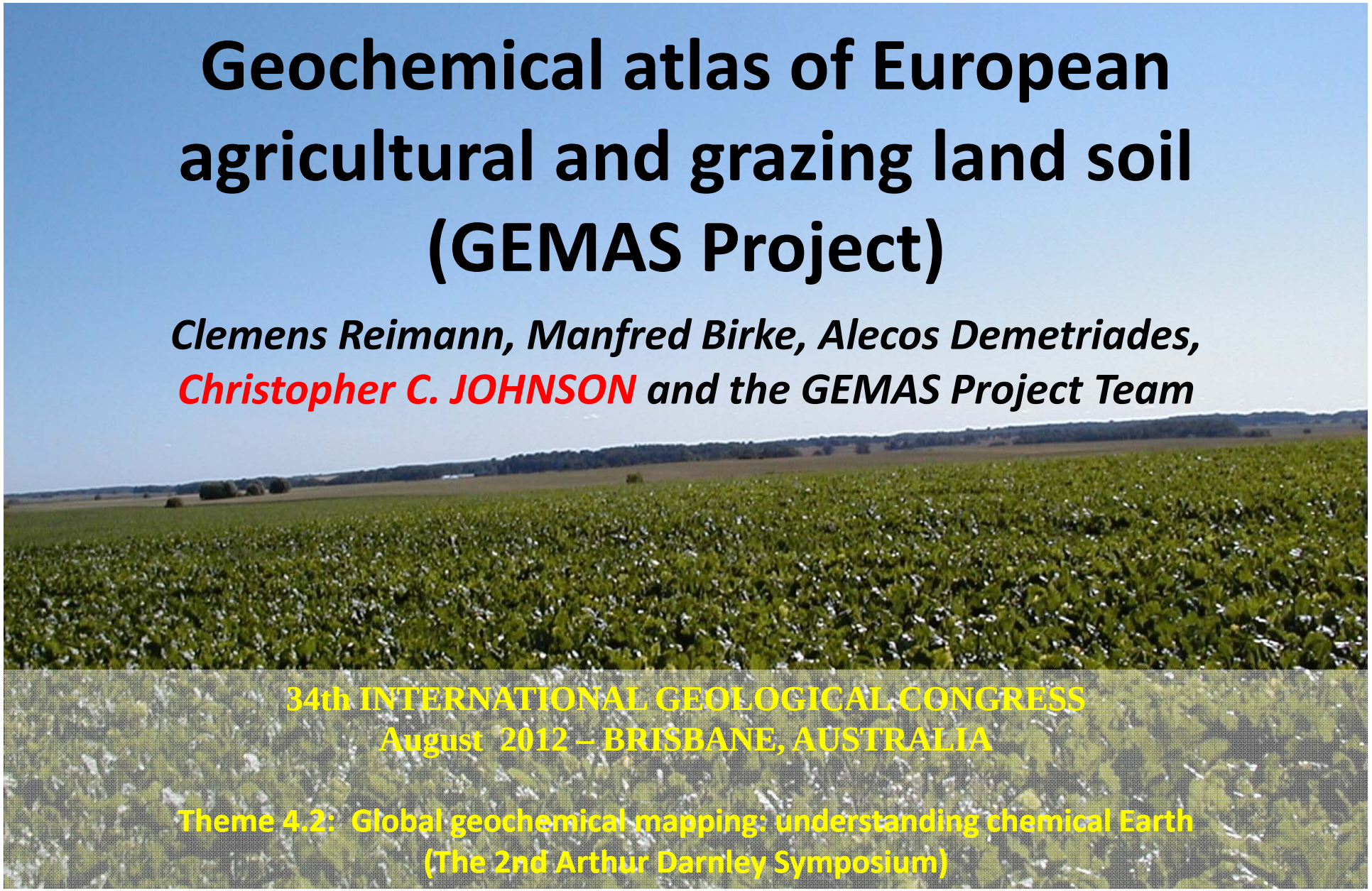
Geochemical atlas of European agricultural and grazing land soil (GEMAS Project)

Clemens Reimann, Manfred Birke, Alecos Demetriades,
Christopher C. JOHNSON and the GEMAS Project Team



34th INTERNATIONAL GEOLOGICAL CONGRESS
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Theme 4.2: Global geochemical mapping: understanding chemical Earth
(The 2nd Arthur Darnley Symposium)

http://gemas.geolba.ac.at/

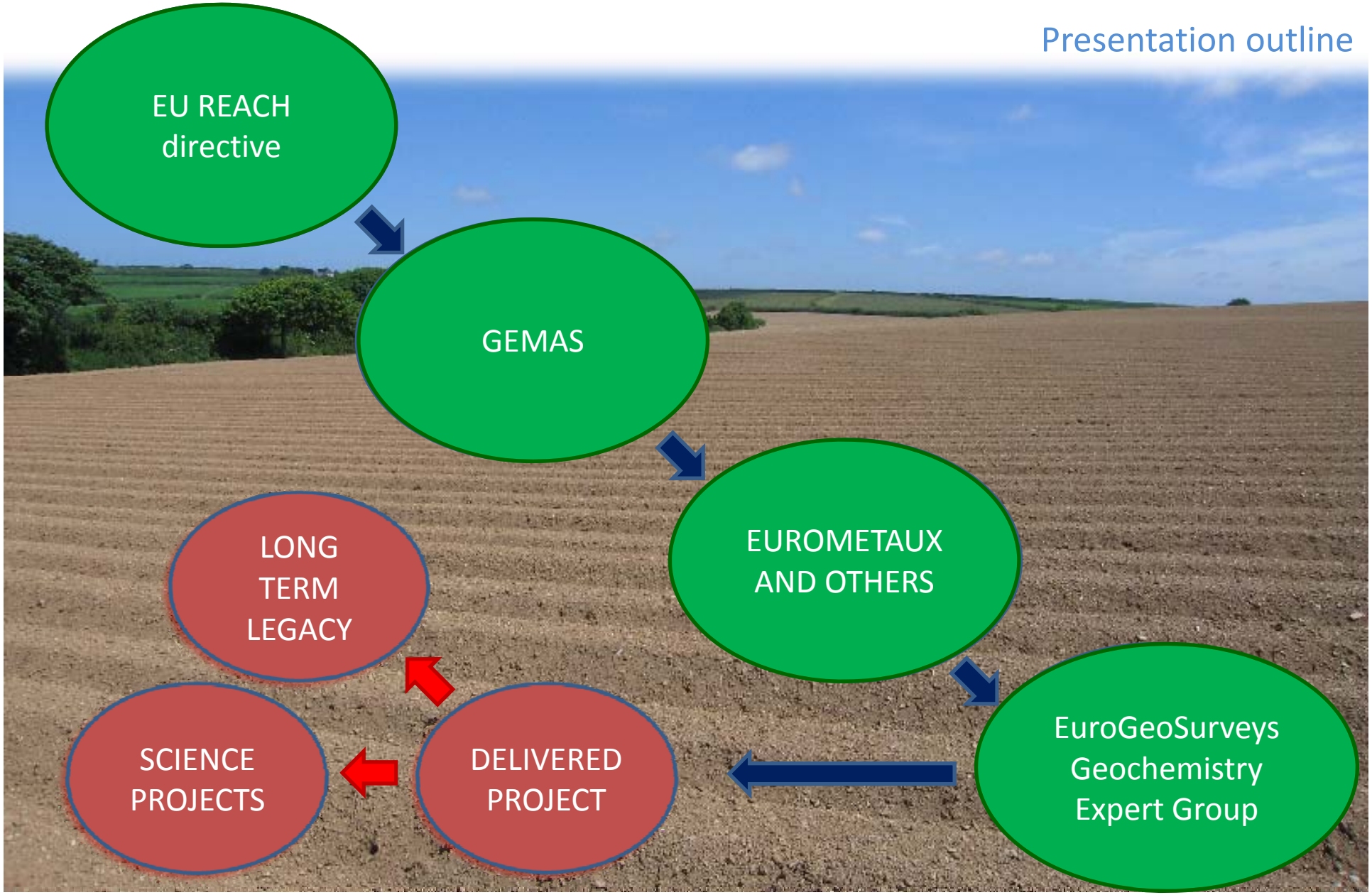
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

GEMAS

GEochemical Mapping of Agricultural Soils

EuroGeoSurveys
European Geoscience for Society
The Geological Surveys of Europe

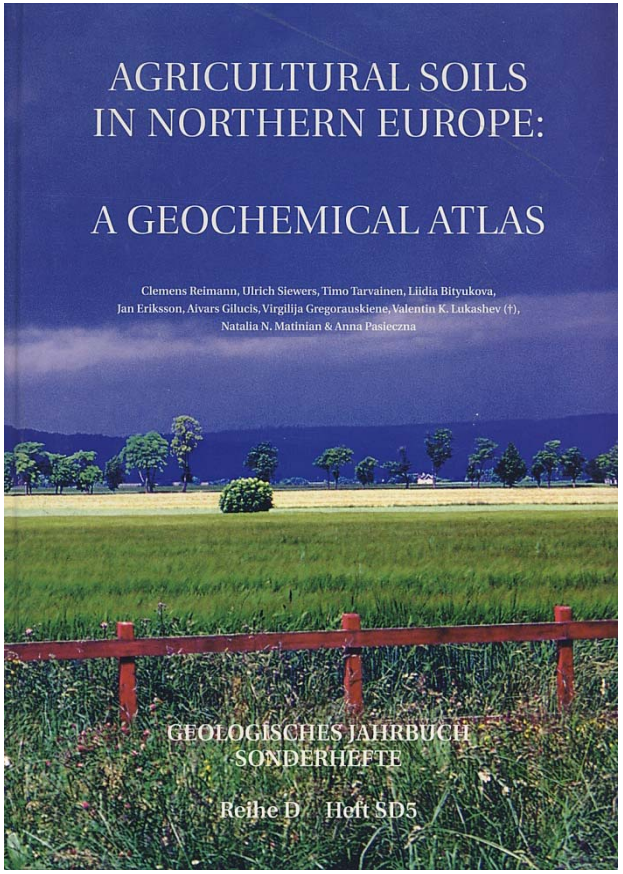
Presentation outline



- REACH* – **R**egistration, **E**valuation and **A**uthorisaton of **Ch**emicals. European regulation which came into force 1st June 2007.
- REACH specifies that industry must prove that it can produce and handle its substances safely.
- Industries handling metals needed harmonised data on the natural distribution of chemical elements, "soil quality" and of soil properties governing metal availability in soils at the continental scale.

* http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

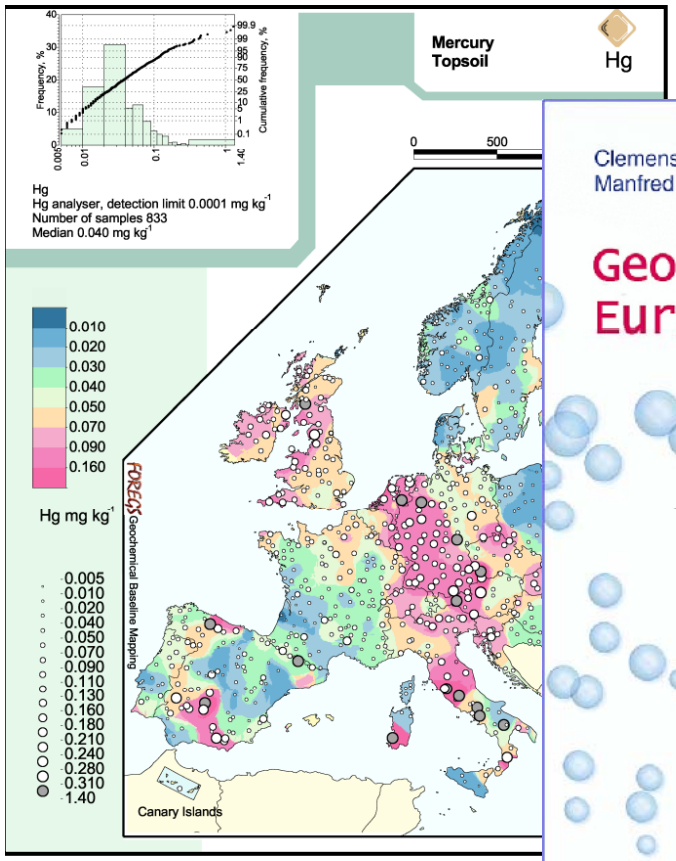
- Consistent soil chemical data required at a continental scale – Darnley et al. (1995).
- Follow the example of the Northern Europe Baltic Soil Survey*
- Focus on agricultural soils.
- REACH dictates that the sample depth should be 0-20 cm for Ap and 0-10 cm for Gr, and the <2 mm grain size fraction is analysed.

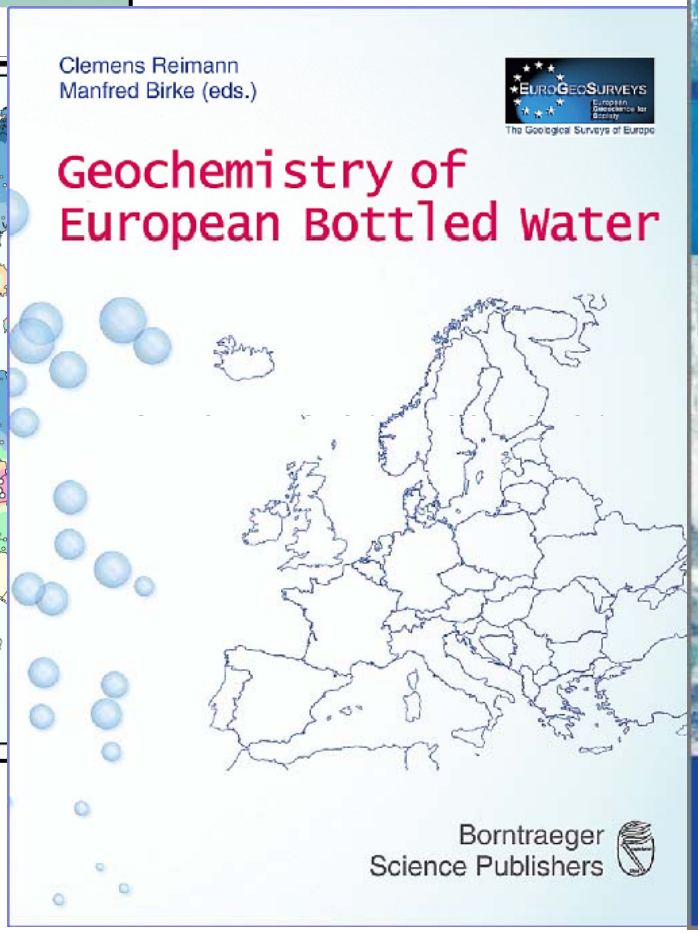


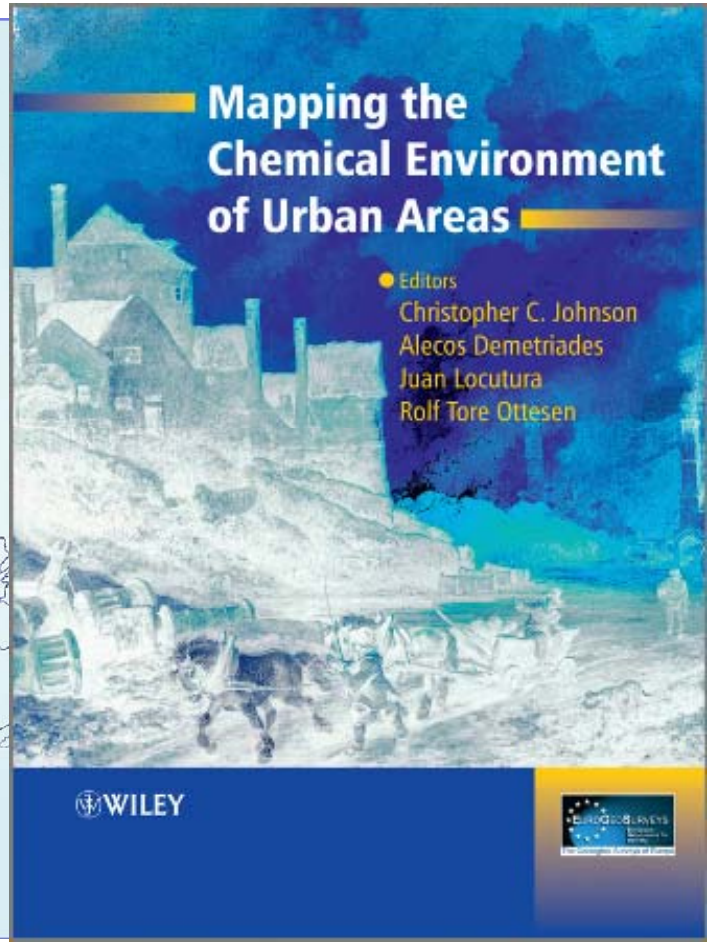
*Reimann et al. 2003. Agricultural soils in northern Europe: A geochemical atlas. Geologisches Jahrbuch, Sonderhefte, Reihe D, Heft SD 5, Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. 279 pp.

GEMAS – The Project Group

EuroGeoSurveys Geochemistry Expert Group







EuroGeoSurveys

- ❑ 33 European Geological Surveys.
- ❑ aims to address European issues; to promote contribution of geosciences to EU affairs; to assist EU to obtain technical advice; and to provide a network among the geological surveys. ***Visit the EGS stand in the Exhibition Hall***

Sampling

- Sampling commenced in 2008 following protocols of a field manual* and training day.
- Total of 33 participating countries, member states of EU (except Malta and Romania) plus some neighbours (e.g., Norway, Serbia and Ukraine).
- Density of 1 sample site per 2500 km^2.
- Collection of two samples in each cell as close as possible – agricultural (Ap) and grazing land (Gr) soil.

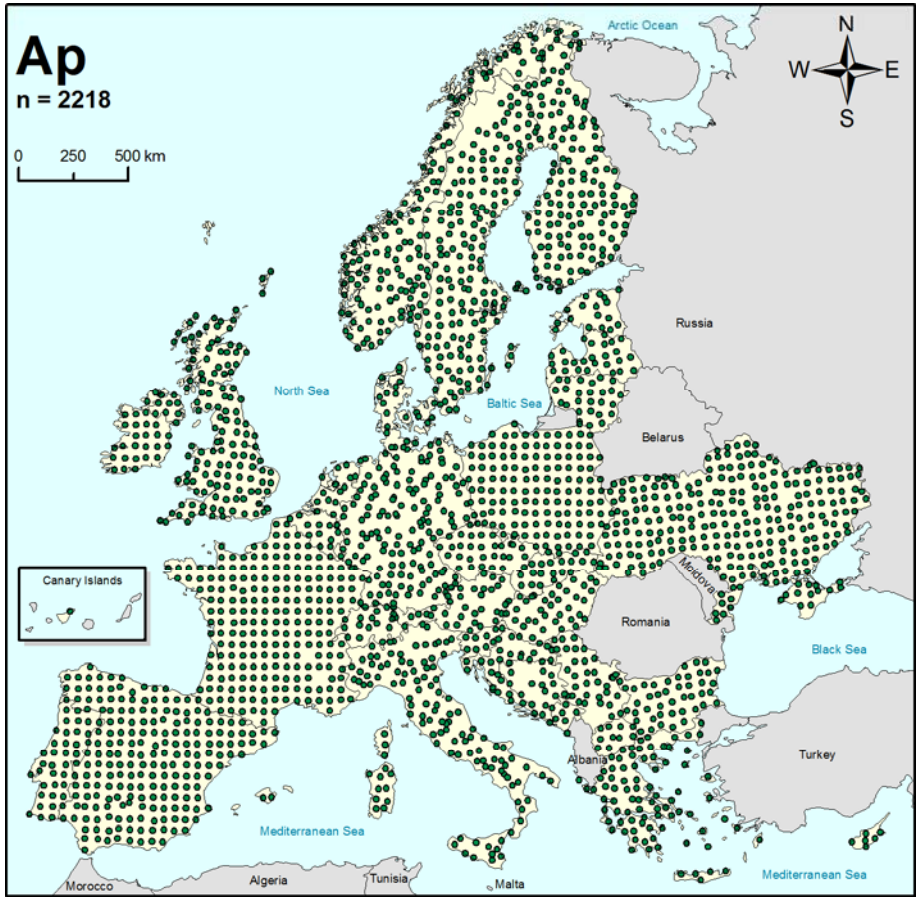
* www.ngu.no/upload/Publikasjoner/Rapporter/2008/2008_038.pdf

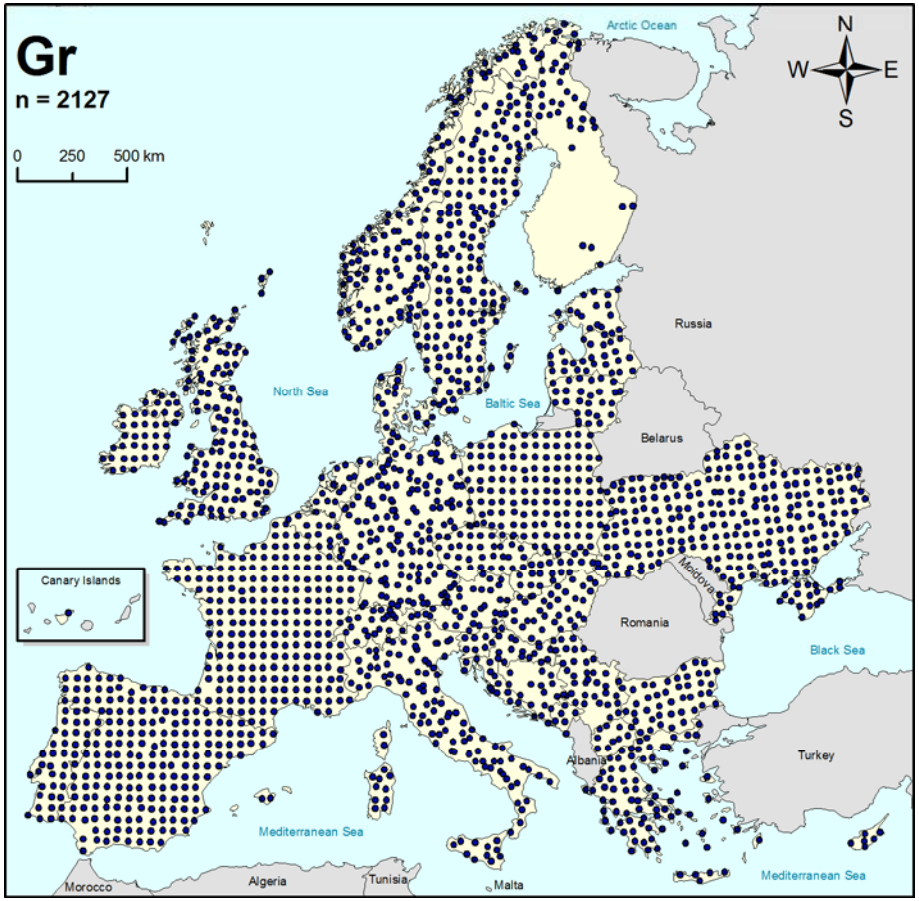
Sample distribution in Europe

Agricultural soils (Ap)
(0 – 20 cm, n = 2218)

Grazing land soils (Gr)
(0 – 10 cm, n = 2127)

1 site/2500 km^2, collected during 2008; 33 European countries; 5,600,000 km^2





Agricultural (0-20 cm) - Ap

Grazing (0-10 cm) - Gr

- Samples are a composite of five subsamples collected from the corner and centre of a 10-m square.
- Average distance between Ap and Gr was 500 m, though as much as 50 km is recorded.
- All sites documented with photographs.
- Field duplicate taken every 20th sample.

- **Sample preparation:** air dried, sieved, homogenised and split to subsamples.
- **Aqua regia extraction on 15 g aliquots (ICP-MS):** 53 elements (Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Pd, Pt, Rb, Re, S, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Y, Zn, and Zr).
- **Total element concentrations (XRF):** 41 elements (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, SO_3, Cl, F, As, Ba, Bi, Ce, Co, Cr, Cs, Cu, Ga, Hf, La, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sn, Sr, Ta, Th, U, V, W, Y, Zn, and Zr).
- **Pb-isotopes** (Ap samples); **Sr-isotopes** (Gr samples).
- **pH** (in a 0.01 M $CaCl_2$ solution)**, TOC** (total organic carbon)**, TC, TS, LOI.**
- **CEC** (cation exchange capacity, by silver-thiourea method).
- **K_d values** for the elements (Ag, B, Co, Cu, Mo, Mn, Ni, Pb, Sb, Se, Sn, Te, V, and Zn).
- **PSD analysis** (800 Ap and Gr samples) and **MIR spectroscopy.**

- ❑ **randomisation** of samples before analysis.
- ❑ **field duplicates** taken at a rate of 1 duplicate every 20 samples.
- ❑ **replicate** made from each field duplicate (Thompson and Howarth-plots, analysis of variance).
- ❑ frequent insertion of **project standards** (Ap, Gr) at a rate of 1 per 20 samples (for plotting X-charts).
- ❑ use of **international reference materials** (ORIS, SONE-1).
- ❑ **proficiency test** using two project standards (23 laboratories from 16 countries).
- ❑ Each parameter was **measured in one single laboratory.**

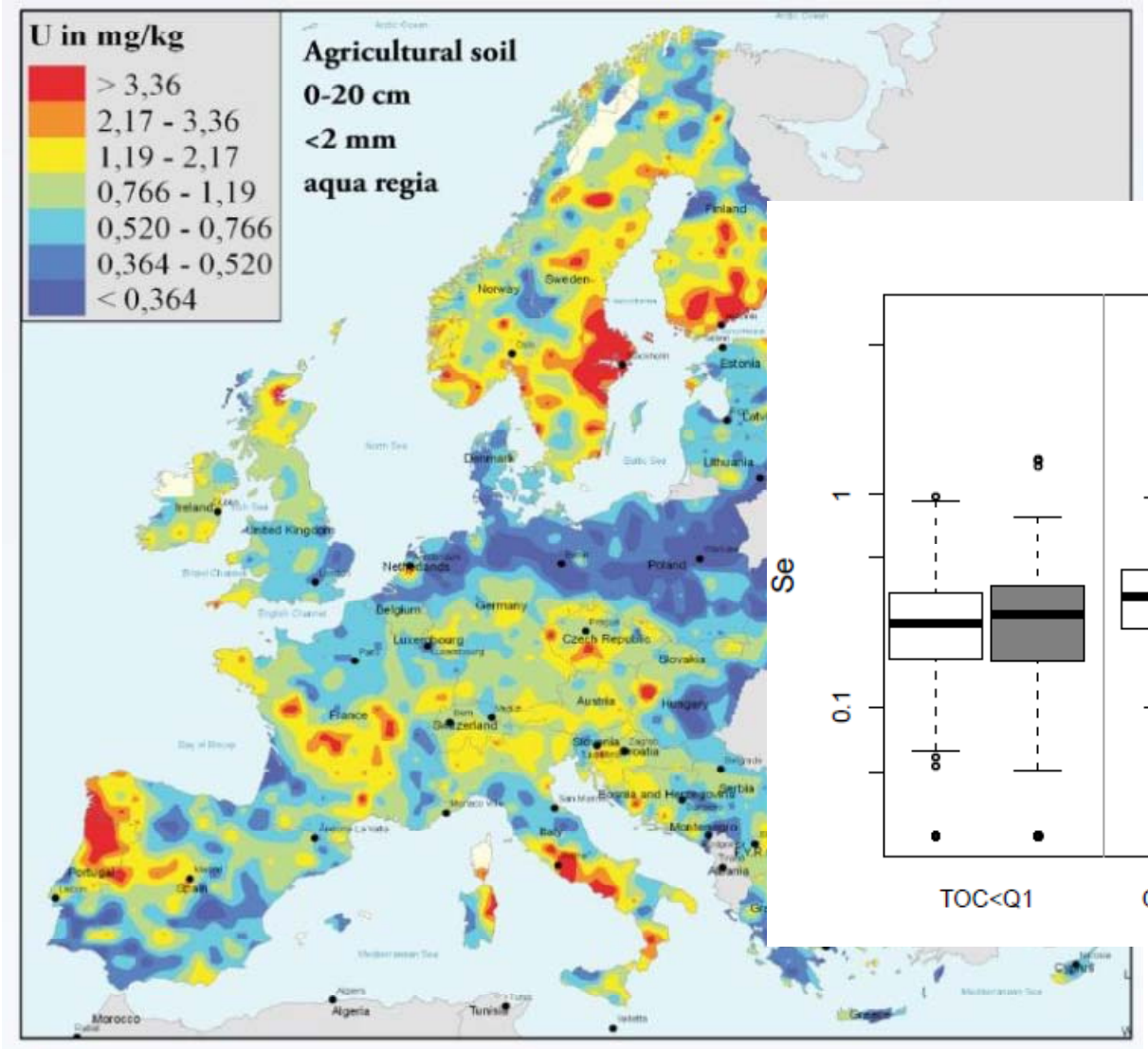
QC results are documented in two reports (freely available on the internet):

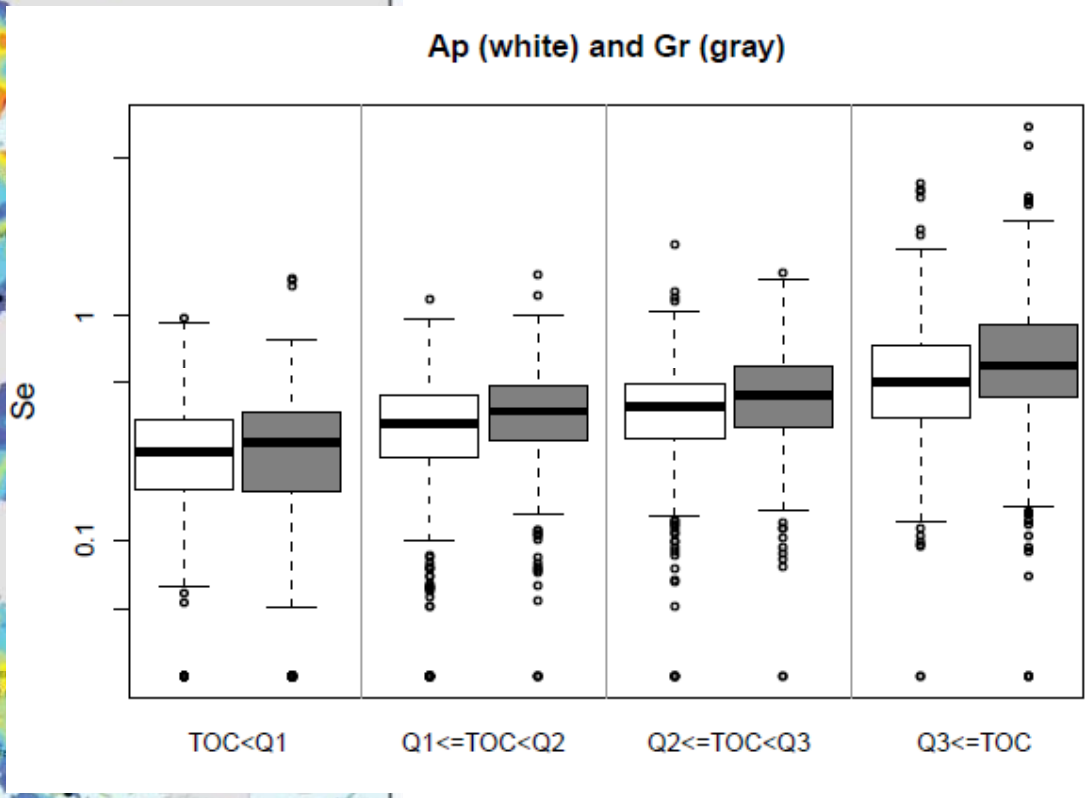
Reimann et al. (2009): Evaluation of quality control results of aqua regia extraction analysis.

Reimann et al. (2011): Evaluation of quality control of total C and S, TOC, CEC, XRF, pH and PSD analysis.

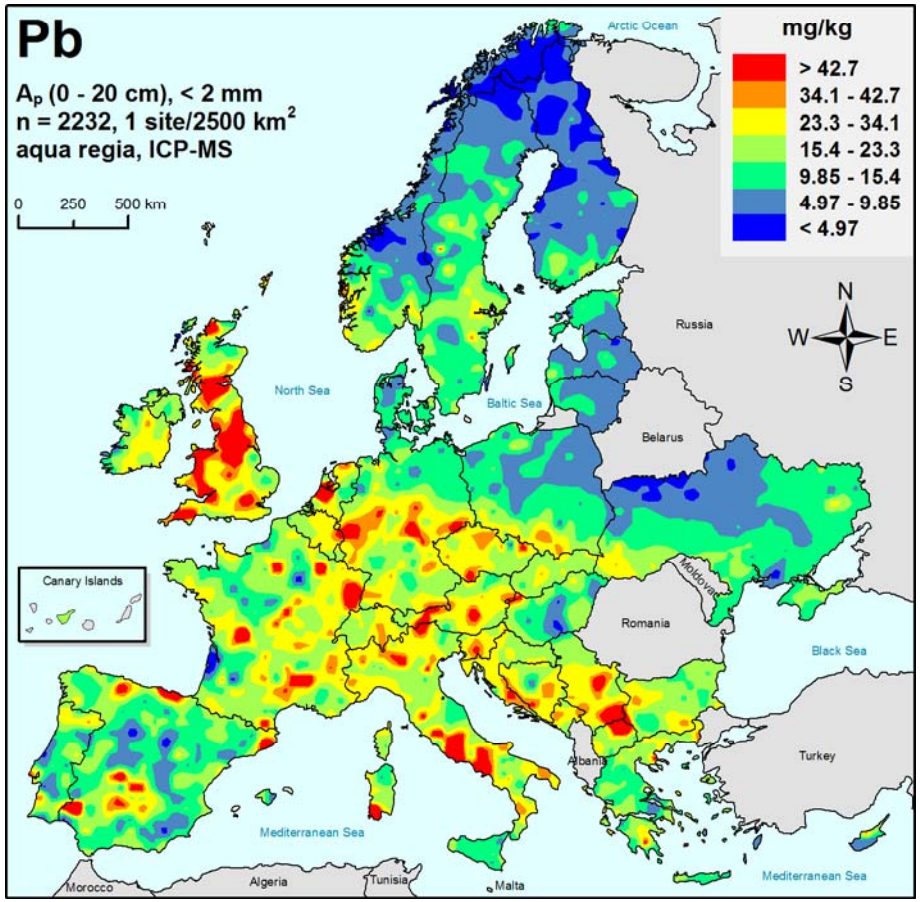
- Because of a confidentiality agreement with Eurometaux, results exist at present as a database centrally held by Executive Committee members.
- National representatives are the contact points for information about their countries. Their contact details can be found at http://gemas.geolba.ac.at/.
- The Chair of the EuroGeoSurveys Geochemistry Expert Group (Clemens Reimann) is the contact point for more general project enquiries (Clemens.Reimann@ngu.no).
- All data shall be freely available on a CD-rom that will accompany the GEMAS atlas volumes in 2013 and 2014.

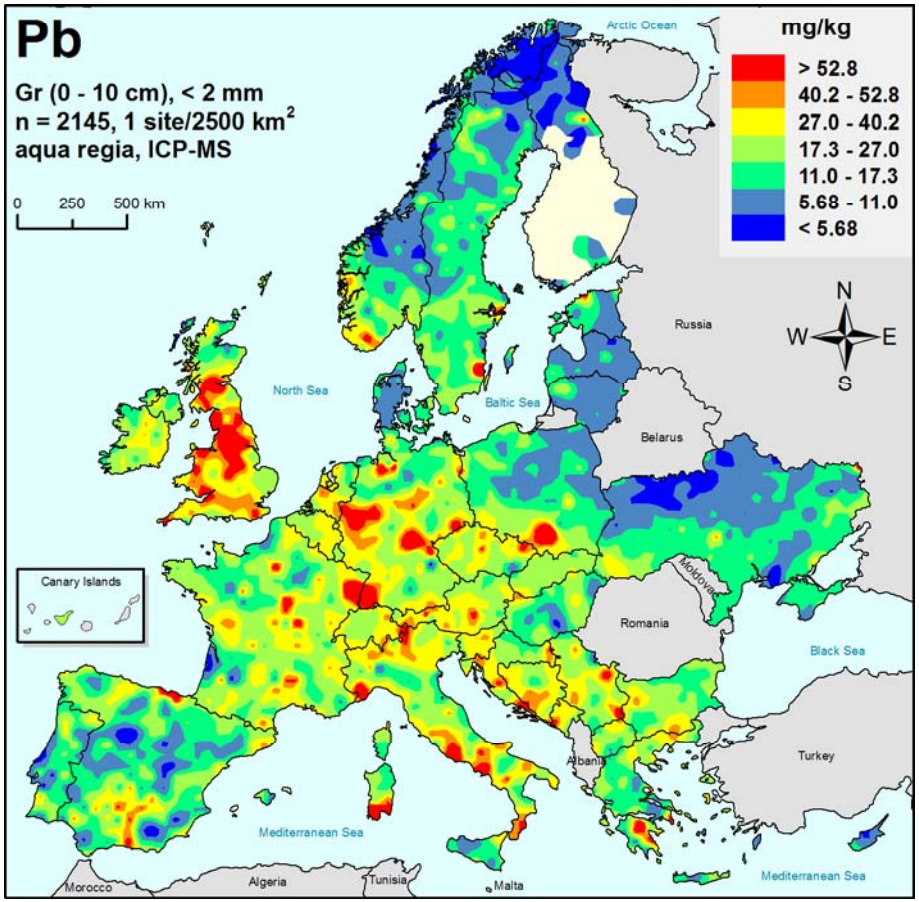
Data interpretation and plotting





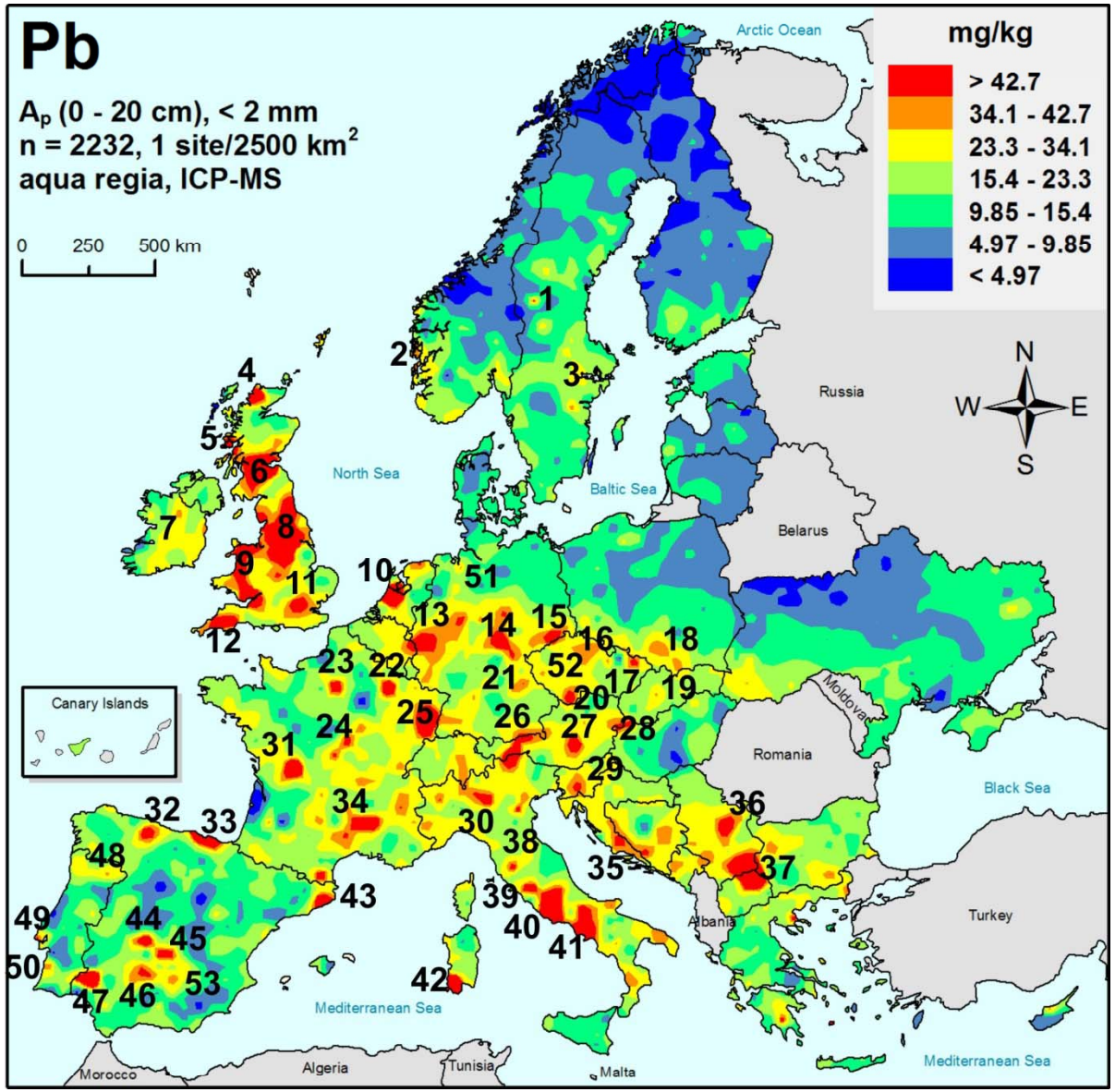
Comparison of A_p and Gr soils





Pb: Two independent sample materials show comparable patterns

Identification of anomalies



Ore deposits: 1, 3, 7, 8, 9, 12, 13, 14, 15, 16, 18, 19, 21, 24, 25, 26, 27, 20, 31, 33, 34, 35, 36, 37, 38, 39, 42, 44, 47, 53

Geology: 5, 20, 28, 29, 40, 41, 43, 46, 48

Cities: 2, 10, 11, 23, 49

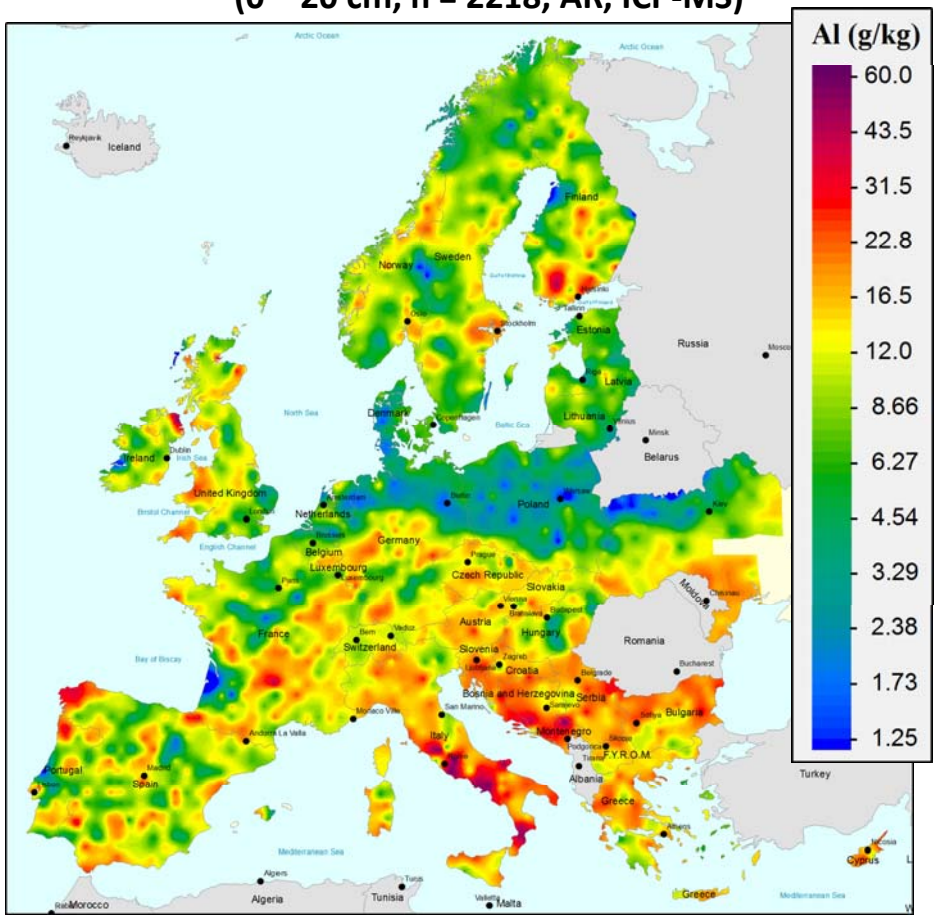
Contamination: 6, 17, 32, 50, 51, 52

Unexplained: 4, 22, 45

Distribution of Al in Ap soils of Europe

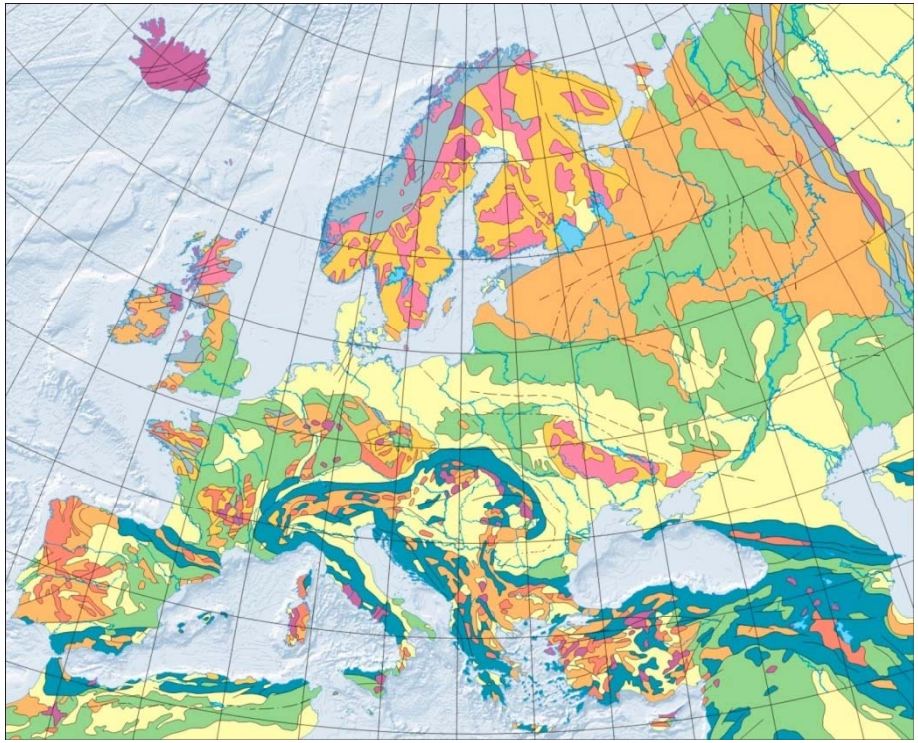
Agricultural soils (Ap)

(0 – 20 cm, n = 2218, AR, ICP-MS)



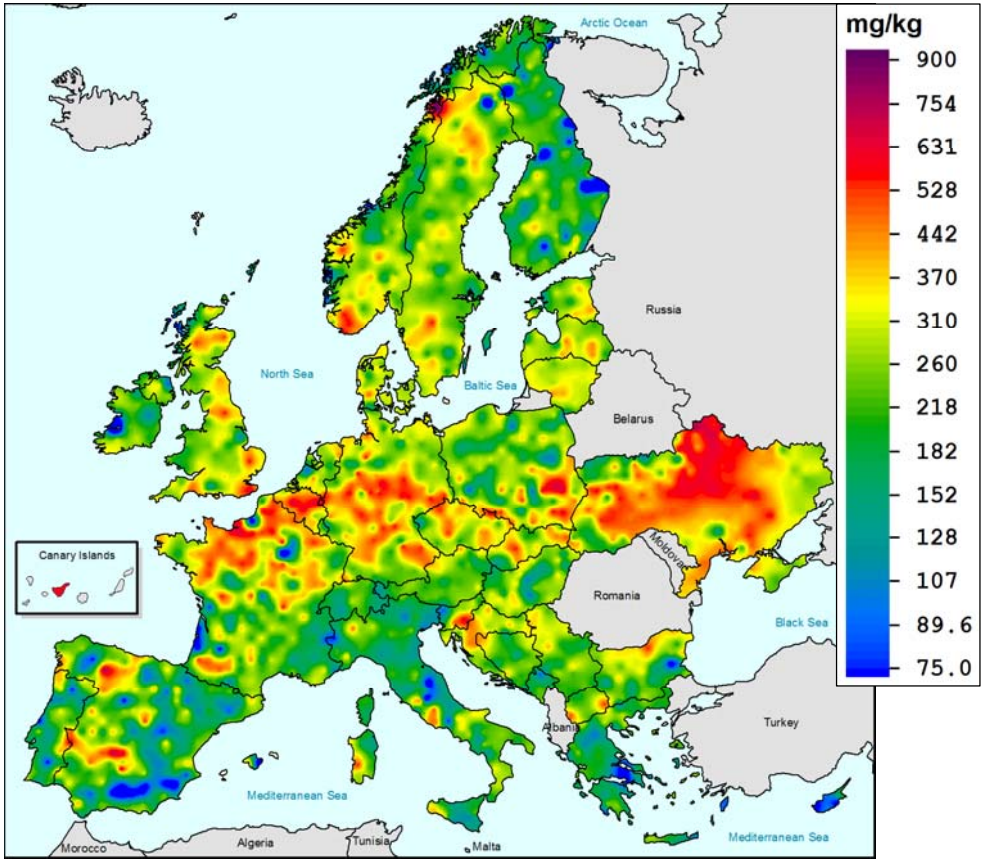
Geological map of Europe

(Hrnciarova T., Mackovcin P. et al., 2009)

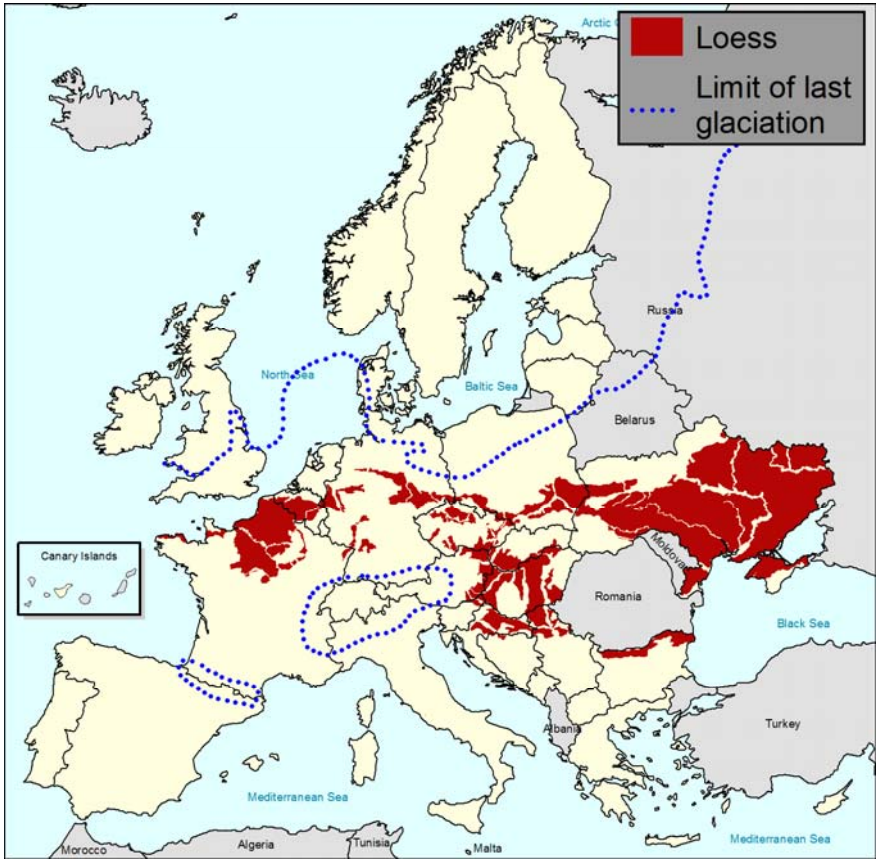


Distribution of total Zr in agricultural soils (Ap) of Europe

Zirconium (Zr)
(0 – 20 cm, n = 2219, XRF)



Parent material associations
(after Hartwich et al., 2005)



- **GEMAS geochemical atlas.**
- **Peer-reviewed journal publications.**

The concept of compositional data analysis in practice — Total major element concentrations in agricultural and grazing land soils of Europe

Clemens Reimann [a,*], Peter Filzmoser [b], Karl Fabian [a], Karel Hron [c], Manfred Birke [d], Alecos Demetriades [e], Enrico Dinelli [f], Anna Ladenberger [g] and The GEMAS Project Team [1]

Science of the Total Environment 426 (2012) 196–210

Comparing results from two continental geochemical surveys to world soil composition and deriving Predicted Empirical Global Soil (PEGS2) reference values

Earth and Planetary Science Letters 319-320 (2012) 269–276

Patrice de Caritat [a,*], Clemens Reimann [b], NGSA Project Team [1] and GEMAS Project Team [2]

Lead and lead isotopes in agricultural soils of Europe – The continental perspective

Clemens Reimann [a,*], Belinda Flem [a], Karl Fabian [a], Manfred Birke [b], Anna Ladenberger [c], Philippe Négrel [d], Alecos Demetriades [e], Jurian Hoogewerff [f], The GEMAS Project Team [1]

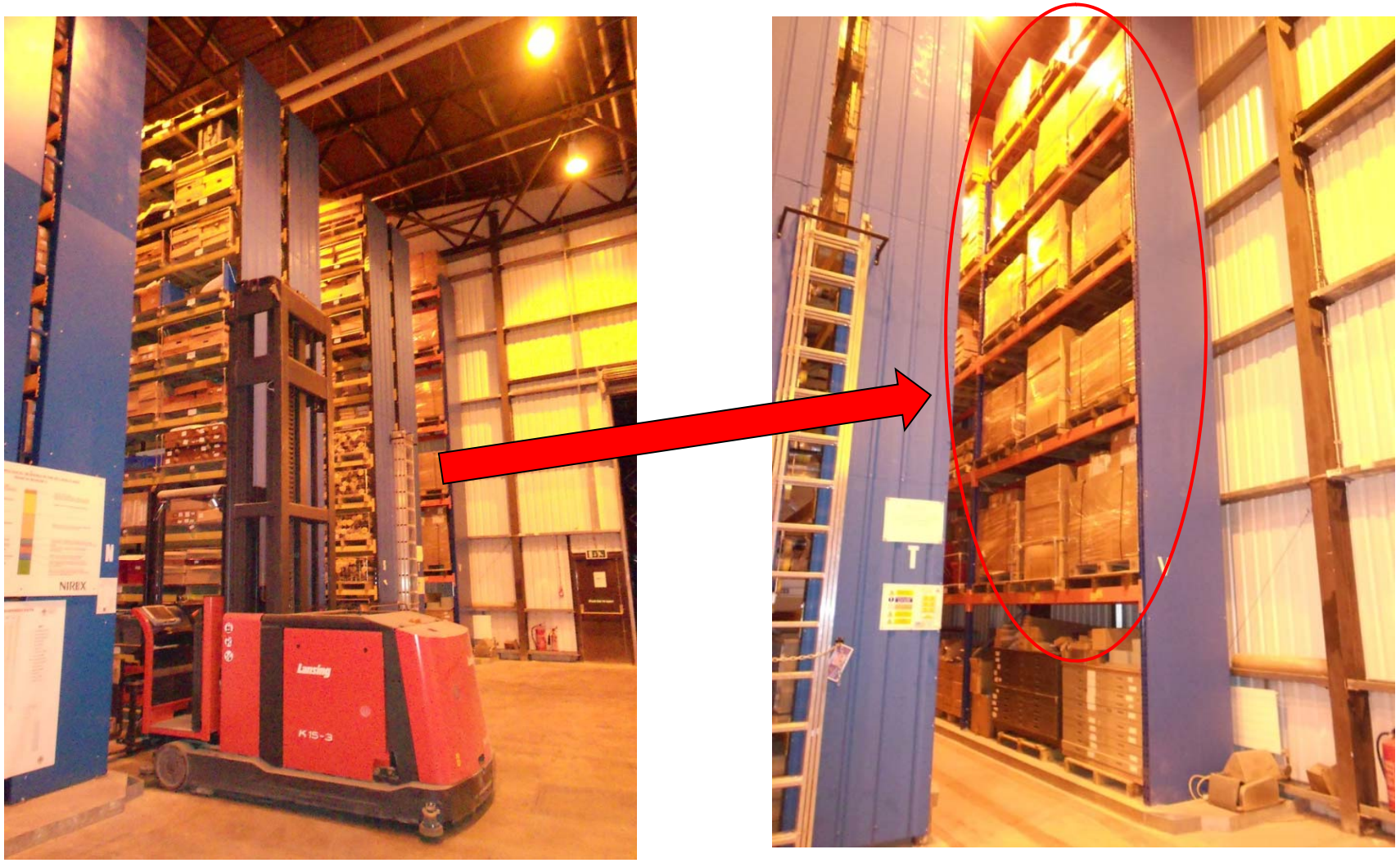
Applied Geochemistry 27 (2012) 532–542

New soil composition data for Europe and Australia: Demonstrating comparability, identifying continental-scale processes and learning lessons for global geochemical mapping

Science of the Total Environment 416 (2012) 239–252

Clemens Reimann [a,*], Patrice de Caritat [b]
GEMAS Project Team [1]
and NGSA Project Team [2]

Legacy : GEMAS Sample Storage



- A high quality and harmonised data set of metal concentrations in agricultural and grazing land soils at the European scale has been created.
- Natural variation is large for most elements, usually several orders of magnitude (between one and four orders of magnitude for total concentrations, and up to five orders of magnitude in AR extraction).
- Natural processes (geology and climate) drive the regional distribution patterns observed on most maps. Most element distributions show a break in concentrations between northern and southern Europe along the maximum extent of the last glaciation.

- For most of elements the median values in agricultural and grazing land soils are very similar.
- Results show that low density mapping (1 site per 2500 km^2) is ideal for working at the European scale and delivers very informative maps, displaying robust element distribution patterns.
- Generally, contamination is hardly visible at this scale, and can only be reliably detected at a local scale. Higher density of soil sampling is required for contaminated land assessments.

- GEMAS is an excellent example of the delivery of a project according to the principles outlined by Darnley *et al*. 1995.
- The project demonstrates how global geochemical mapping has evolved and matured over the past two decades. Baseline geochemical data are still a fundamental national requirement, but here we show a low density survey that has been carried out to address a specific legislative driver (REACH).
- Not only can we be confident that geochemical mapping is now being carried out in a way that makes national comparisons possible, but the GEMAS-NGSA (National Geochemical Survey of Australia) work demonstrates how we are now able to deliver interoperable data sets on a global scale.

For more information on the progress of GEMAS, please consult the project's website at:

http://gemas.geolba.ac.at/

Thank you for your attention