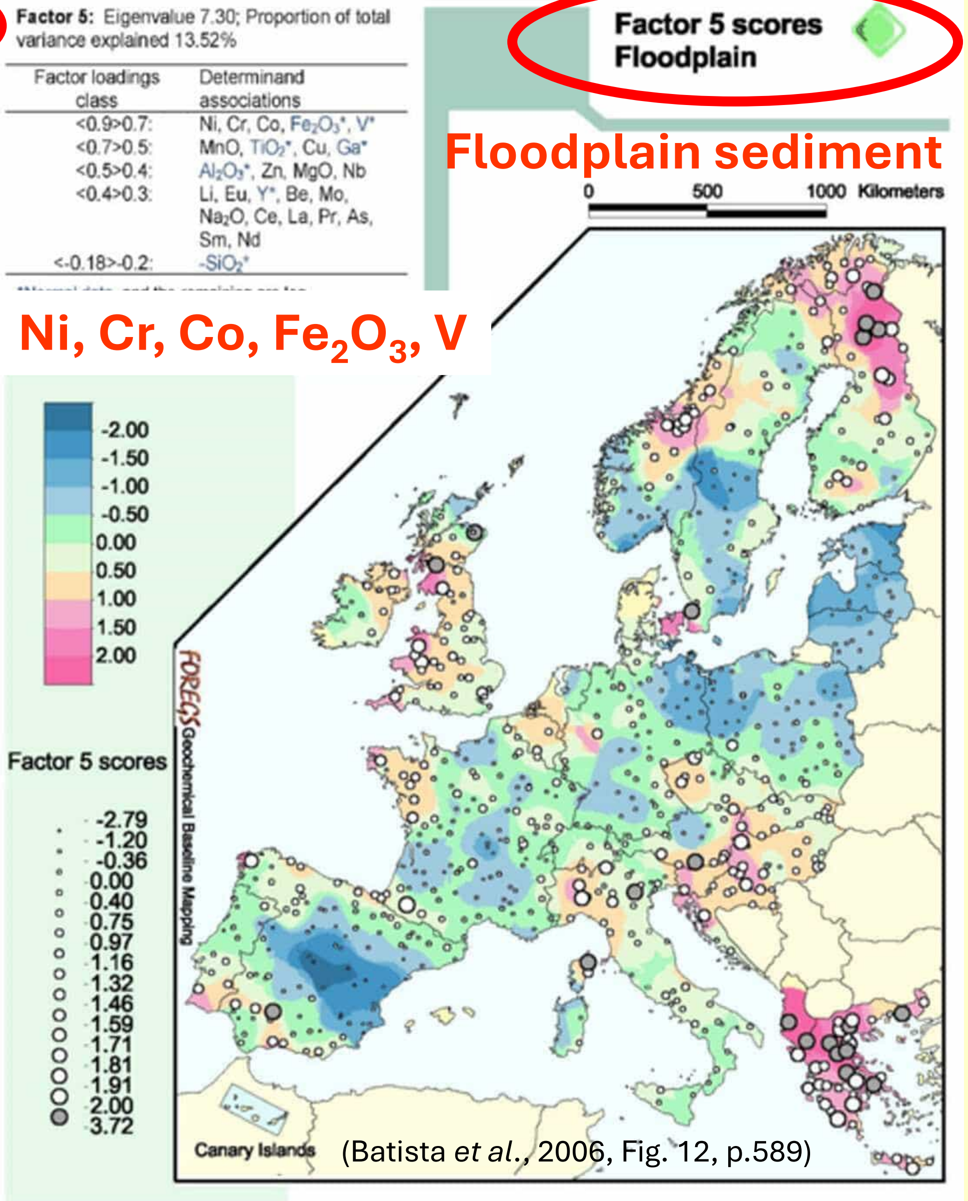
*Normal data, and the remaining are log transformed



(Batista *et al*., 2006, Fig. 11, p.588)

Factor 5: Eigenvalue 7.30; Proportion of total variance explained 13.52%

Factor loadings class	Determinand associations
<0.9>0.7:	Ni, Cr, Co, Fe_2O_3*, V*
<0.7>0.5:	MnO, TiO_2*, Cu, Ga*
<0.5>0.4:	Al_2O_3*, Zn, MgO, Nb
<0.4>0.3:	Li, Eu, Y*, Be, Mo, Na_2O, Ce, La, Pr, As, Sm, Nd
<-0.18>-0.2:	-SiO_2*

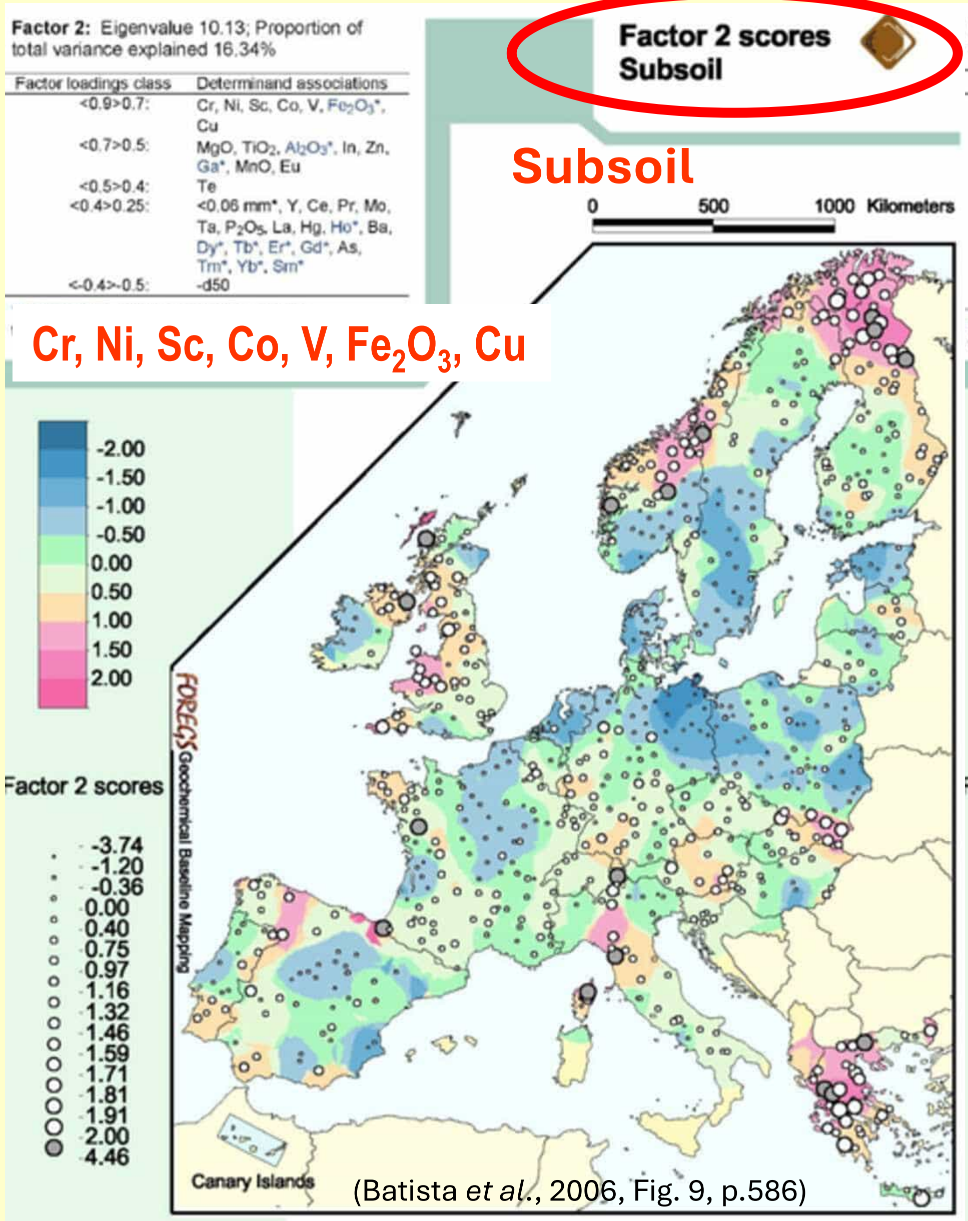


(Batista *et al*., 2006, Fig. 12, p.589)

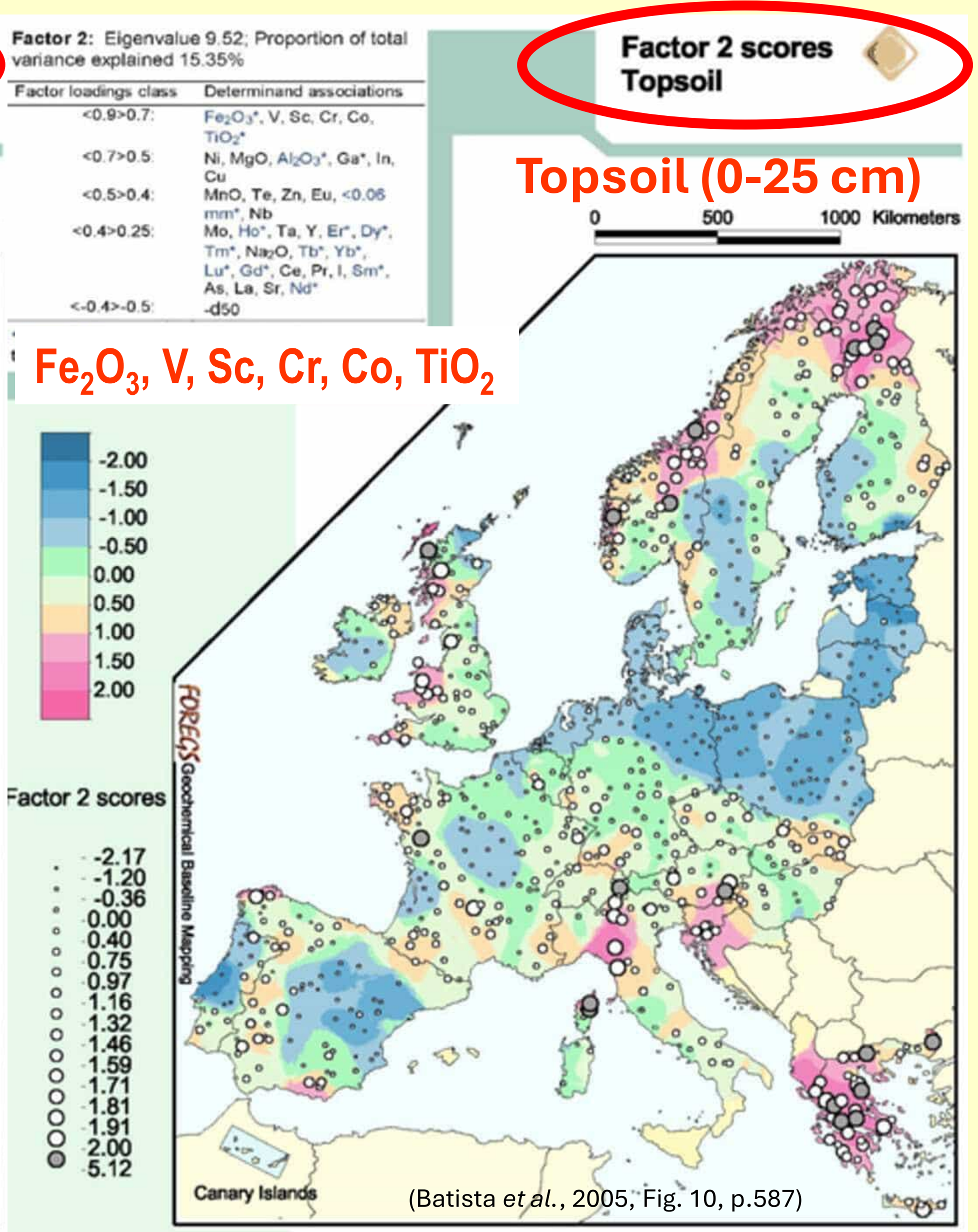
Factor analysis: Association of elements in mafic and ultramafic rocks

Mafic-Ultramafic rock element factor

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)



(Batista *et al.*, 2006, Fig. 9, p.586)



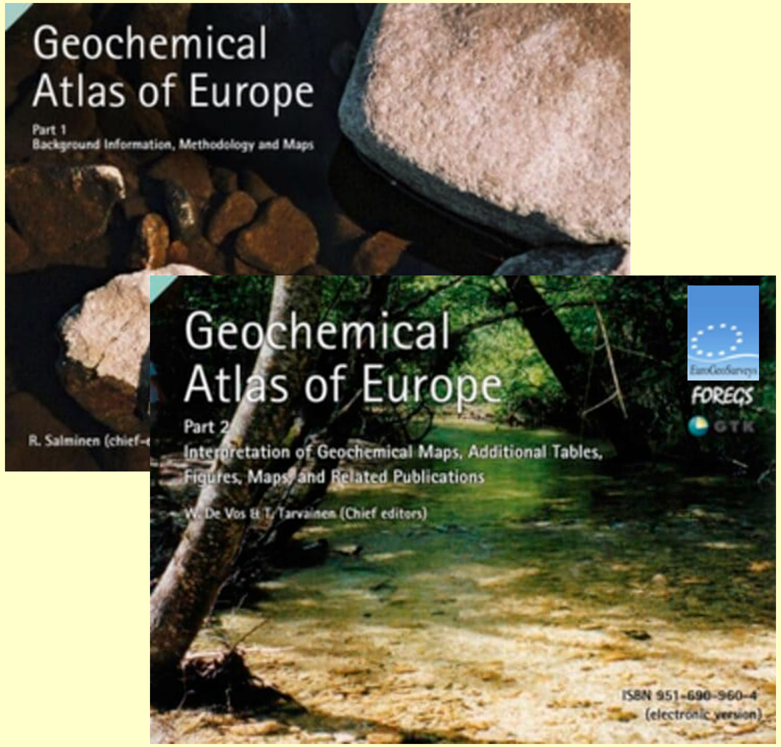
(Batista *et al.*, 2005, Fig. 10, p.587)

Factor analysis: Association of elements in mafic and ultramafic rocks

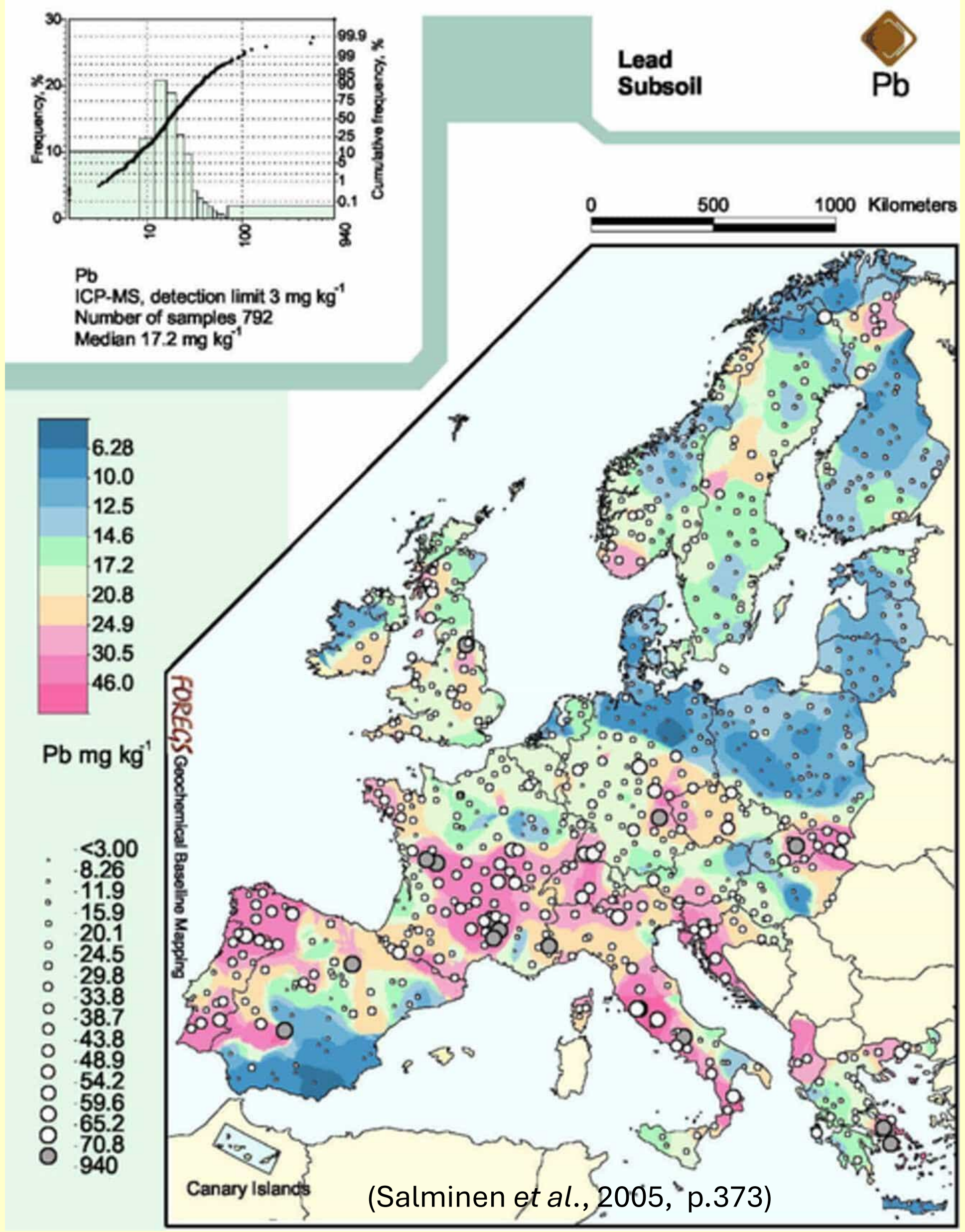
Mafic-Ultramafic rock element factor

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Use of geochemical data in:



- Mineral exploration,
- Farming & forestry
- Land use policy
- Health issues
- Environmental policy

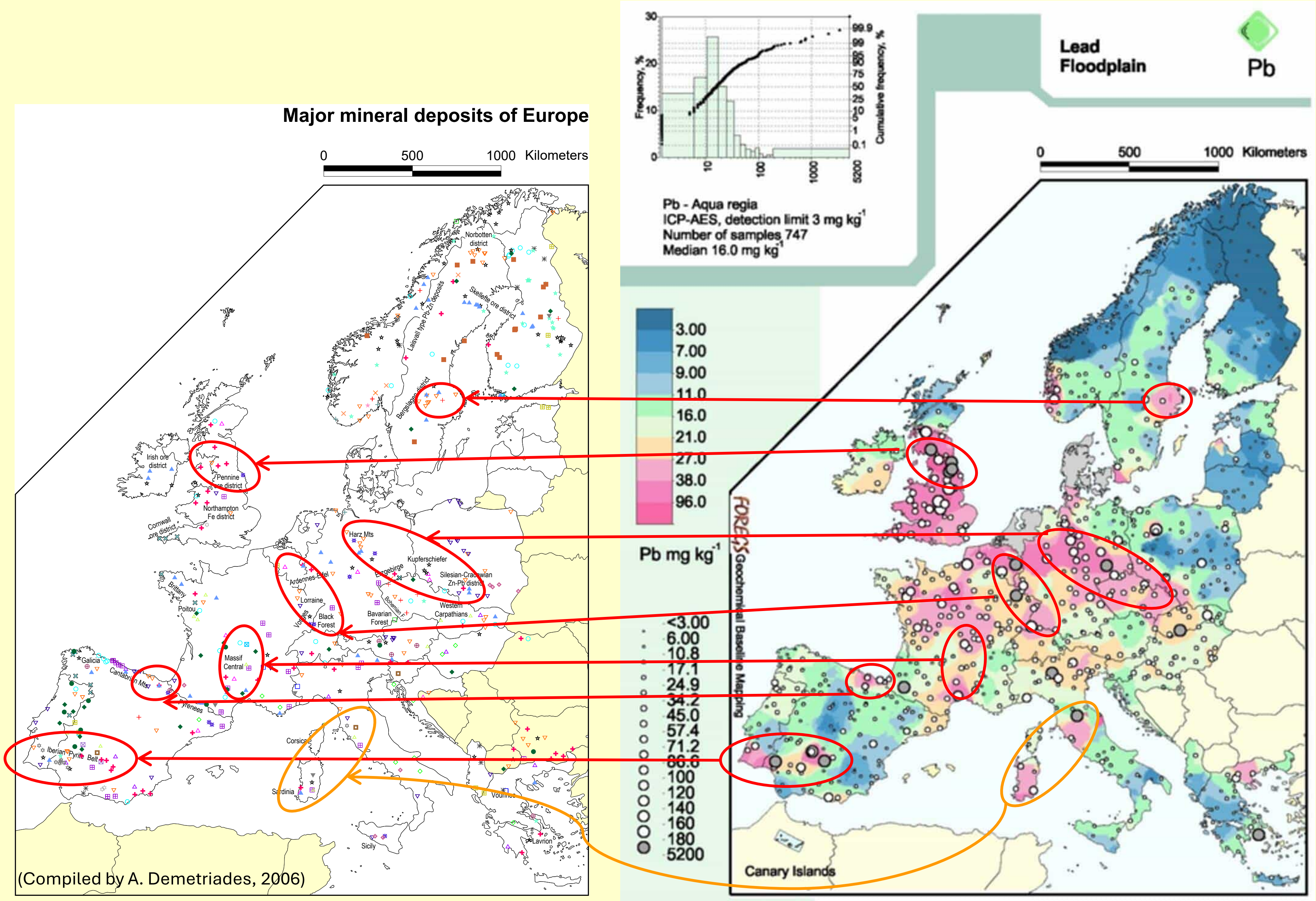


(Salminen *et al*., 2005, p.373)

Use of continental scale geochemical data in mineral exploration:

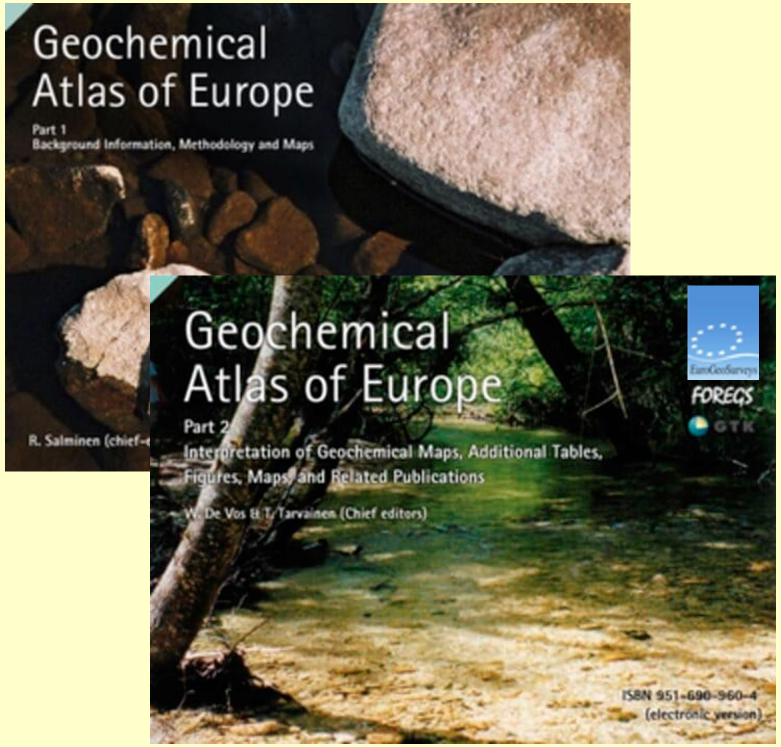
Location of new metallogenic provinces?

At the continental-scale of 1 sample site/4800 km^2 only large-size anomalies are delineated, namely those associated with metallogenetic provinces



De Vos, Tarvainen et al., 2006, p.430,
http://weppi.gtk.fi/publ/foregsatlas/articles/Discussion.pdf

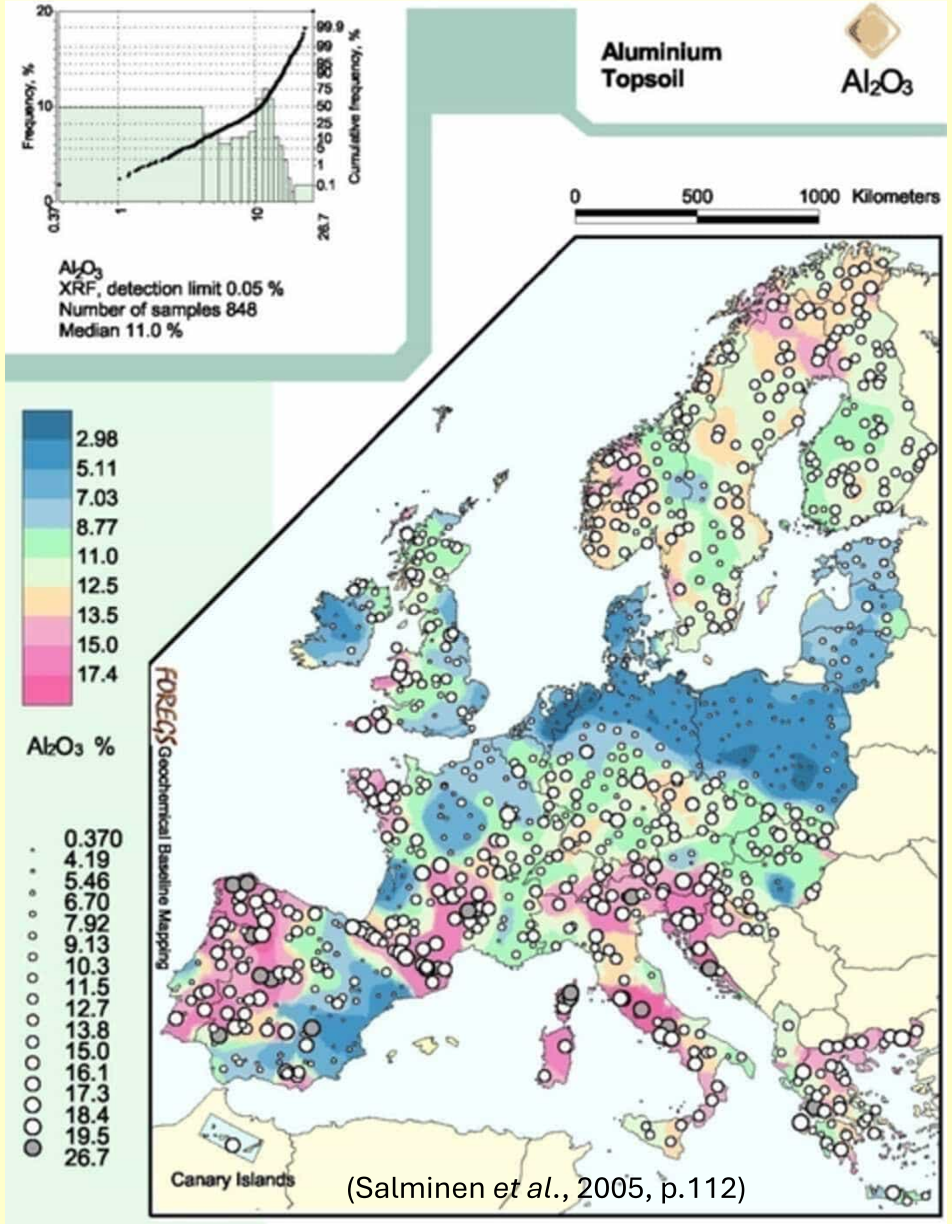
Salminen et al., 2005, p.381,
http://weppi.gtk.fi/publ/foregsatlas/maps/Floodplain/f_aricpaes_pb_edit.pdf



Use of geochemical data in

- Farming and
- Forestry

Essential chemical elements for plants and animals



(Salminen *et al.*, 2005, p.112)

- Seventeen trace elements are considered essential for all plants: Al, B, Br, Cl, Co, Cu, F, Fe, I, Mn, Mo, Ni, Rb, Si, Ti, V and Zn.

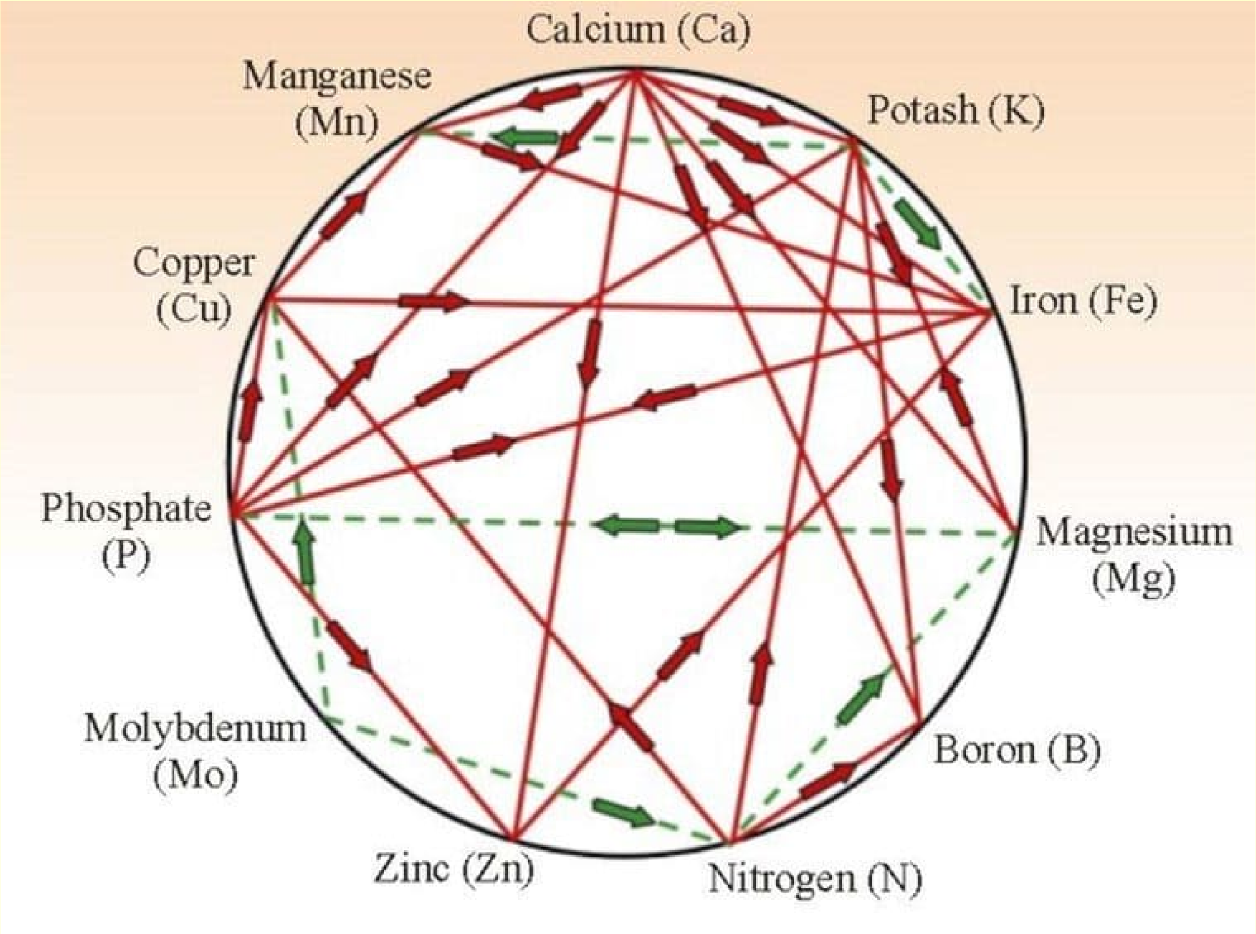
- Essential elements for animals are: Ca, Cl, Co, Cr, Cu, F, Fe, I, K, Mg, Mn, N, P, S, Se and Zn

The Geochemical Atlas of Europe can pinpoint problem areas for follow-up work.

Synergism: Increased availability of a nutrient to the plant due to the increase level of another nutrient

Antagonism: Decreased availability to the plant of a nutrient, due to the action of another nutrient

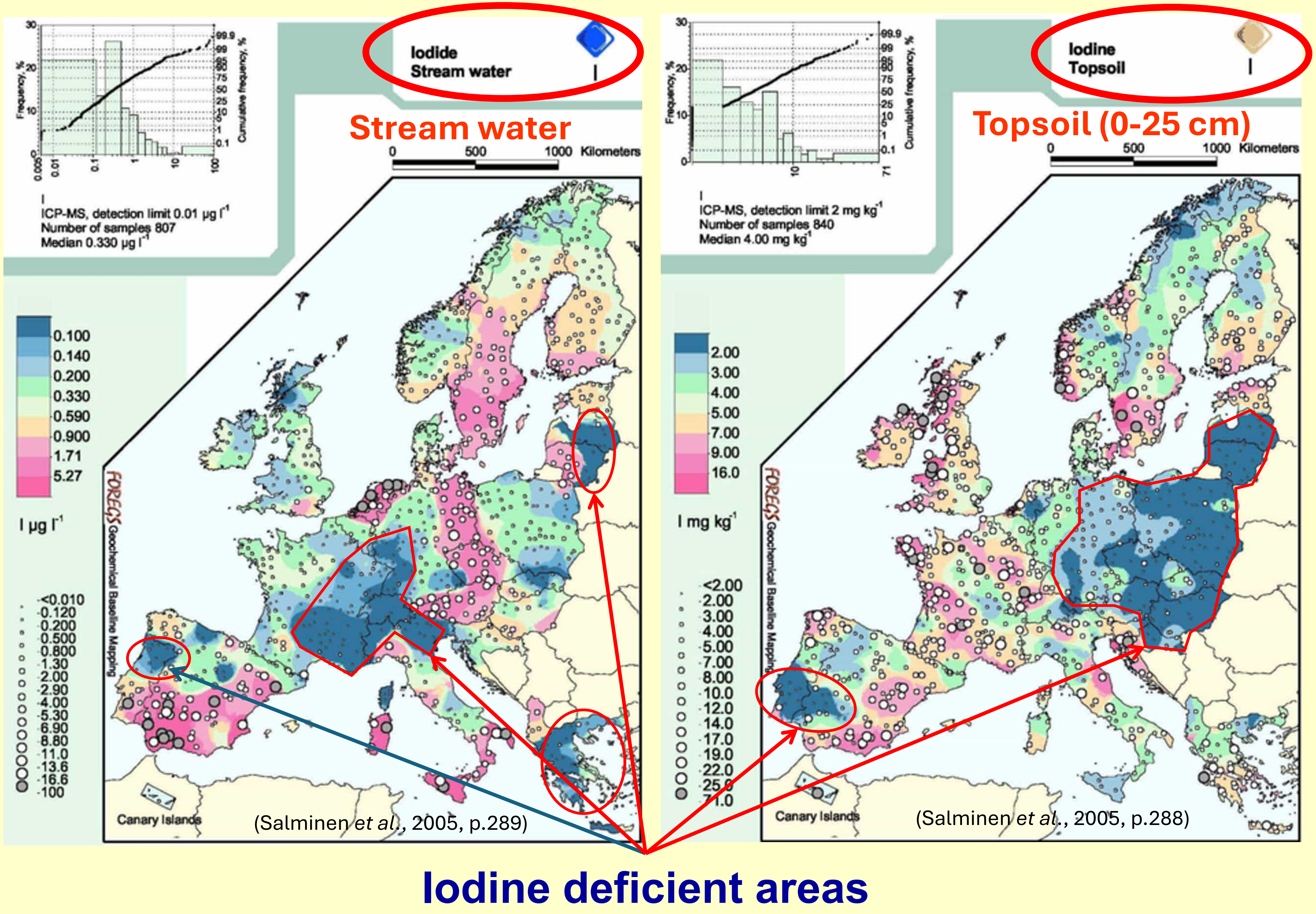
Mulder's chart Interaction between the various nutrients



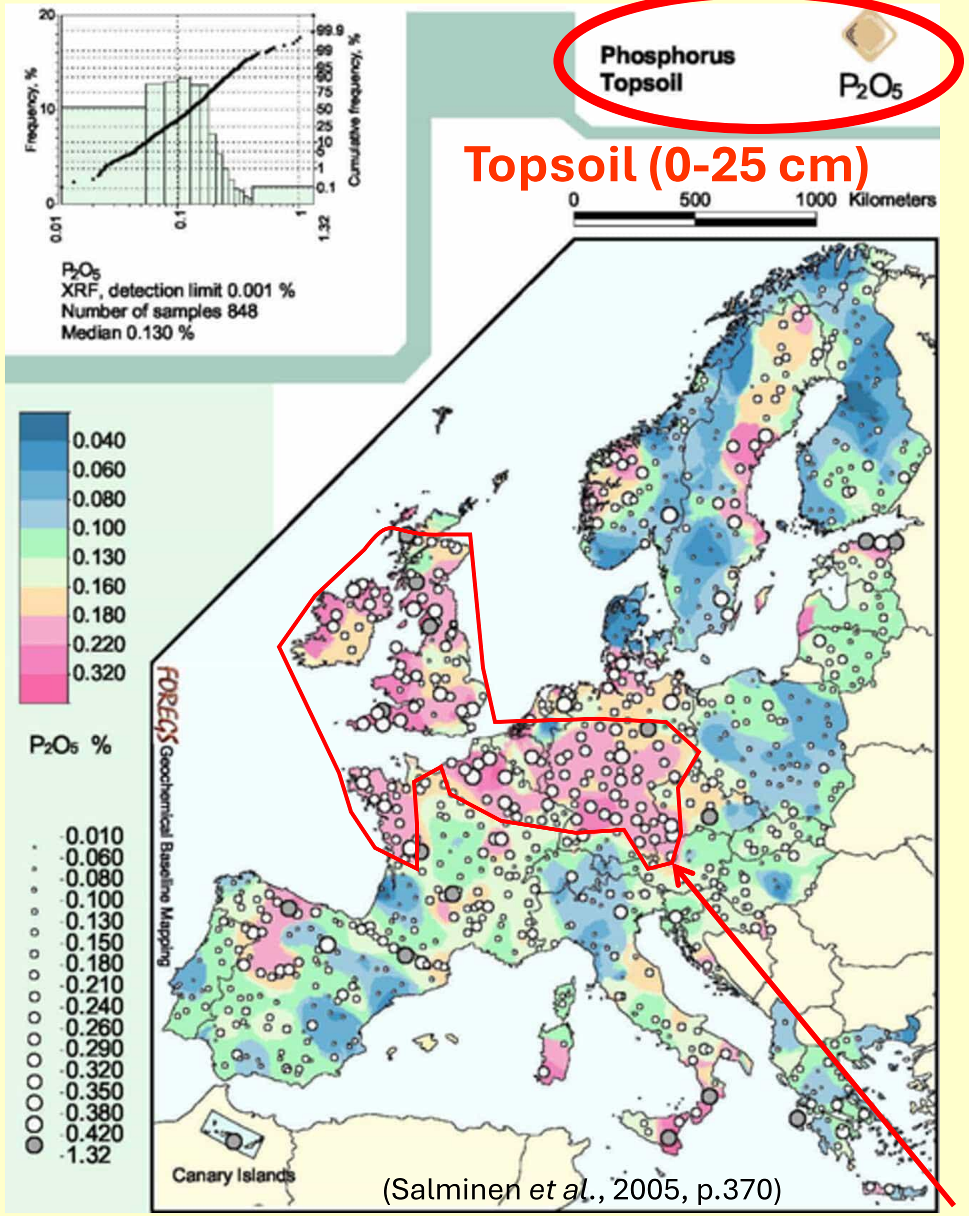
Source: https://www.canr.msu.edu/news/more_reasons_for_soil_testing

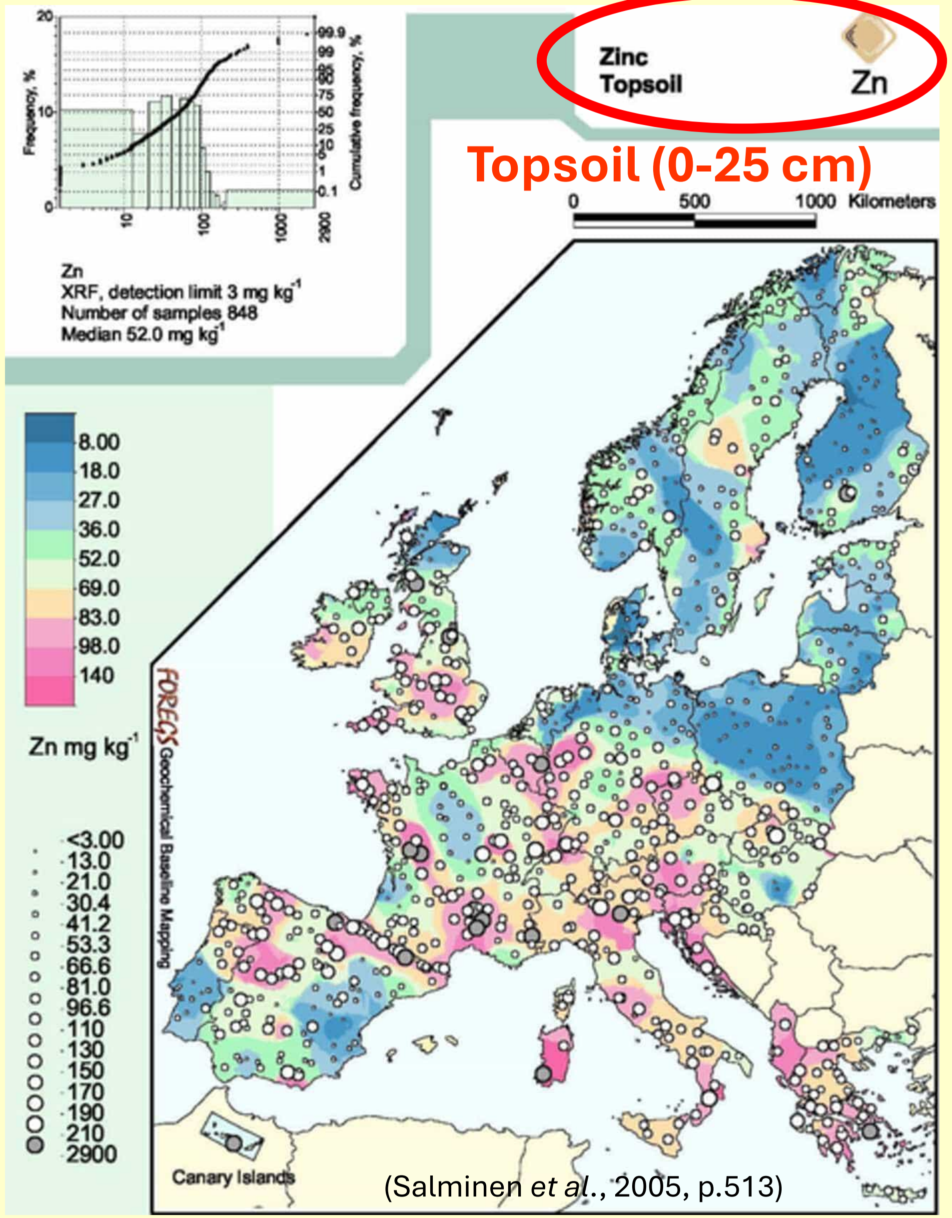
- Zn absorption by a plant is dependent upon the levels of P, Fe & Ca in soil.

- High P levels in soil antagonise the uptake of Zn, Cu & K, but stimulate the uptake of Mg.



EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)



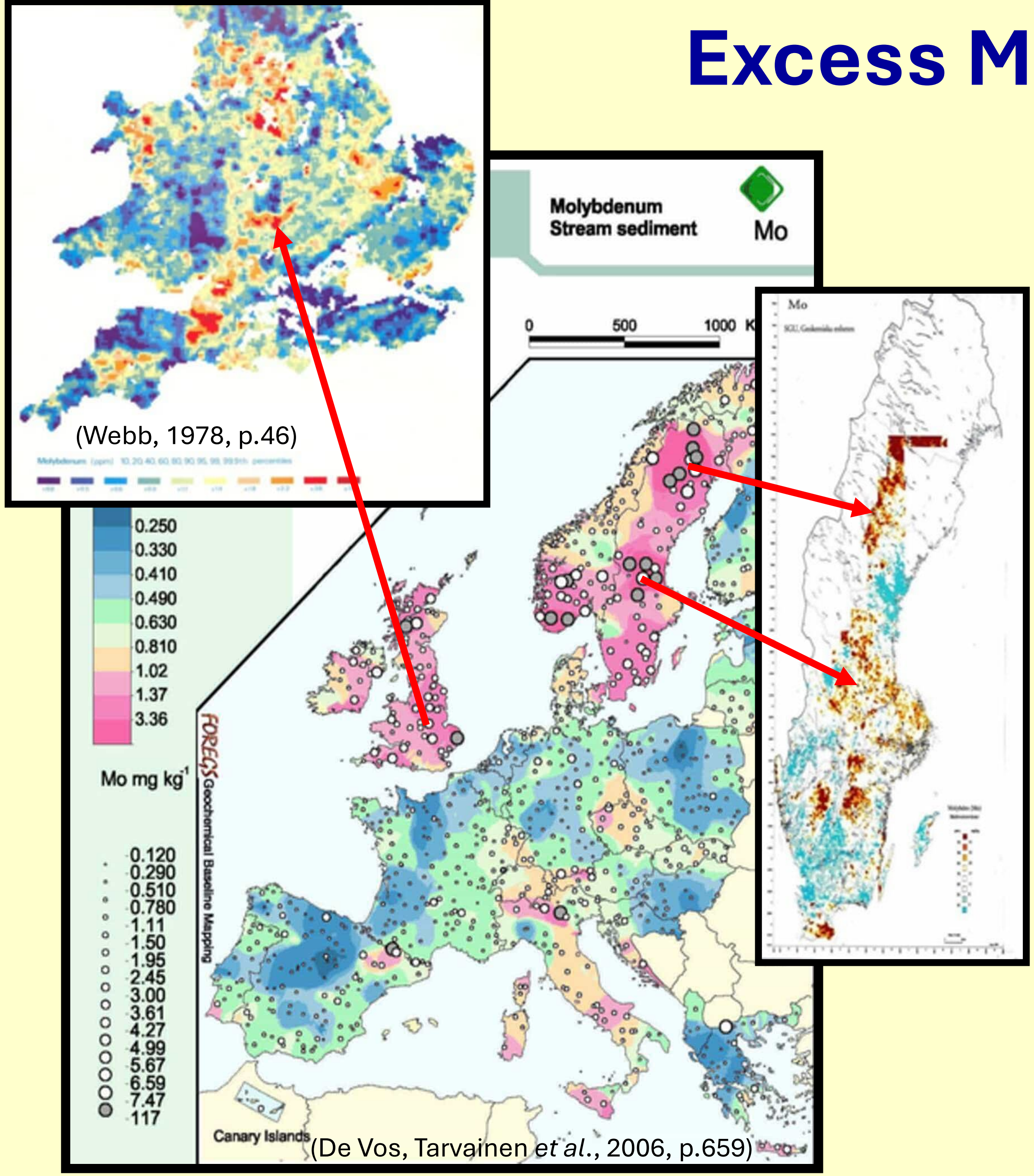


Zinc (Zn) absorption by a plant is dependent upon the levels of Phosphorus (P), and

High Phosphorus (P) levels in soil antagonise the uptake of Zinc (Zn)

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Excess Mo in soil



(Webb, 1978, p.46)

(De Vos, Tarvainen *et al.*, 2006, p.659)

In England, excess Mo in soil, and thence in pastures and fodder, caused a similar Mo excess in grazing cattle. Due to the excess of this element, these cattle acquired a deficiency in another element, Cu.

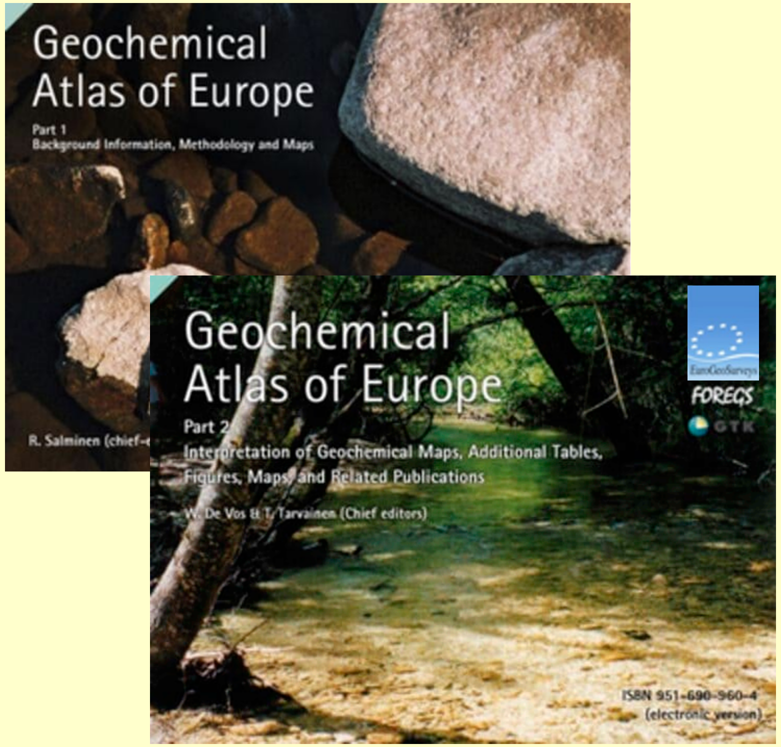
Copper deficiency in these cattle was exhibited as stunted growth, late maturity and decreased production. Supplementing the Mo-rich pastures with Cu corrected the problem.

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Use of geochemical data in land use policy

The Geochemical Atlas of Europe can be used for effective land use planning, *i.e.*, to decide if the particular land is fit for:

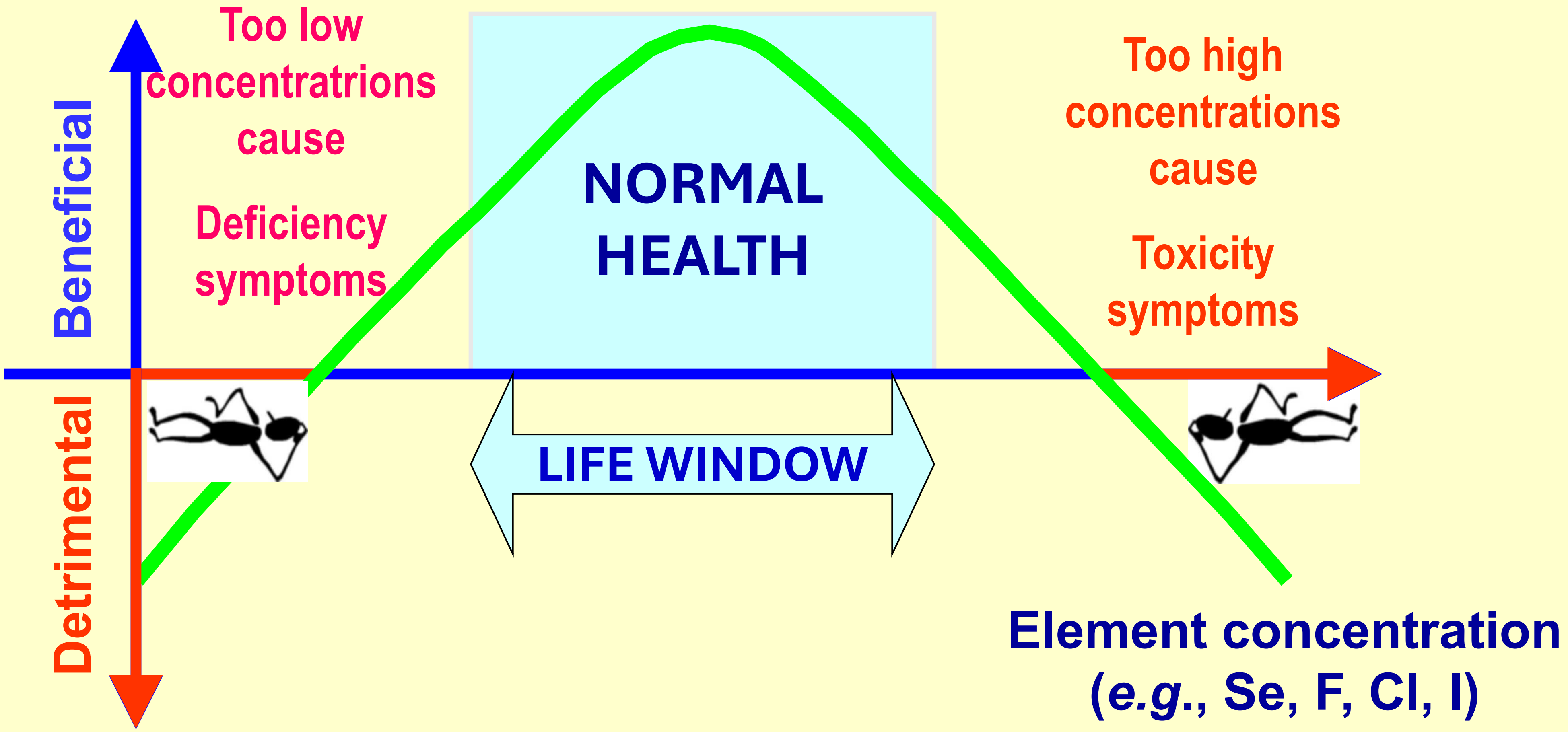
- **agriculture,**
- **animal husbandry,**
- **parks,**
- **new towns, *etc*.**



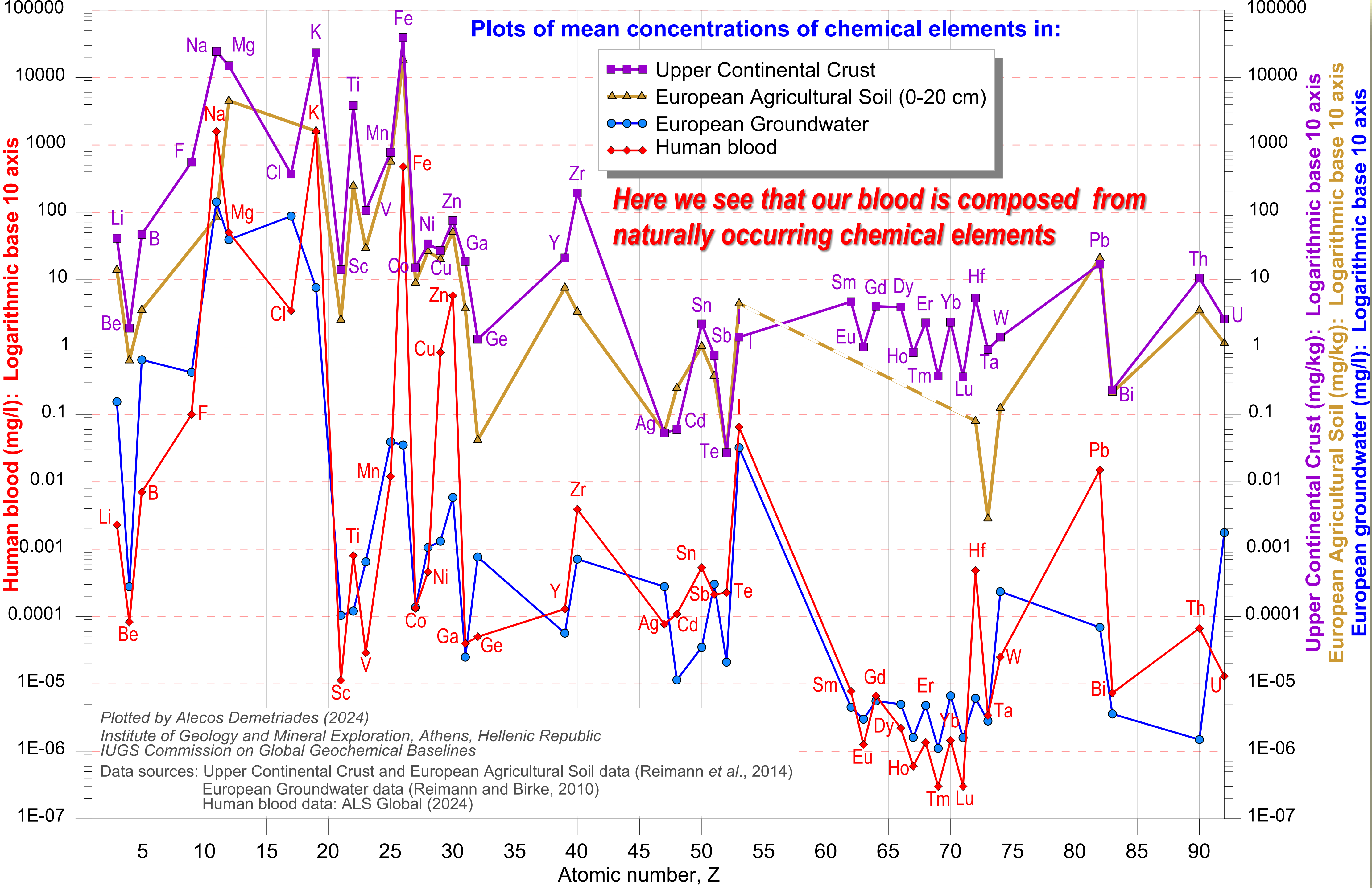
Use of geochemical data in health issues

DOSE – RESPONSE CURVE

In this diagram we see the relationship between the concentration of chemical elements and human health

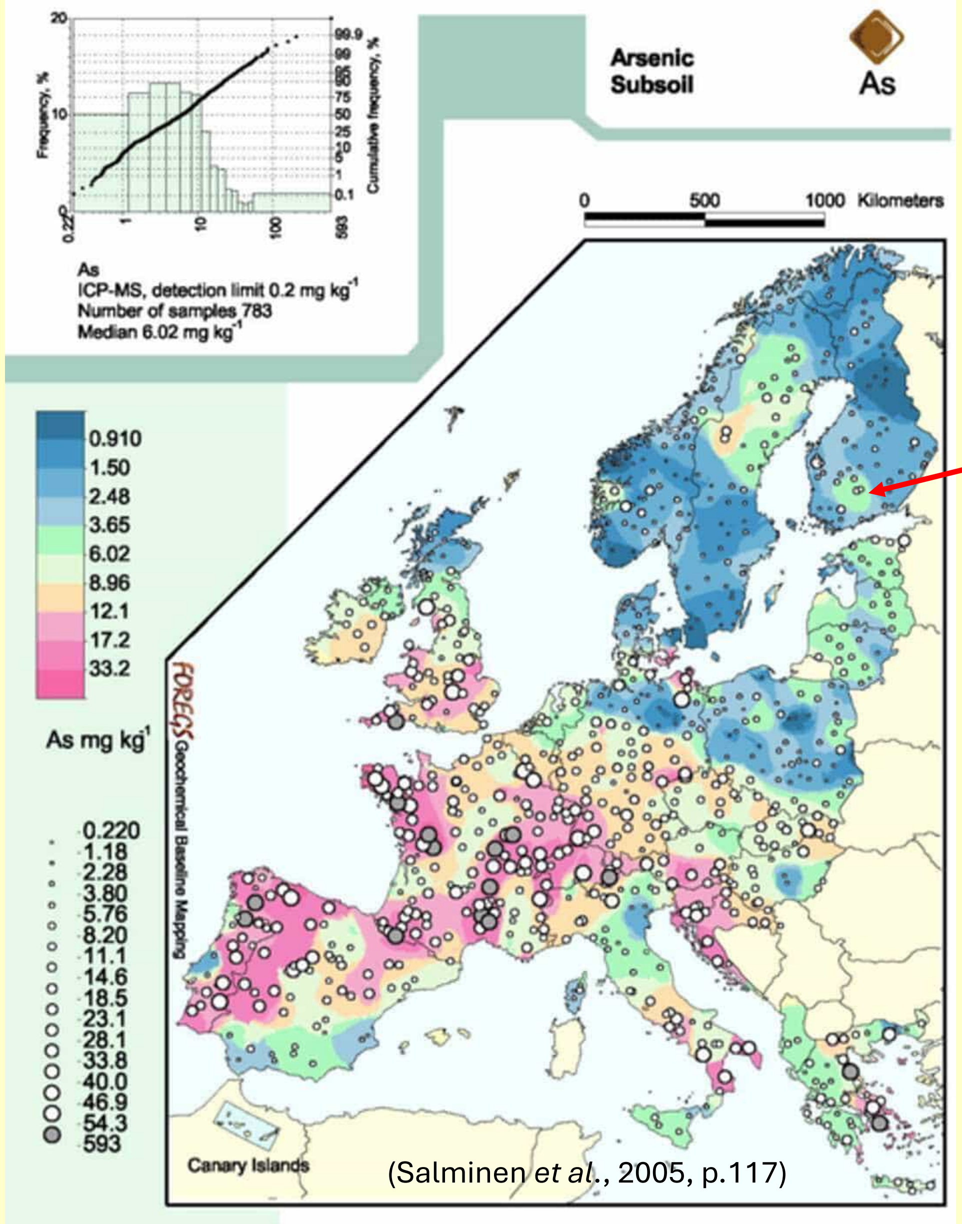


EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)



Plots of mean concentrations of chemical elements in:
Upper Continental Crust
European Agricultural Soil (0-20 cm)
European Groundwater
Human blood
Here we see that our blood is composed from naturally occurring chemical elements
Human blood (mg/l): Logarithmic base 10 axis
Upper Continental Crust (mg/kg): Logarithmic base 10 axis
European Agricultural Soil (mg/kg): Logarithmic base 10 axis
European groundwater (mg/l): Logarithmic base 10 axis
Atomic number, Z
Plotted by Alecos Demetriades (2024)
Institute of Geology and Mineral Exploration, Athens, Hellenic Republic
IUGS Commission on Global Geochemical Baselines
Data sources: Upper Continental Crust and European Agricultural Soil data (Reimann et al., 2014)
European Groundwater data (Reimann and Birke, 2010)
Human blood data: ALS Global (2024)

Arsenic distribution and health .....



(Salminen *et al.*, 2005, p.117)

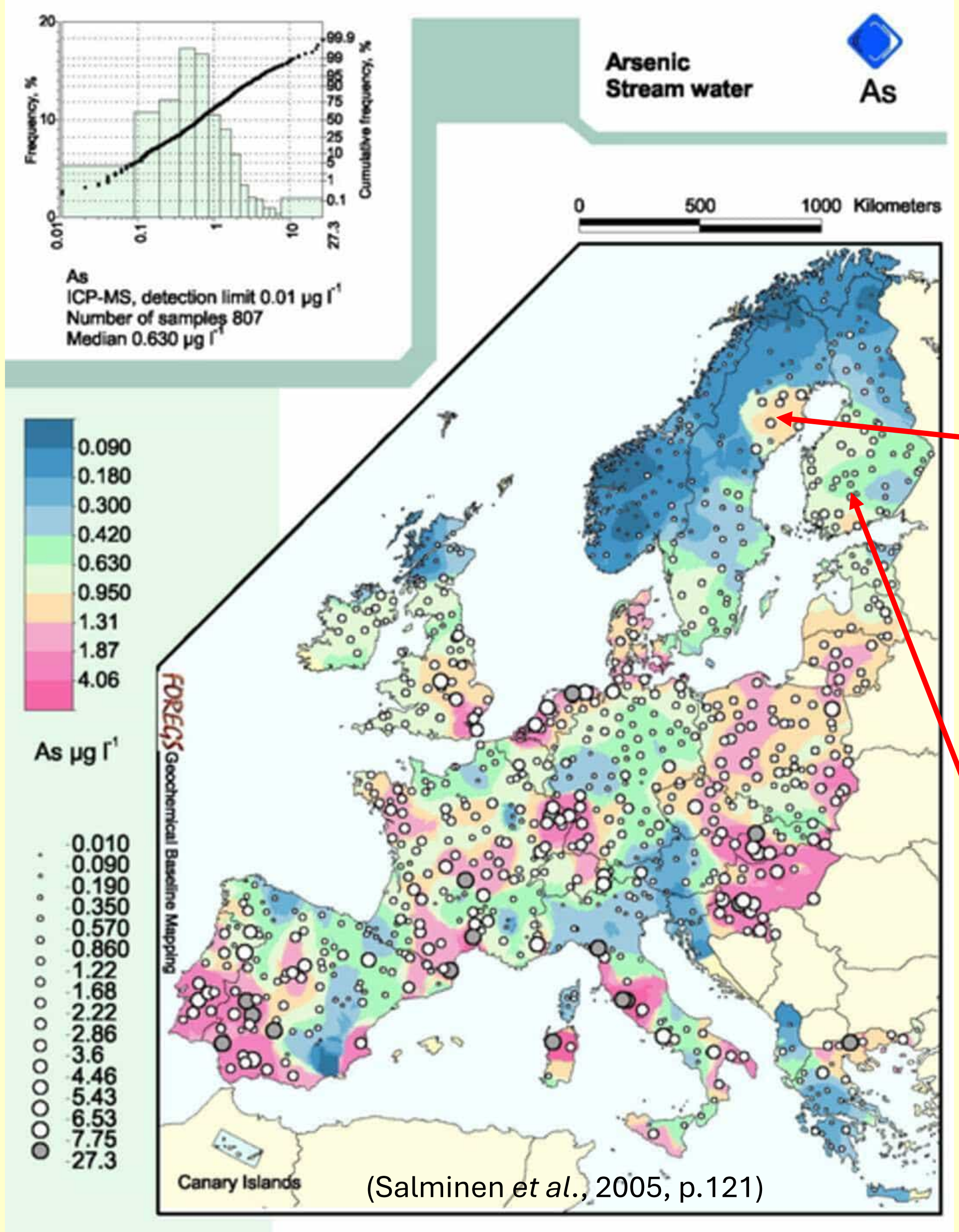
Pirkanmaa, Finland

Subsoil reflects bedrock chemistry.

What is the As-concentration in bedrock hosted groundwater?

The maximum As-value is 2230 µg/l in a bedrock drinking water well.

Arsenic distribution and health

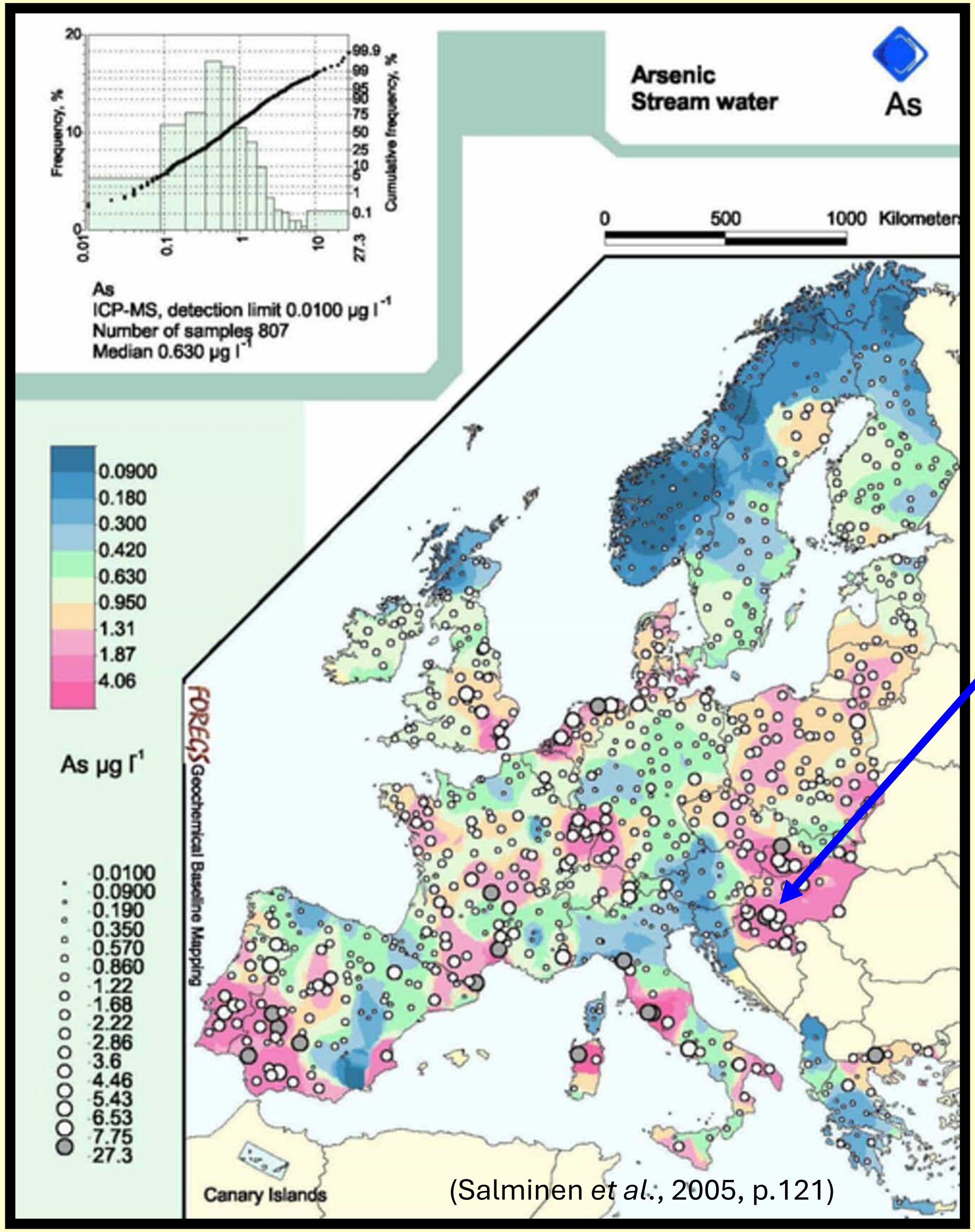


(Salminen *et al*., 2005, p.121)

10 µg/l Arsenic is the maximum admissible concentration in drinking water (WHO/EU)

Values up to 800 µg/l As have been found so far in the area of the As-anomaly in Sweden.

Pirkanmaa Finland: Maximum As-value is 2230 µg/l in a bedrock drinking water well.



(Salminen *et al.*, 2005, p.121)

Balkan endemic nephropathy (BEN) is a severe, potentially fatal kidney disease leading to end-stage renal failure requiring blood dialysis, and is often associated with a particular kidney cancer. The disease only occurs amongst rural villagers in Croatia, Bosnia, Bulgaria and Serbia without access to municipal (treated) water supplies. The principal aquifers in the BEN regions are extremely low-rank (geologically young) Pliocene lignite (coal), containing many relatively chemically reactive hydrocarbons. Scientists believe that the water leaches the hydrocarbons from the lignite. Drinking this *'naturally contaminated*' water can result in BEN.

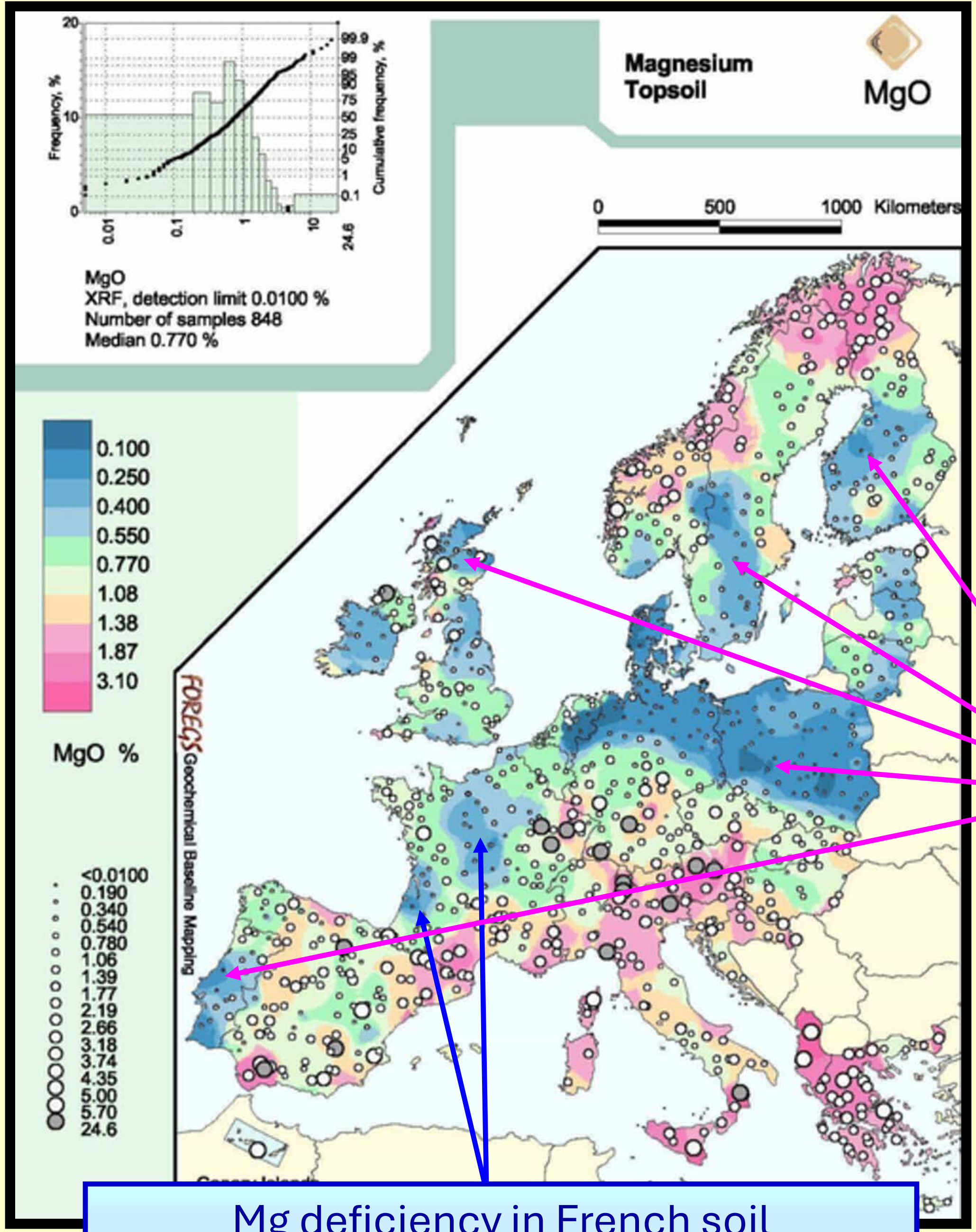
EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Balkan Endemic Nephropathy (BEN)

BEN patient in a dialysis clinic (Romania)

(Provided by Olle Selinus, SGU, Sweden)

Magnesium deficiency in soil



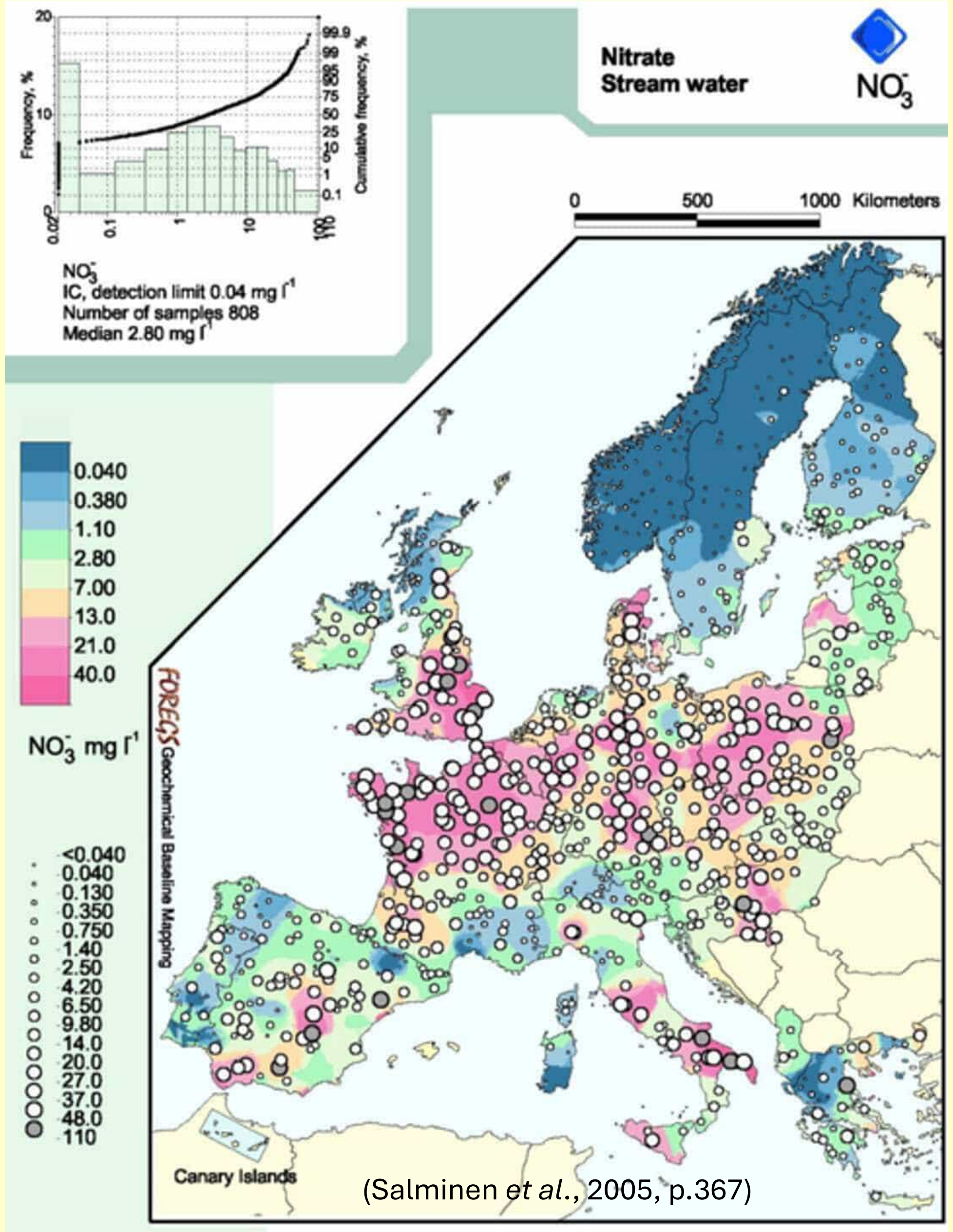
Mg deficiency in French soil

(Salminen *et al.*, 2005, p.318)

In France, magnesium deficiency in certain types of soil has been associated with specific kinds of cancer.

High risk areas with magnesium deficiency in soil should be investigated

FOREGS Geochemical Atlas of Europe

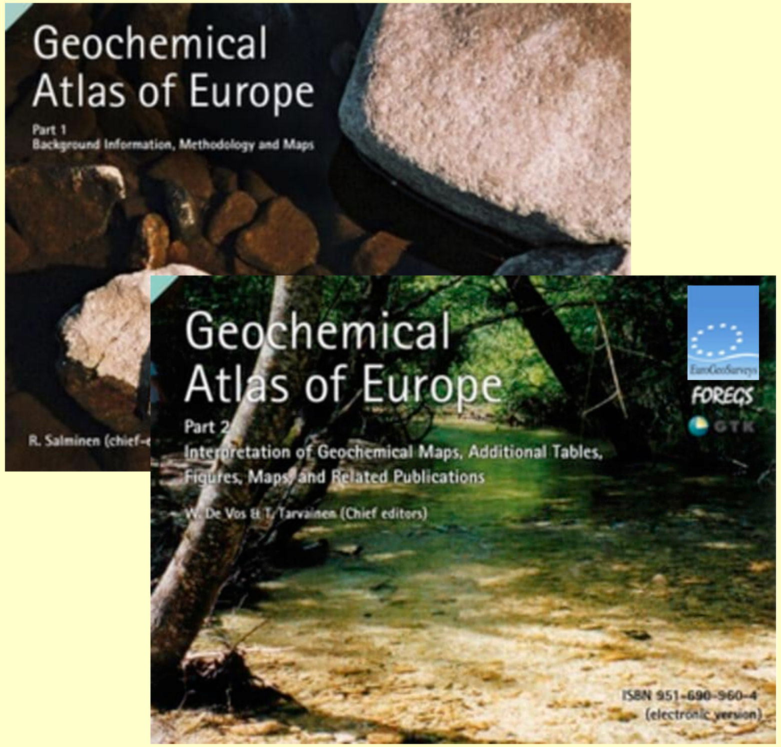


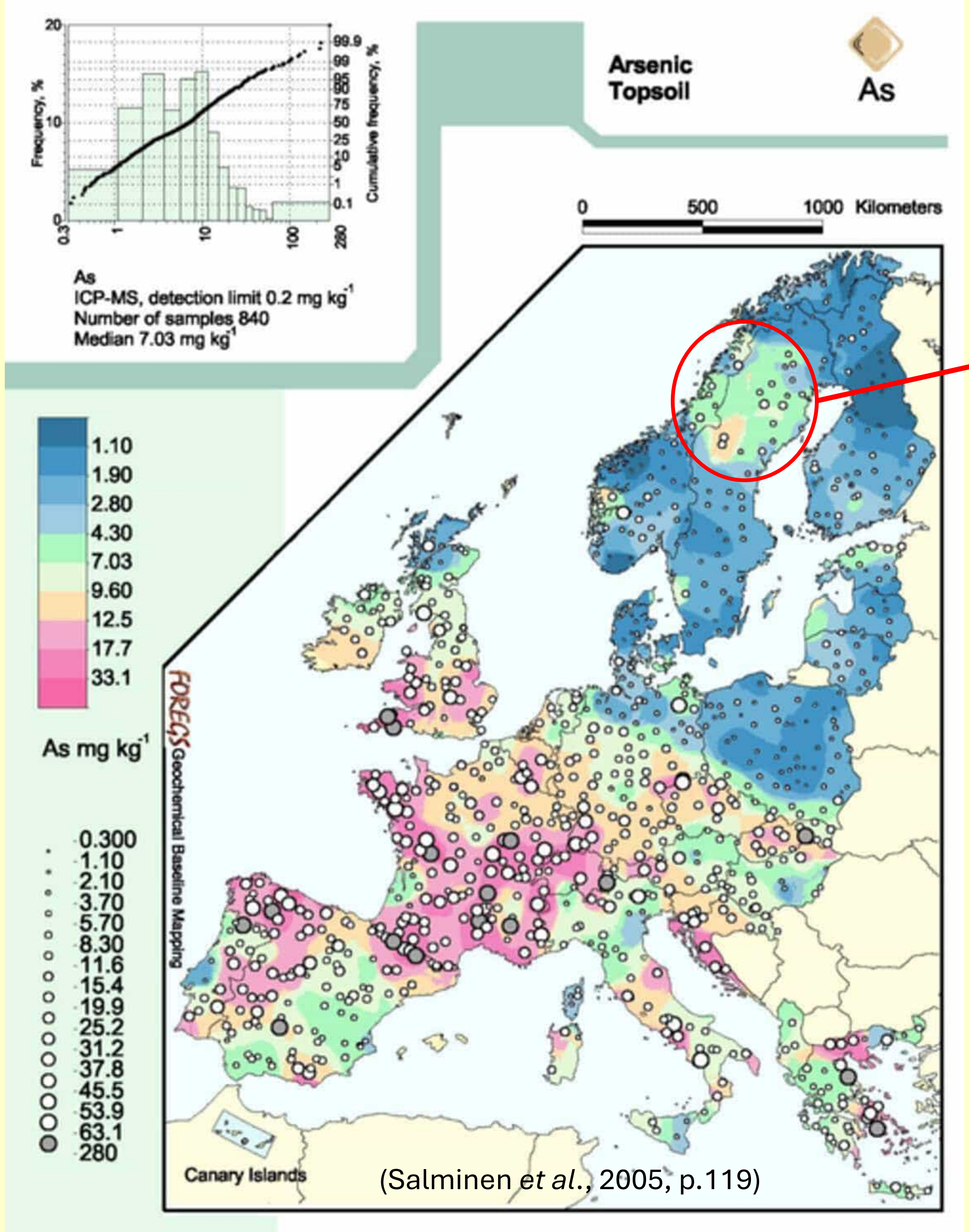
Nitrate concentrations in stream water are elevated in central Europe, due to intensive agriculture.

Should this be a health concern?

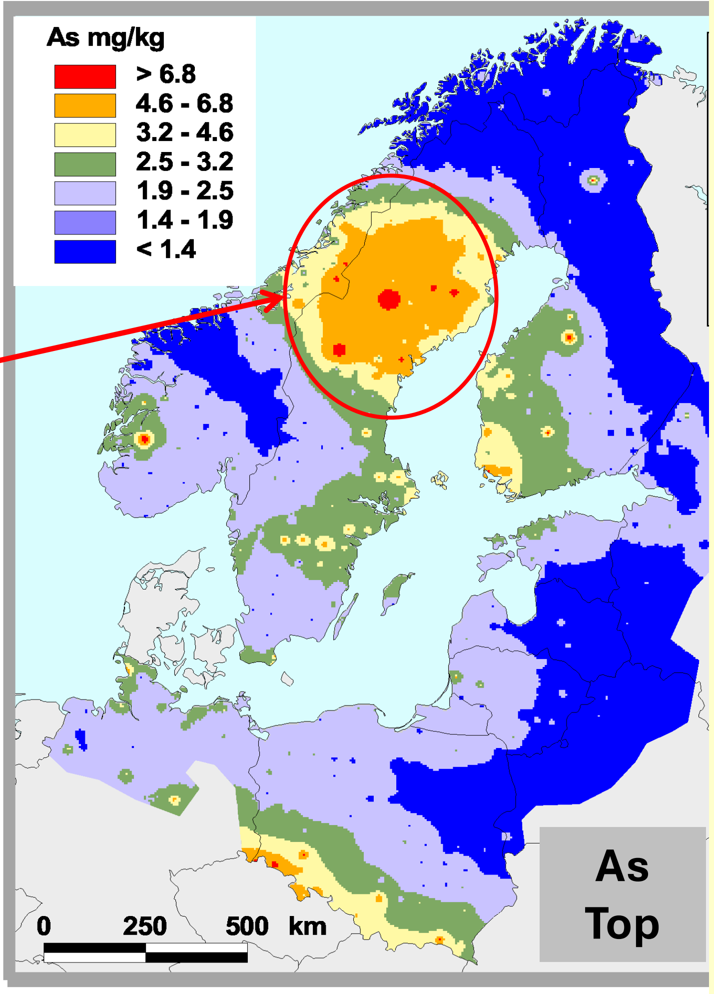
EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Robustness of Geochemical patterns



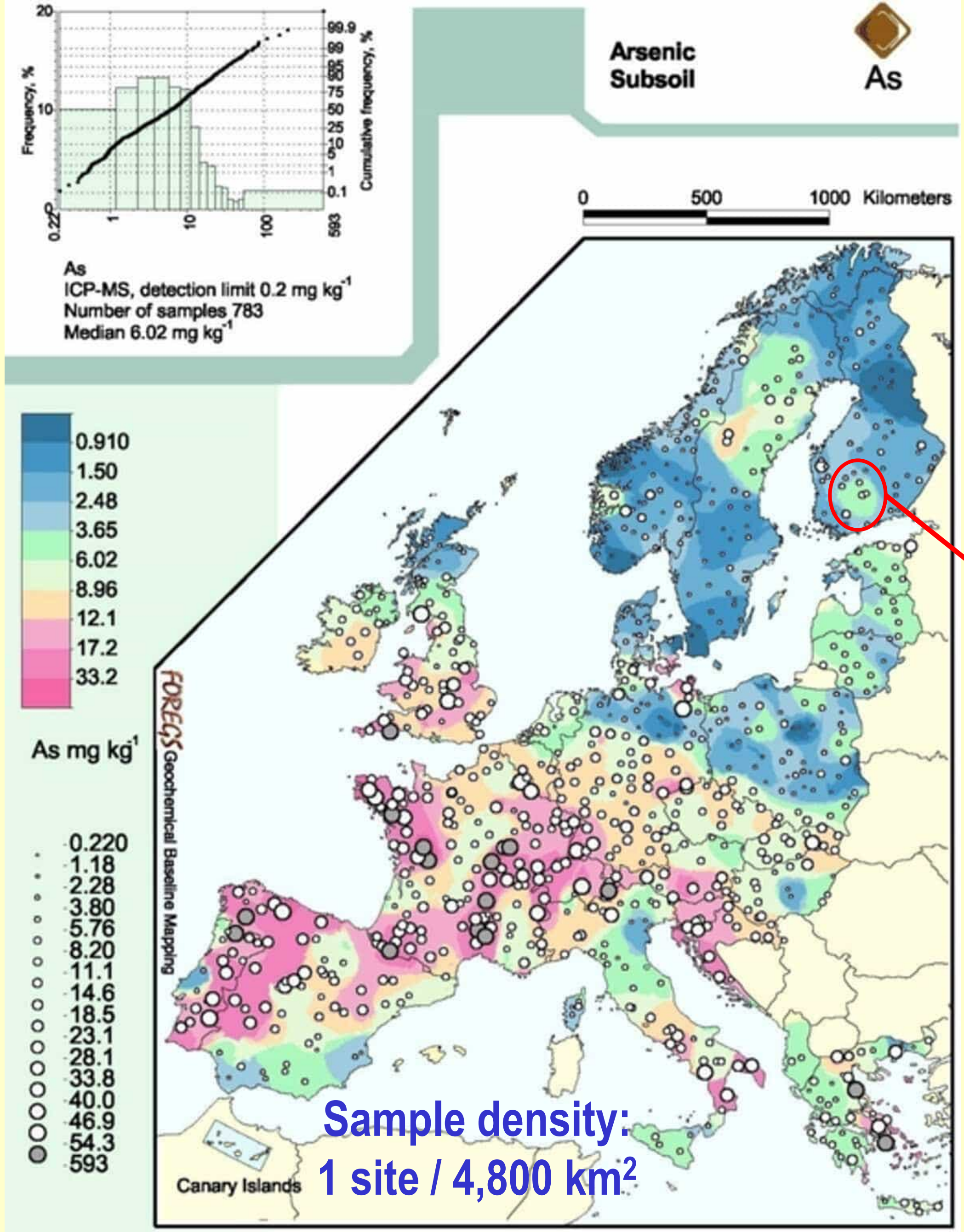


Sample density: 1 site / 4,800 km^2



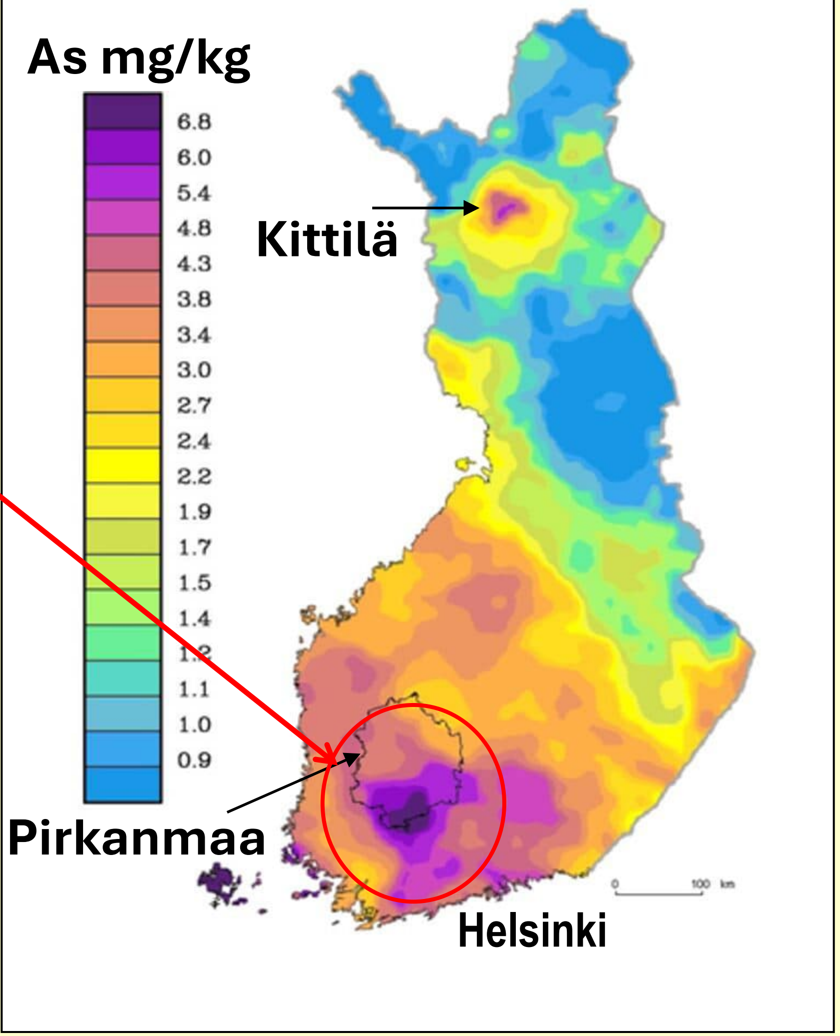
Baltic Soil Survey:
As concentrations in agricultural soil.
Sample density: 1 site / 2500 km^2
Topsoil: 0-25 cm
(Reimann *et al*., 2003, p.63)

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)



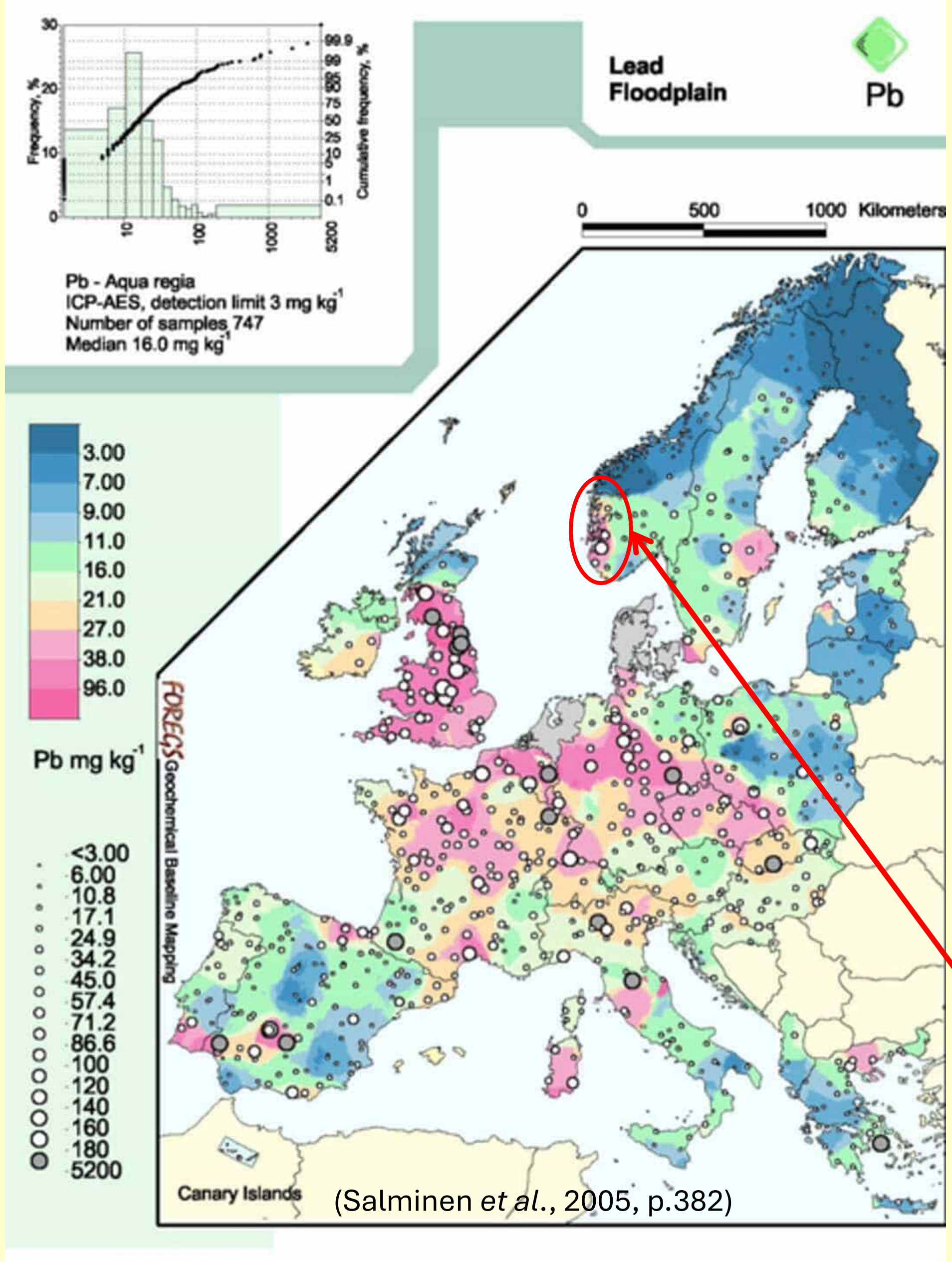
(Salminen *et al.*, 2005., p.117)

Arsenic concentrations in the fine fraction of till soil, Finland

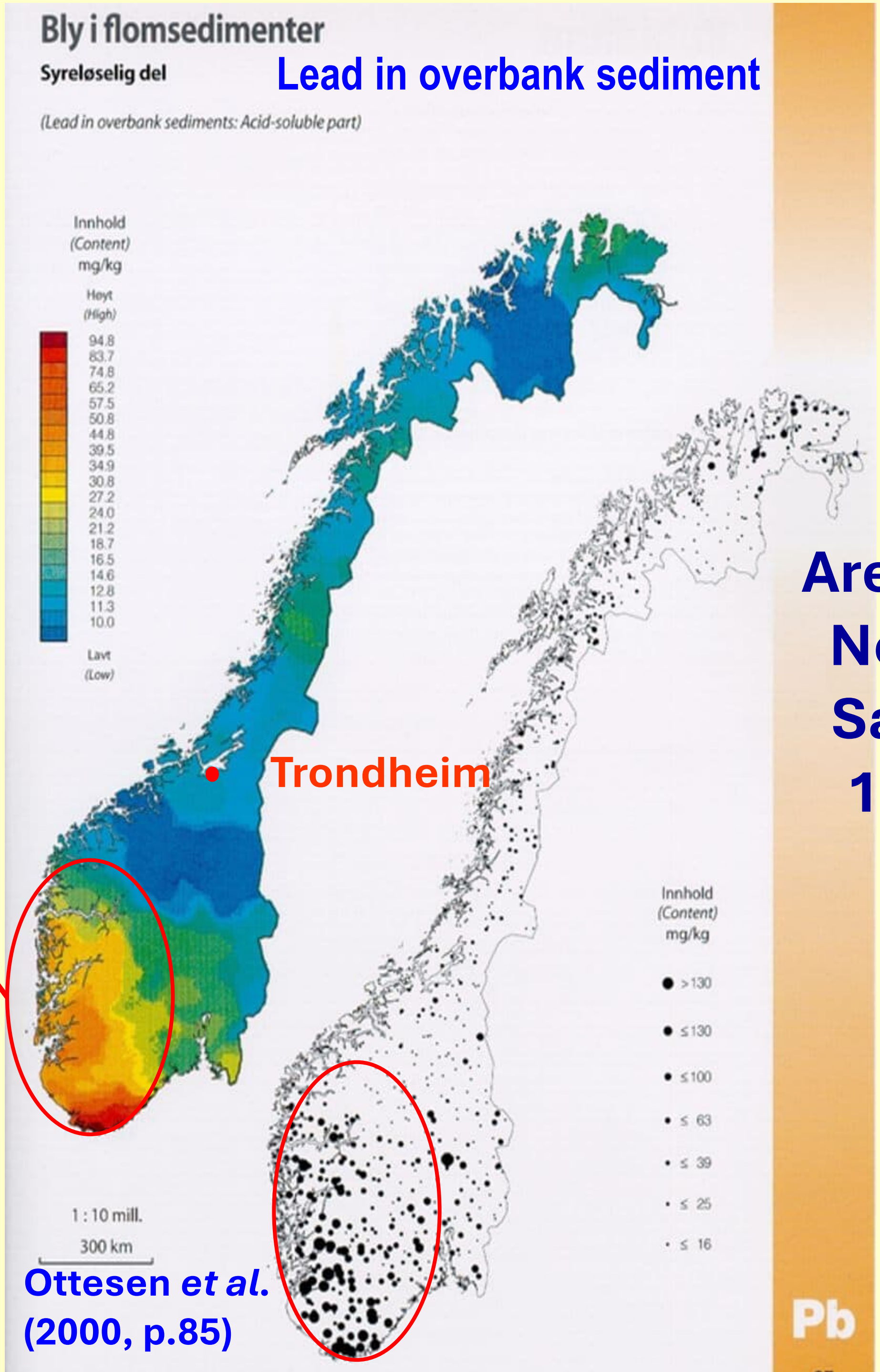


Sample density: 1 site/300 km^2
(Koljonen, 1992)

EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)



Sample density: 1 site / 4,800 km²



Area: 320,000 km²
No. of sites: 690
Sample density:
1 site / 464 km²

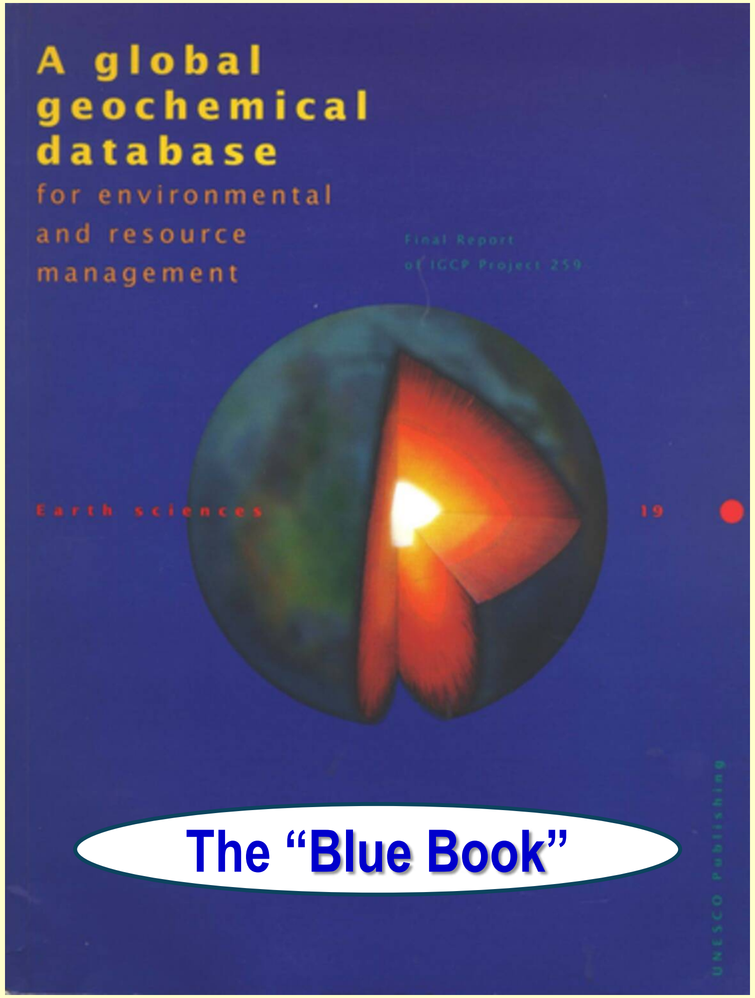
EuroGeoSurveys Geochemistry Expert Group (https://eurogeosurveys.org/)

Concluding remarks

GEOCHEMICAL MAPPING

Professor Kalevi Kauranne, Director of the Geological Survey of Finland, stressed in 1988 the importance of geochemical mapping by the following simple statement:

"Geochemical maps represent the most urgent and important task within geology for today's human society".



Darnley *et al*., 1995, p.x:

"Everything in and on the Earth - mineral, animal and vegetable - is made ….. from naturally occurring chemical elements…..

The existence, quality and survival of life depends upon the availability of elements in the correct proportions and combinations".

Mary Lou Zoback in her

2000 Presidential Address:

Grand Challenges in Earth and Environmental Sciences: Science, Stewardship, and Service for the Twenty-First Century

Stated ***"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, 2001, p.41).

Source GSA Today, December 2001:
https://www.geosociety.org/gsatoday/archive/11/12/pdf/i1052-5173-11-12-41.pdf

We are now in a New destructive geological era, the *Anthropocene*

The *Anthropocene* is characterised by humanity's extensive destructive impact on the Earth's landscapes.

These anthropogenic environmental changes affect the quality of the air we breathe and of the water we drink, the soil we grow our food, our exposure to infectious diseases, and even the habitability of the places where we live.

Margaret Atwood (2015*) states:

"It's Not Climate Change – It's Everything Change"

*(https://medium.com/matter/it-s-not-climate-change-it-s-everything-change-8fd9aa671804)


Soil, Sediment & Water are
the most valuable natural
resources for our quality of life,
and we need to know their
chemical composition, and our
impact on them.

SO, HOW CAN WE STUDY THE CHANGES?

Geochemical mapping provides the tools for visualising the spatial variation and intensity of the human induced threats.

https://blog.efmdglobal.org/2019/07/09/leadership-for-the-anthropocene/

The question is:

What sort of global geochemical baseline mapping do we need?

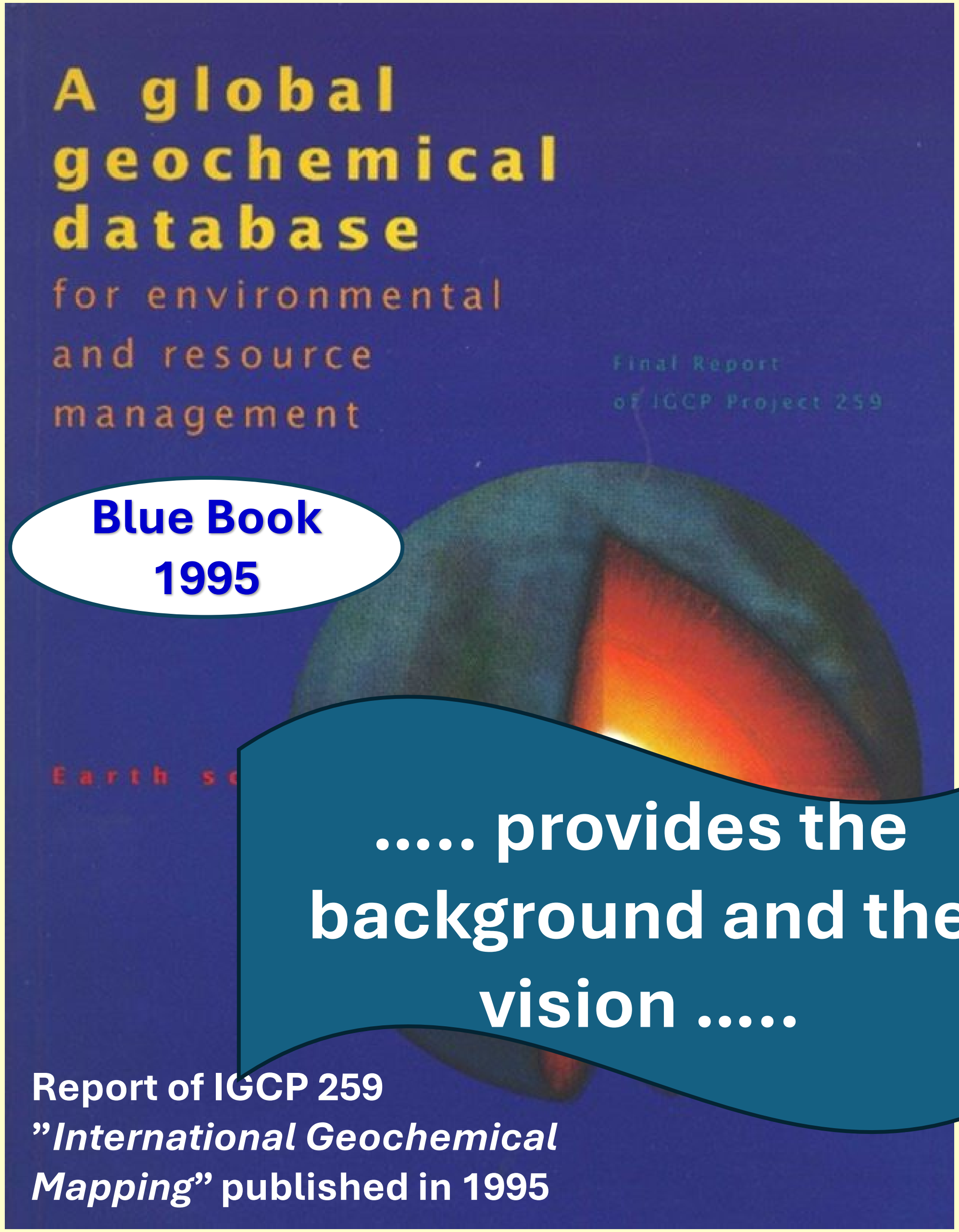
We do not need just any global geochemical database.

We urgently need a harmonised global geochemical database.

The FOREGS geochemical mapping is widely regarded as a pilot for the IUGS project of Global Geochemical Baselines. Therefore, standardised procedures must be used in all 196 countries for the production of a harmonised global geochemical database, namely:-

- **Randomised sampling.**
- **Samples collected by the same procedure, using the same equipment.**
- **Samples prepared in the same laboratory, and**
- **Samples analysed in the same laboratory with the same analytical method or methods.**

At all stages, a strict quality-controlled procedure must be installed.
All standardised procedures are described in the IUGS Manual of Standard Methods.



Blue Book 1995

Report of IGCP 259 ”*International Geochemical Mapping*” published in 1995

2022

….. provides the background and the vision …..

….. provides the standardised methodology ….

http://globalgeochemicalbaselines.eu.176-31-41-129.hs-servers.gr/datafiles/file/Blue_Book_GGD_IGCP259.pdf

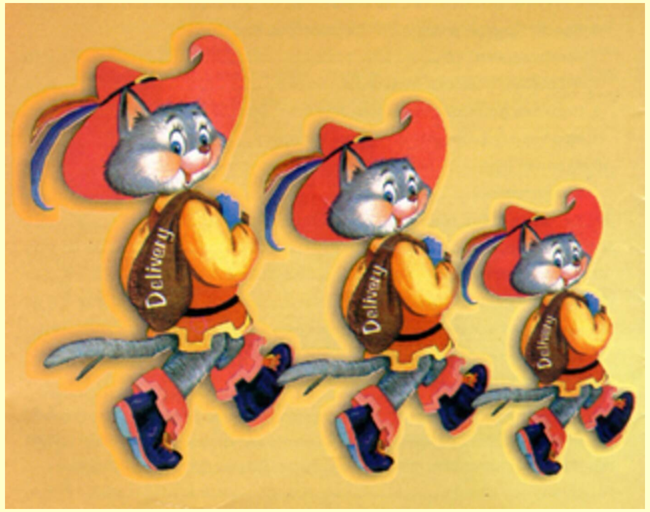
http://www.globalgeochemicalbaselines.eu/content/174/iugs-manual-of-standard-methods-for-establishing-the-global-geochemical-reference-network-/

IUGS
International Union of Geological Sciences

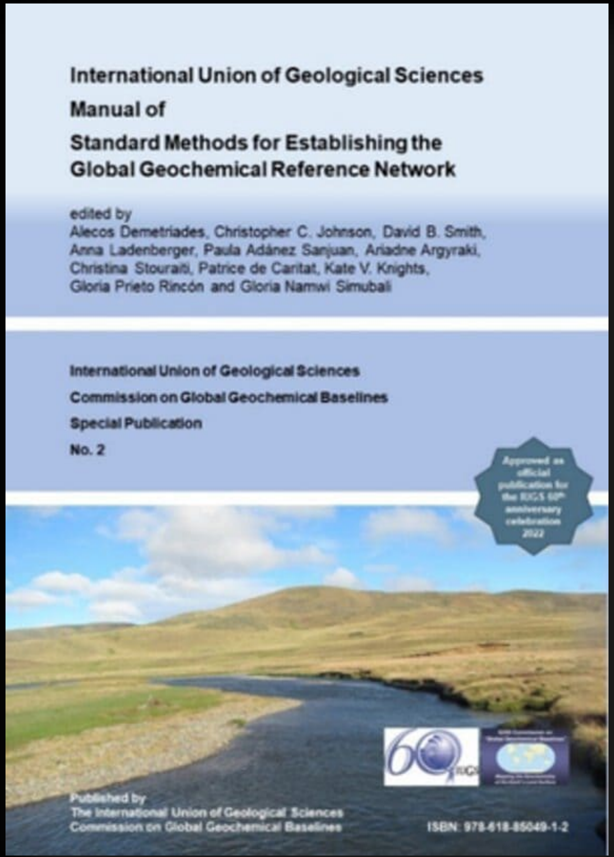
IUGS Commission on
"Global Geochemical Baselines"

Mapping the Geochemistry
of the Earth's Land Surface

Ultimate objective of the 21st century is the completion of the harmonised "Global Geochemical Database" for environmental and resource management



Geological Surveys
can deliver it to decision makers,
the scientific community and the public



Final conclusion, the IUGS Manual of Standard Methods presents, for the first time, a comprehensive overview of the standardised methods that should be employed across the land surface of the Earth to map the distribution of chemical elements in rock, soil, sediment and water.

IUGS

IUGS Commission on "Global Geochemical Baselines"

Mapping the Geochemistry of the Earth's Land Surface

@CGGBIUGS

@CGGB_IUGS

https://www.youtube.com/channel/UC51fN-9mrg3_br6l-xbeO9Q/videos

What is needed is a robust project management structure that is independent of the interest of an individual nation or organisation, and most importantly Political will.

Thank you for your attention

ps://euroge

https://www.globalgeochemicalbaselines.eu/

The FOREGS multi-media geochemical atlas

Alecos Demetriades

Chairperson of the IUGS Commission on Global Geochemical Baselines

The impetus for the FOREGS Geochemical Baseline Mapping Project was the devastating Chernobyl nuclear accident in April 1986. One month after the accident, the first Working Group on Regional Geochemical Mapping of the then Western European Geological Surveys (WEGS) met in Trondheim (Norway). The discussion was centred around the Chernobyl accident and the spread of the radioactive cloud over most of Europe. It was concluded that Europe lacked geochemical baseline data to assess the impact of radioactive and other contaminating elements on its environment. The Working Group submitted a proposal to the WEGS Directors for the multi-media and multi-element geochemical mapping of Europe by collecting surface water, groundwater, surface soil (A horizon), soil C horizon and overbank sediment at a sampling density of 1 sample site/500 km^2. Although the proposal was met with their general approval, a decision was not taken. In the coming years, the Working Group performed different continental-scale orientation surveys to prove the applicability of the proposed methodology. At the same time, the WEGS Regional Geochemical Mapping Group was participating in IGCP 259 'International Geochemical Mapping' (1988-1992). After the publication of the IGCP 259 report in 1995, the Directors of the Forum of European Geological Surveys (FOREGS), the successor of WEGS, approved in 1996 the go-ahead for the geochemical baseline mapping of Europe, according to the specifications of the IGCP 259 report. The project began with the compilation of the Field Manual in 1997, and directly afterwards, the sampling campaigns started in 26 European countries using a catchment basin approach at an average density of approximately 1 sample site/4,800 km^2 covering an area of about 4,450,000 km^2. Samples of humus, residual soil (A and C horizon), stream water, and stream sediment were collected from second-order streams, and floodplain sediment from third-order streams using the Global Terrestrial Network grid cells of 160x160 km. All solid samples were prepared in the same laboratory, and all sample sets were analysed in the same laboratory for the same suite of elements and subjected to the same quality control procedure. The project ended in 2006 with the publication of a two-volume geochemical atlas of Europe. The text, maps and data sets are freely available from a dedicated website managed by the Geological Survey of Finland (http://weppi.gtk.fi/publ/foregsatlas/). The FOREGS Geochemical Baseline survey is the first multinational project carried out with the same methodology, producing the first harmonised multi-media geochemical data sets for a whole continent, as a testament to multi-national collaboration.

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