e-SOTER

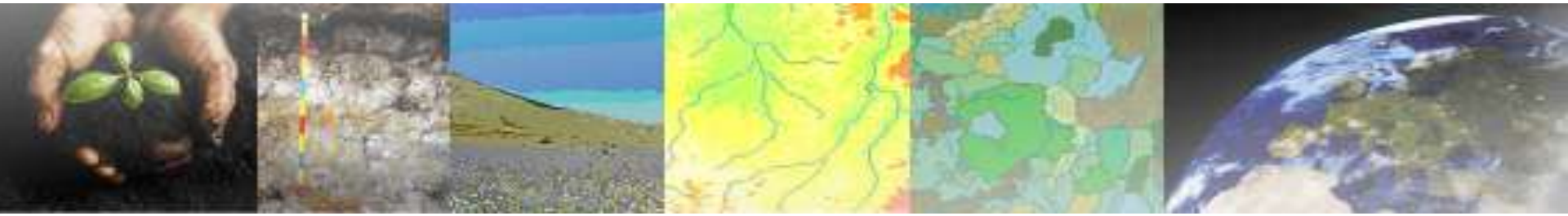
Regional pilot platform as EU contribution to a Global Soil Observing System

A new classification of soil parent material

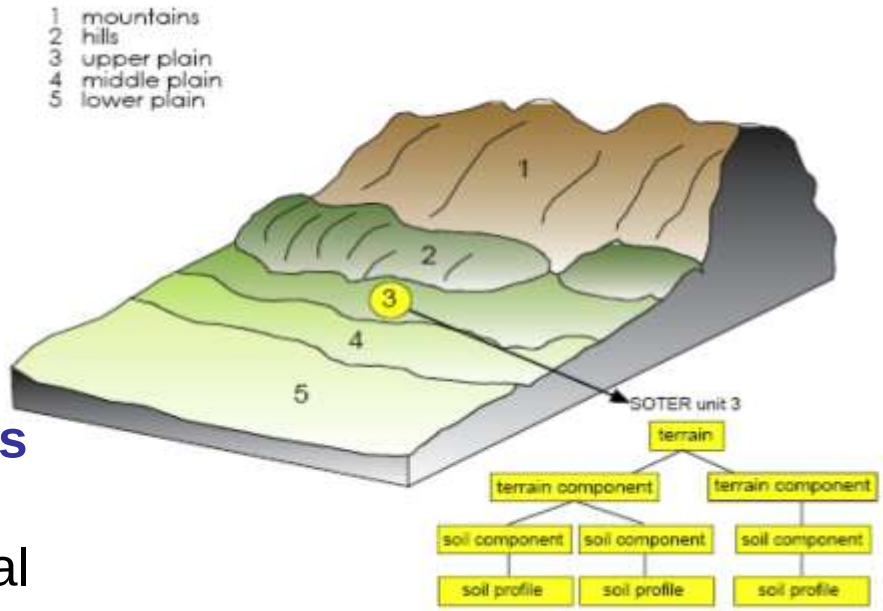
- Research about PM in soil mapping -

Ulrich Schuler

Rainer Baritz, Jan Willer, Harald G. Dill

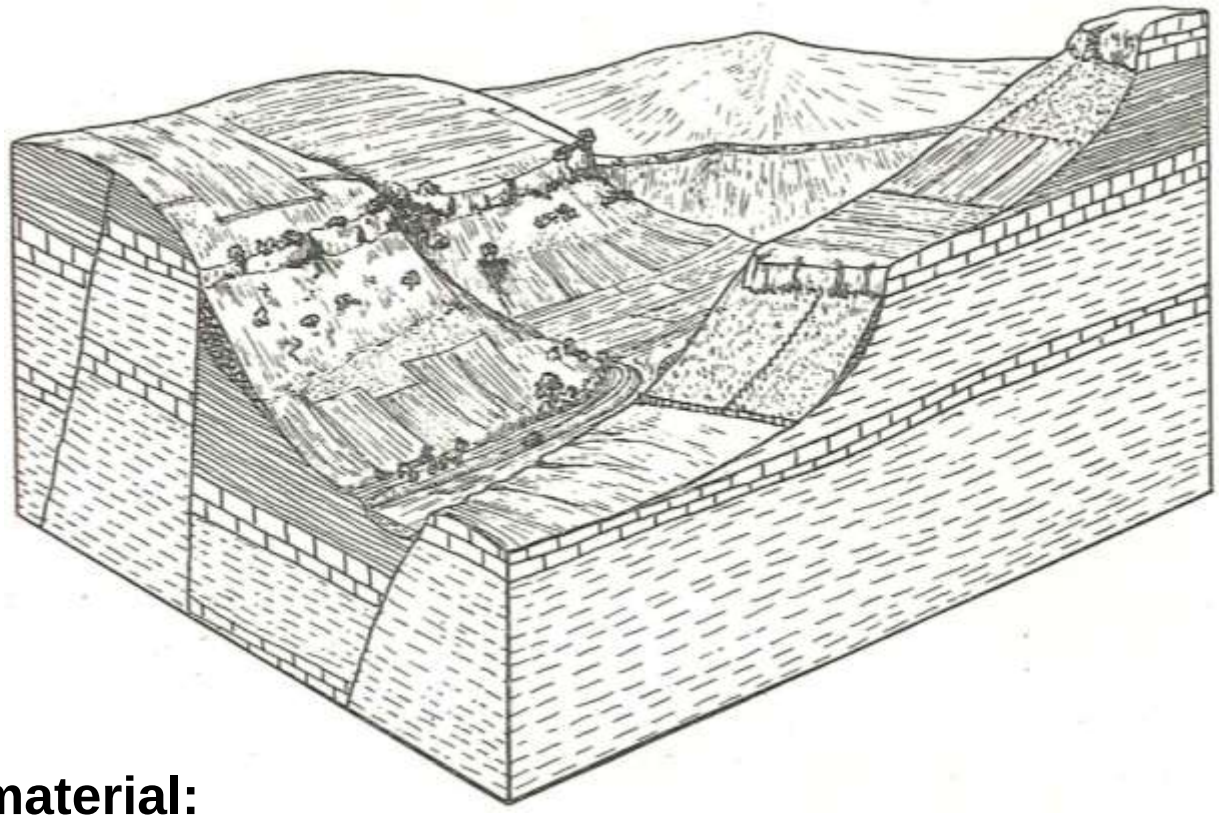


Background and motivation



- SOTER (SOilTERrain) is a mapping approach, which combines **landforms** and **parent material** to form terrain units, which are represented by typical soil (associations).
- Usually, „parent material“ information is derived from geological maps. Alterantively, PM information can be gained by interpretation of RS- or gamma spectrometric data.
- However, there is still no common accepted PM classification in soil science. Therefore, PM is classified and interpretated in different ways.

Importance of parent material



Parent material:

- is crucial for our understanding of processes in the landscape
- is one important factor of soil formation
- influences soil properties
- is important for soil prediction → e.g. SCOR**P**AN approach

Workplan

Block I

1. **Define PM:** investigate the definition of (soil) parent material
2. **PM classification:** investigate and revise existing PM classifications (lists of PM, done by soil mappers), so that different geology maps can be re-interpreted in an harmonized way, and that PM during soil mapping is identified correspondingly

⇒ **Main focus of this presentation is on work in Block I**

Workplan

Block II

3. **Soil mapping using PM information:** investigate how PM is applied in soil mapping

4. **Soil mapping using gamma spectrometry:** delineation of substrates, soils and soil properties

Block I

1. Definition of soil PM

Existing soil parent material definitions

- initial state of soil formation (Jenny 1941)

- unconsolidated organic and mineral material in which soil forms (NRCS, 1993)

- (rock) material, which has been formed before pedogenesis took place (KA5, 2005)

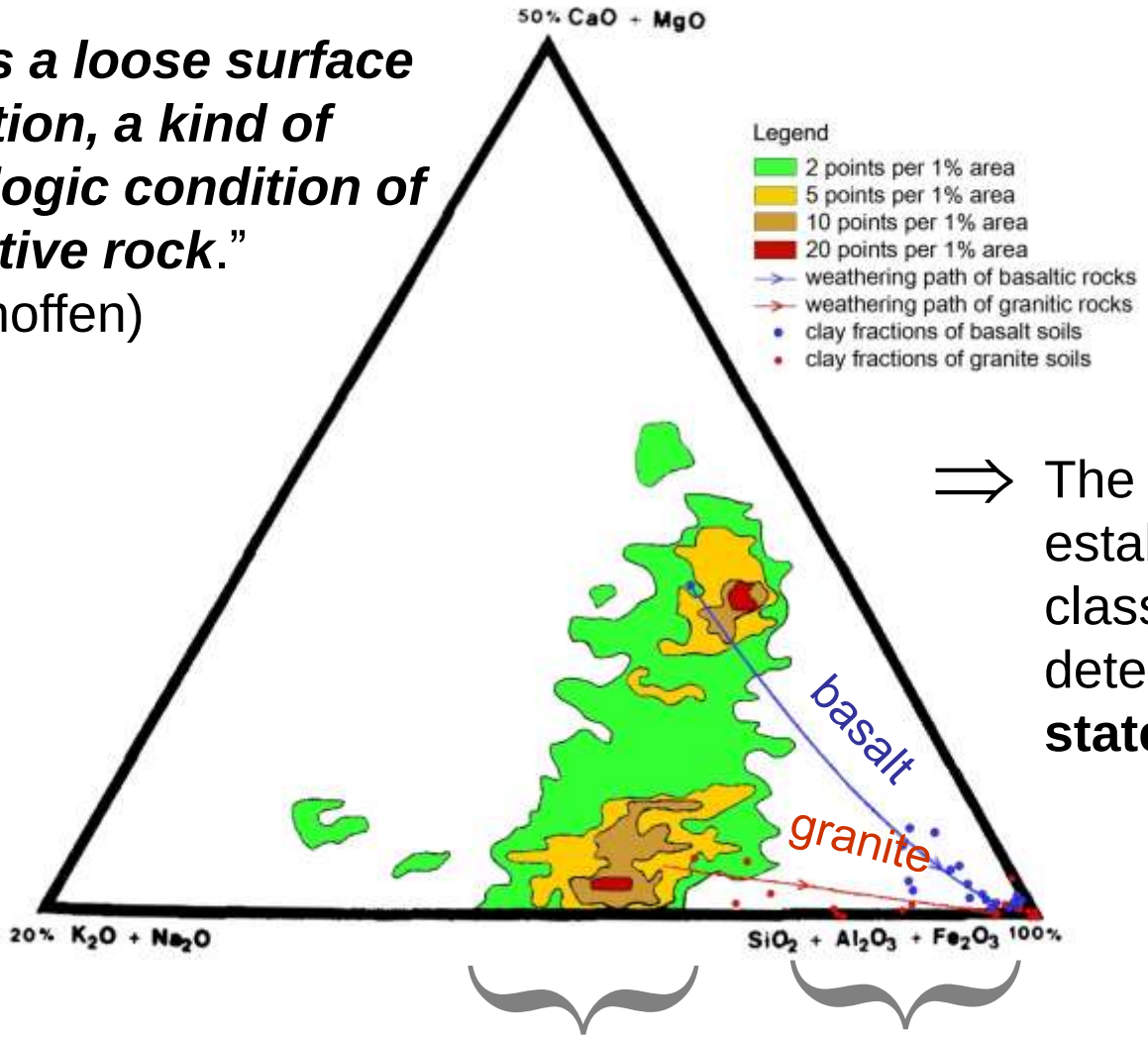
- unconsolidated material, mineral or organic, from which the solum develops (Neuendorf et al. 2005)

- material from which the soil has presumably been derived (FAO 2006)

- geological deposit over and within which a soil develops. Typically, the parent material is the first recognizably geological deposit encountered when excavating beneath the soil layer. It represents the very-near-surface geology (BGS 2009)

Definition of the initial point of soil formation
-Death of rock = birth of soil-

"***Soil is a loose surface formation, a kind of pathologic condition of the native rock***."
(Richthoffen)



⇒ The major problem in establishing a new soil PM classification is the determination of the **initial state of soil formation**.

Initial geochemistry of the **<u>unweathered</u>** rock

geochemistry of the **<u>weathered</u>** rock

Existing soil parent material classifications (Selection)

KA 5 (Ad-hoc-AG Boden, 2005). Bodenkundliche Kartieranleitung (5th Edition). Hannover, Germany.
→ national maps, soil profiles

ESBN (Finke, P., Hartwich, R., Dudal, R., lbàñez, J. Jamagne, M., King, D, Montanarella, L., Yassoglou, 2001). Georeferenced Soil Database for Europe. Manual of Procedures. Version 1.1 by European Soil Bureau Scientific Committee. Joint Research Centre, Italy.
→ ESDB map, EU relevant soil mapping projects

FAO 2006. Guidelines for soil description. FAO, Rome, Italy.
→ international maps, soil profiles

ESBN soil parent material classification (Finke et al., 2001) -Selection-

Class	Group	Type	Subtype
consolidation degree, major rock type, relief position, genesis	geochemical character, genetic rock type, facies, rock genesis, relief position	rock type, rock genesis, facies, genesis, relief position, age	rock type, cementation, consolidation degree, porosity, geochemical character, relief position, age
100 consolidated clastic sedimentray rocks	**120** psammite, arenite	**121** sandstone	**1213** clayey sandstone
100 consolidated clastic sedimentray rocks	**140** facies rocks	**141** flysch	**1413** conglomeratic flysch
300 igneous rocks	**310** acid to intermediate plutonic rocks	**313** diorite	**3132** ?gabbro diorite?
300 igneous rocks	**370** pyroclastic rocks (tephra)	**372** tuffite	**3721** sandy tuffite
500 unconsolidated deposits (alluvium, weathering residuum and slope deposits)	**510** marine and estuarine sands	**511** Pre-Quarternary sand	**5831** Tertiary sand
500 unconsolidated deposits (alluvium, weathering residuum and slope deposits)	**580** slope deposits	**583** talus scree	**5831** stratified slope deposit

FAO soil parent material classification (FAO, 2006) -Selection-

Class	Group	Type
major rock type, consolidation degree	geochemical character, rock genesis	rock type, rock genesis
I igneous rock	**IA** acid igneous	**IA1** rhyolite
I igneous rock	**IB** basic igneous	**IB2** basalt
I igneous rock	**IU** ultrabasice igneous	**IU3** ilmenite, magnetite, ironstone, serpentinite
M metamorphic rock	**MA** acid metamorphic	**MA4** schist
M metamorphic rock	**MB** basic metamorphic	**MB2** schist
S sedimentary rock (consolidated)	**SC** clastic sediments	**SC3** silt-, mud-, claystone
S sedimentary rock (consolidated)	**SO** carbonatic, organic	**SO1** limestone, other carbonate rock
S sedimentary rock (consolidated)	**SE** evaporites	**SE1** anhydrite, gypsum
U sedimentary rock (unconsolidated)	**UG** glacial	**UG2** glacio-fluvial sand

intermediate metamorphic rock is lacking

„Costal sand with shells“

How useful are such terms?

Established soil parent material classifications:

A.) FAO (2006): marin, estuarin (group), sand (type)

B.) ESBN (Finke et al., 2003): marine und estuarine sands (group), Quarternary sand (type), Holocene coastal sand with shells (!) (subtype)

C.) KA5 (2005): coastal deposits (group), costal sand

Problems with existing soil parent material classifications:

- inconsistencies (e.g. acid igneous, basic igneous, pyroclastic, fluvial)
- blending the description of properties and genesis (e.g. river terrace sand)
- inadequate/ missing explanation of „self-defined“ materials (z.B. meadow sand, river sand, decomposition products, old loam)
- use of questionable classification criteria (e.g. Tertiary sand, costal sand with shells)
- questionable selection of rocks (e.g. FAO, 2006: granite is missing, instead minerals such as ilmenite and magnetite are listed)
- classification gaps (e.g. FAO, 2006: acid and basic metamorphits are listed, intermediate metamorphits are missing)

Block I

2. Classification of soil PM

⇒ **Revision of the FAO PM list (Table 12, FAO 2006)**

Objectives for a revised PM classification

- globally applicable (FAO soil profile description)

- compatible with SOTER, OneGeology (term dictionary)

- not too complex

- applicable to all scales

- pedologically relevant structured

Methodology for revising FAO 2006

- review existing rock and PM classifications (OneGeology Europe, BGS dictionary, GeoSciML, FAO and others)

- review the relevance of potential PM components (e.g. consolidation degree, geochemistry) for soils and soil properties

- streamline the existing FAO 2006 PM classification

Results

Concept of the revised soil parent material classification in order to increase the information value for soil property prediction

Property description
- consolidation degree
- geochemical character
- strength of geochemical character
- major rock type
- rock type

Additional infromation about surface processes
- genesis
- process state(continuing/terminated)

Results

Proposal of a new interantional parent material classification -Selection-

Level 1	Level 2	Level 3	Level 4	Level 5
consolidation degree	**geochemical character**	**strength of geochemical character**	**major rock type**	**rock type**
C consolidated	**CS** siliceous	**CSA** acid (>66% SiO_2)	**CSAI** magmatite	**CSAI2** granite, rhyolite, ….
C consolidated	**CC** calcareous	**CCP** pure (>95% carbonates)	**CCPM** metamorphite	**CCPM1** marble
C consolidated	**CK** rock sequence with calcareous rocks	**CKX** not specified	**CKXX** not specified	**CKXXx** rock sequence with calcareous rocks
S semi-consolidated	**SC** calcareous	**CCX** not specified	**CCXS** not specified	**SCXS1** chalk
U unconsolidated	**US** siliceous	**USA** acid (>66% SiO_2)	**USAS** sediment	**USAS1** sand
U unconsolidated	**UC** calcareous	**UCX** not specified	**UCXS** sediment	**UCXS1** carbonate sand

(Extract of the revised FAO PM list)

Advantage of the revised classification regarding the deriviation of soil properties

1 Material description

- consolidation degree → content of coarse fragments, soil thickness, weathering rates

- geochemical character → salt concentration, carbonate concentration, base saturation, nutrient stocks

- strength of geochemical character → content of coarse fragments, texture, clay mineralogy, soil thickness, field capacity, cation exchange capacity, base saturation, nutrient stocks, organic matter, macronutrient and micronutrient concentrations, erodibility, swelling and shrinking, soil structure

- rock types →local soil variability, macro- and micronutrient concentrations, permeability, erodibility, rootability, salinization

Results

Additional information about surface processes -Selection-

Level 1	Level 2	Level 3
Prozess	**Specification**	**State**
a aeolian deposition	**ab** sandy	**abxi** terminated
c chemical deposition	**cd** encrusted	**cdca** continuing
l lake deposition	**lb** littoral	**lbxa** continuing
u fluvial deposition	**ux** not specified	**uxxa** continuing
e erosion	**ew** hydric	**ewxa** continuing
e erosion	**ev** aeolian	**evxa** continuing
w weathering	**wp** physical	**wpfa** continuing
w weathering	**wc** chemical	**wcbi** terminated
x not specified	**xx** not specified	**xxxx** not specified

Advantage of the proposed classification regarding the deriviation of soil properties

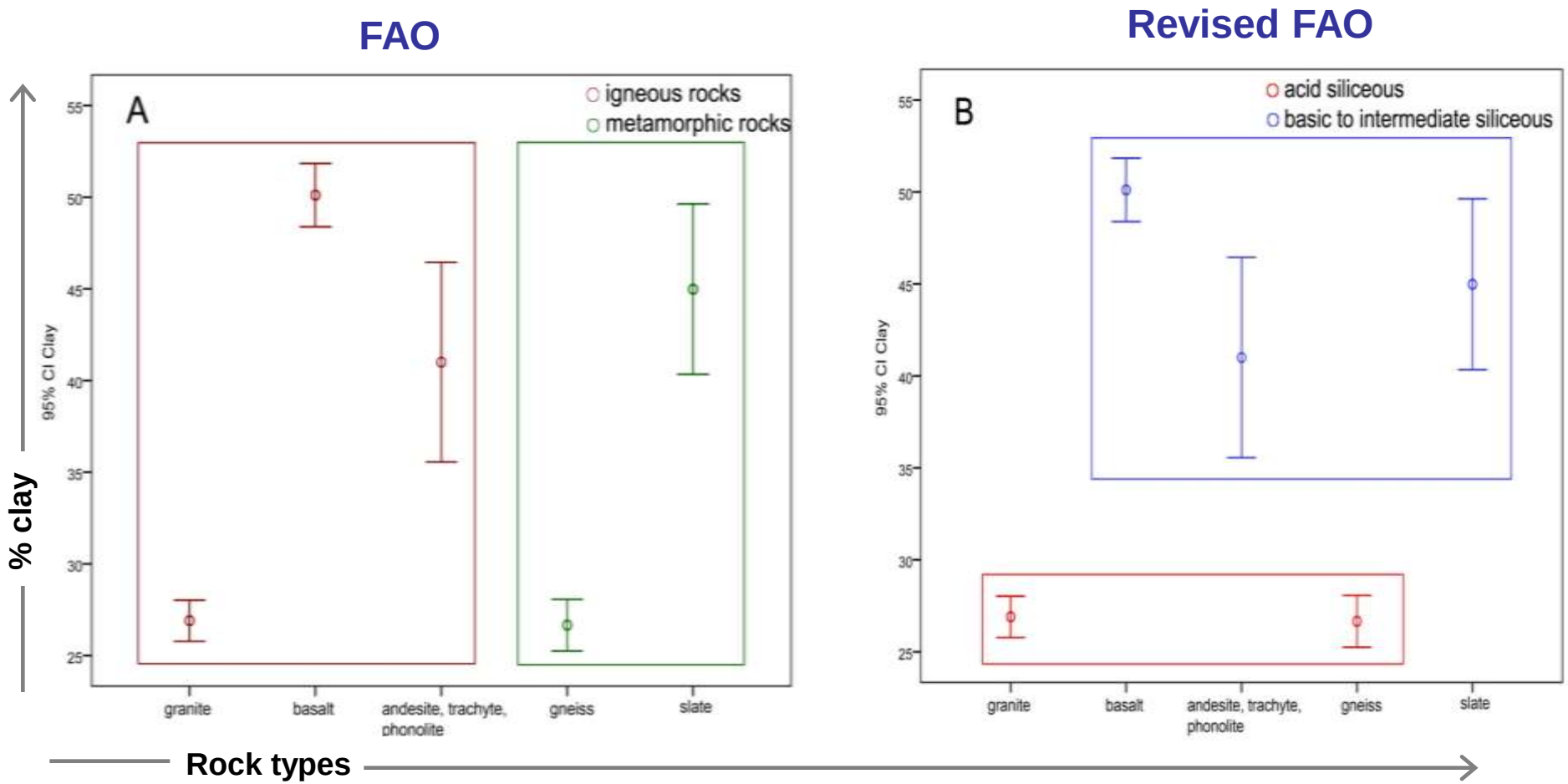
2 Additional surface process information

- Genesis → content of coarse fragments, texture, organic matter

- Process state (continuing/terminated) → degree of soil formation

BGR

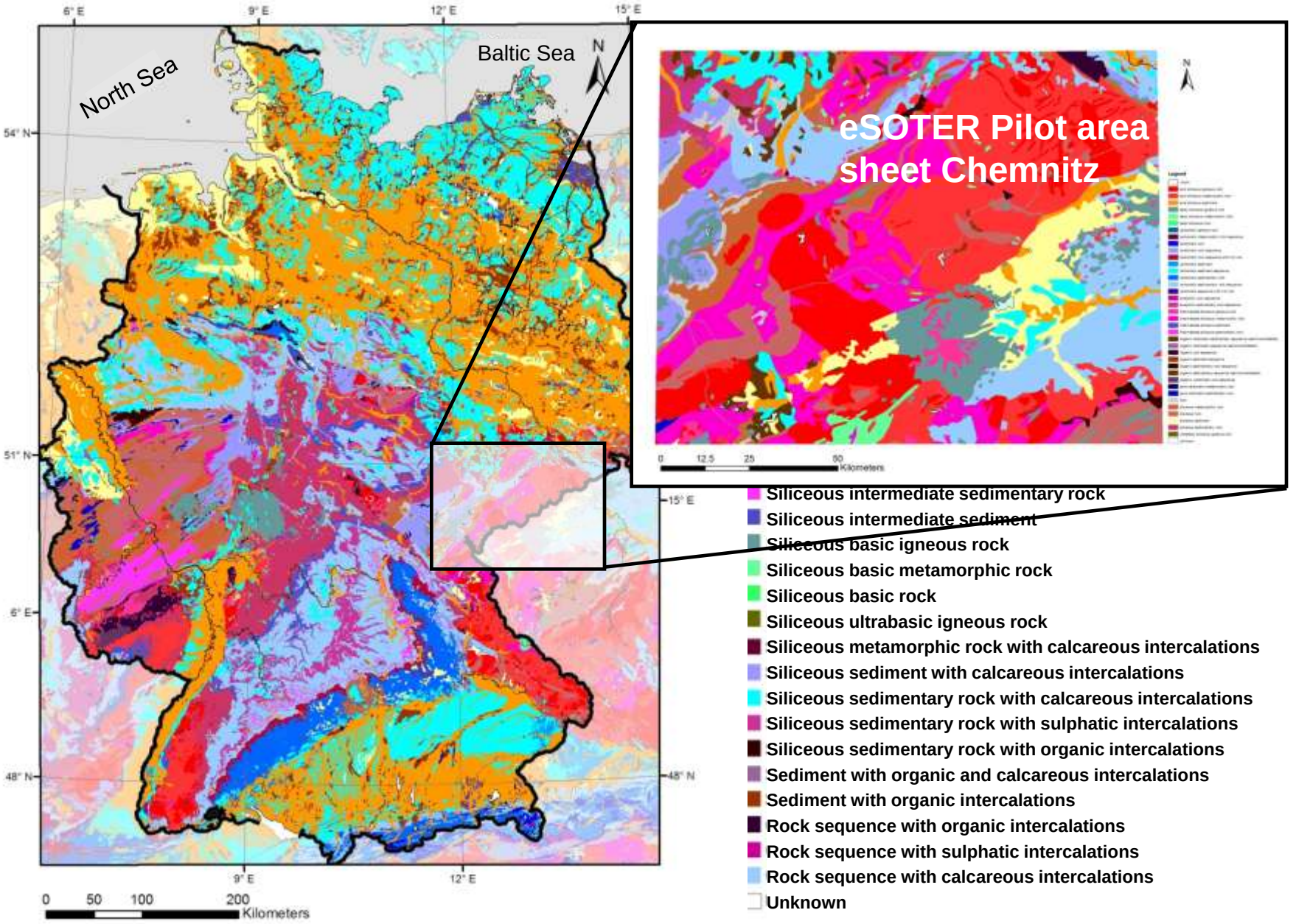
Validation: Analysis of WISE data set



Data: WISE database (Batjes, 2008)

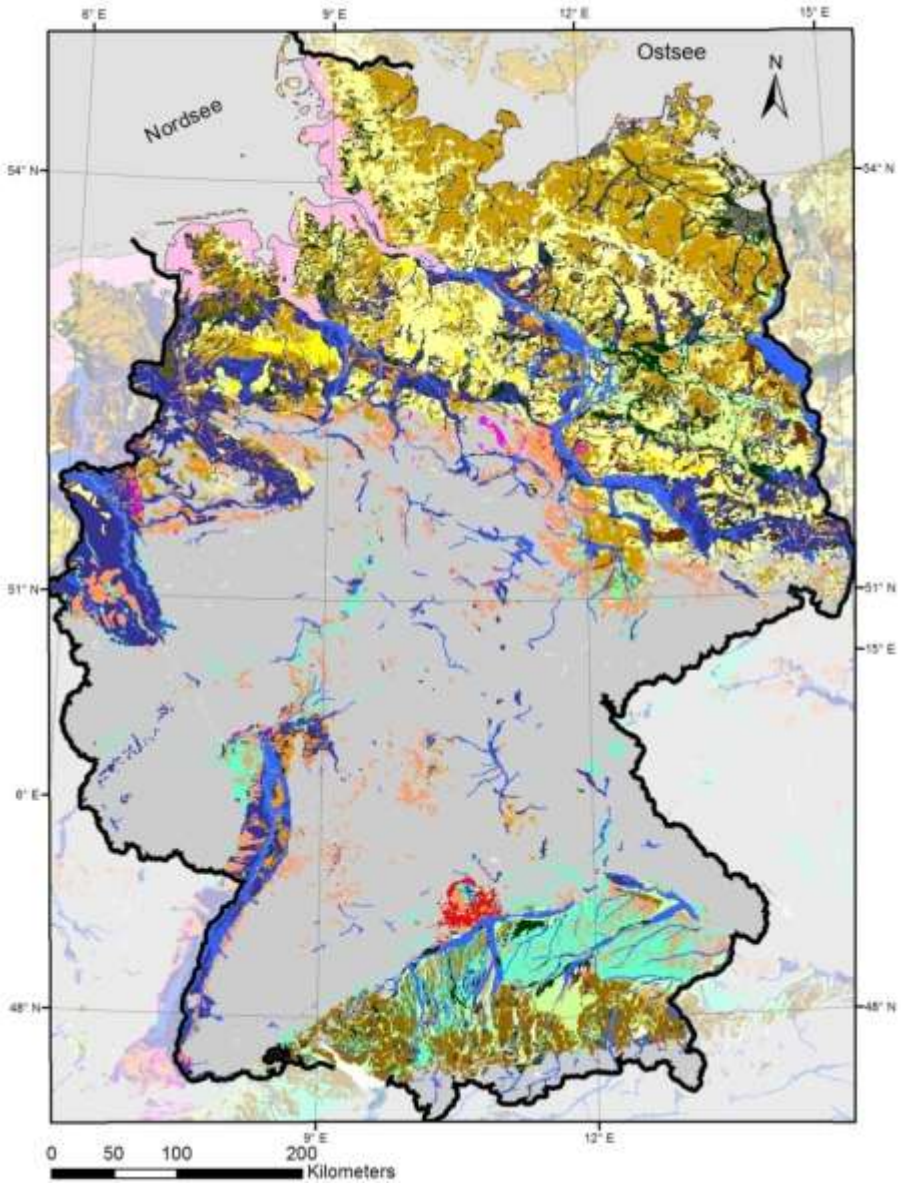
Application: German geology map 1:1Mio

1. Rock types (Level 4)



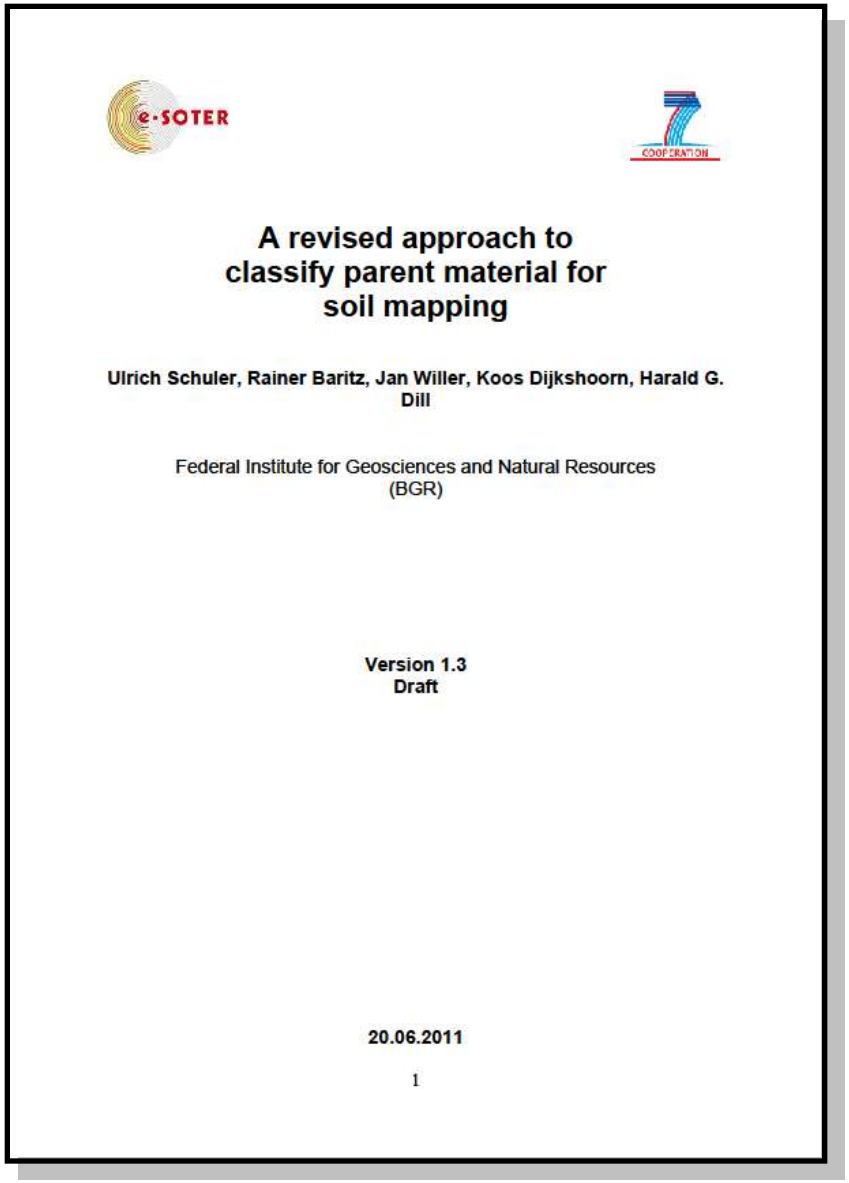
Application: German geology map 1:1Mio

2. Genesis



- Aeolian, sandy, continuing
- Aeolian, sandy, terminated
- Aeolian, sandy-silty, terminated
- Aeolian, silty, terminated
- Chemical, calcareous, continuing
- Glaciofluvial sheet and channel deposition, terminated
- Fluvial, glaciofluvial sheet and channel deposition, terminated
- Glaciolacustrine lake deposition, end moraine deposition, terminated
- End moraine deposition, terminated
- Ground moraine deposition, terminated
- Glacial deposition, terminated
- Impact event, terminated
- Fluvial and lake deposition, terminated
- Lake deposition, terminated
- Marine deposition, continuing
- Marine deposition, terminated
- Rainwater-fed moor formation, continuing
- Groundwater-fed moor formation, continuing
- Moor formation, terminated
- Fluvial deposition, terminated
- Fluvial deposition, continuing
- Regolith formation, continuing
- Unknown

Report:



A revised approach to classify parent material for soil mapping

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Federal Institute for Geosciences and Natural Resources (BGR)

Version 1.3
Draft

20.06.2011

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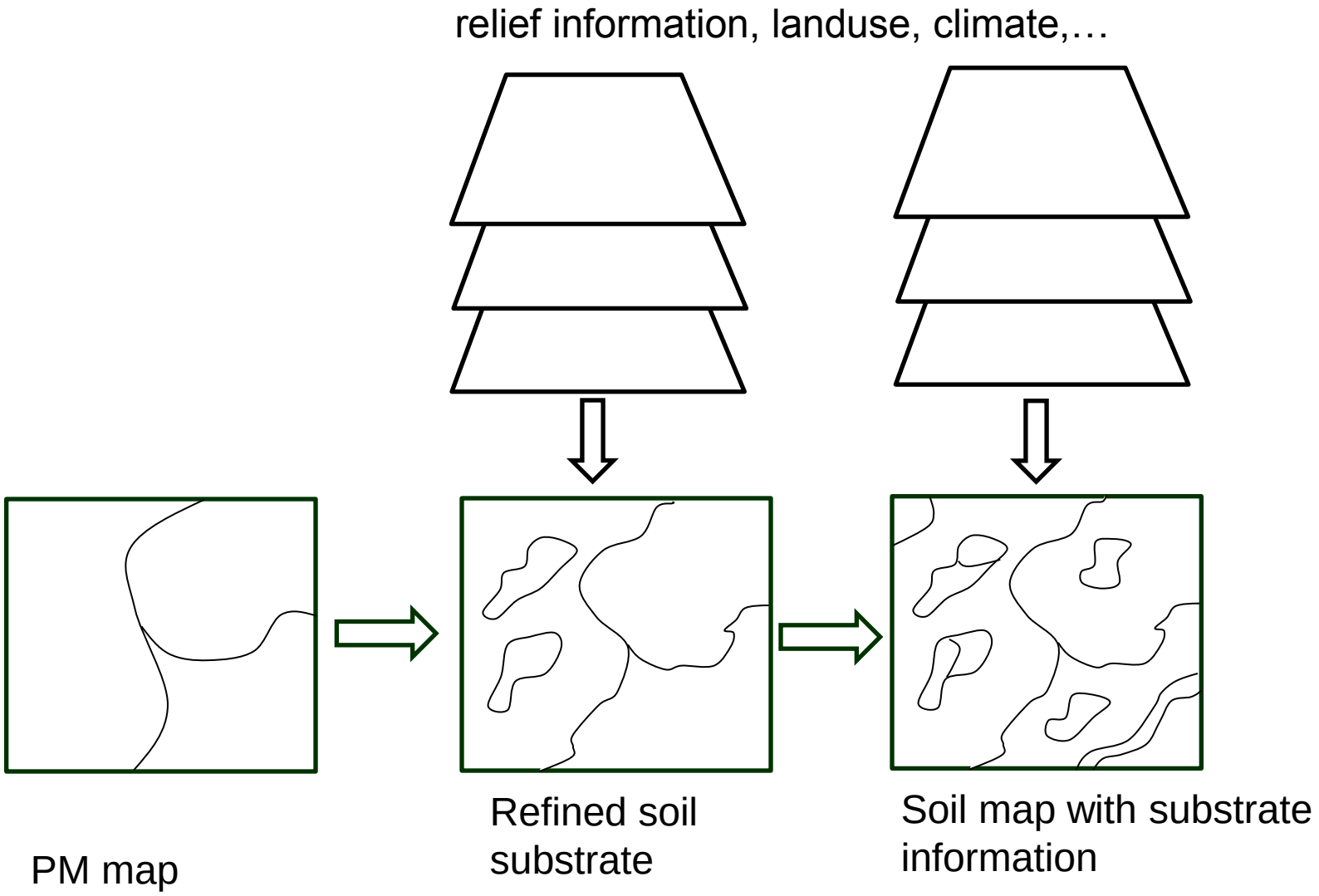
1. **External review**
2. **Publication**
   - Report (ISRIC)
   - Revised SOTER manual
   - Next edition of the FAO „Guidelines for soil profile description“

Block II

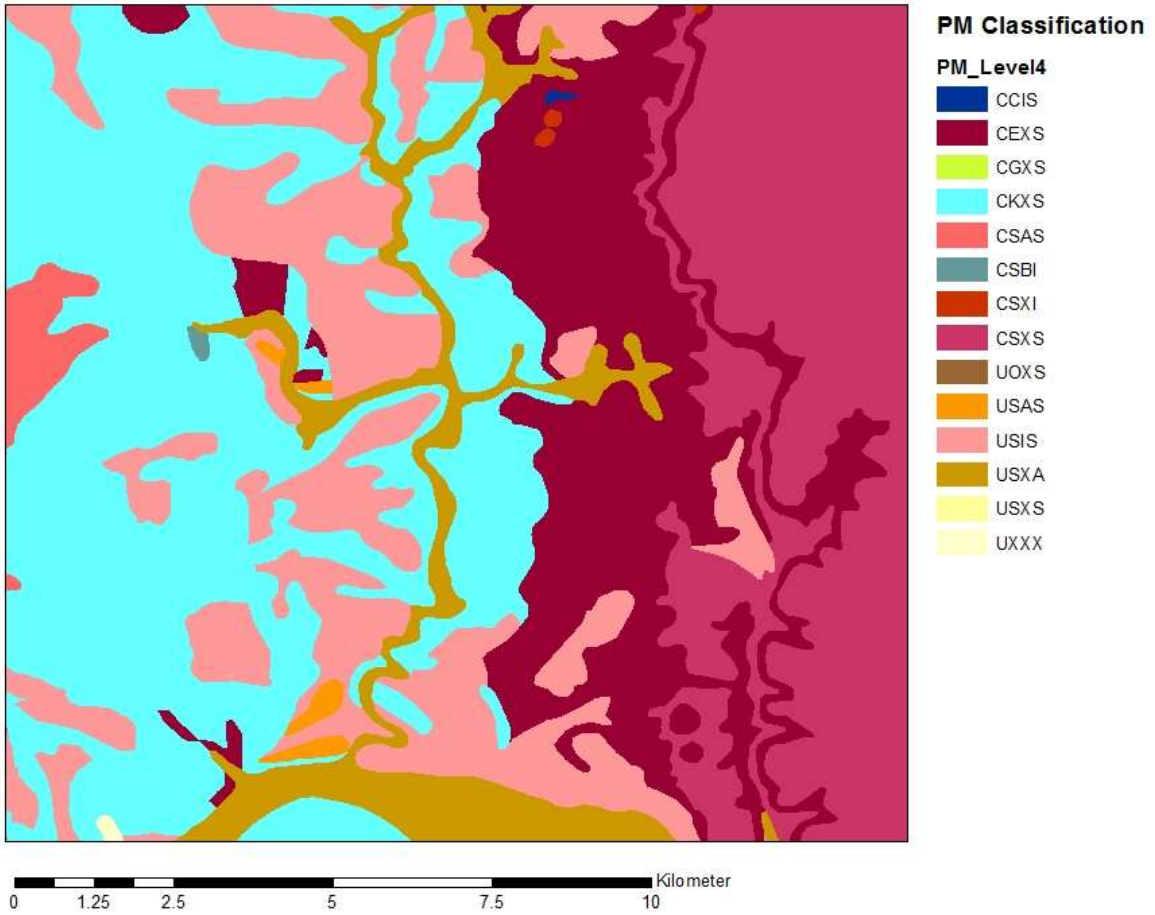
3. Soil mapping using PM information

Using PM maps in an DSM approch



Example: PM Map

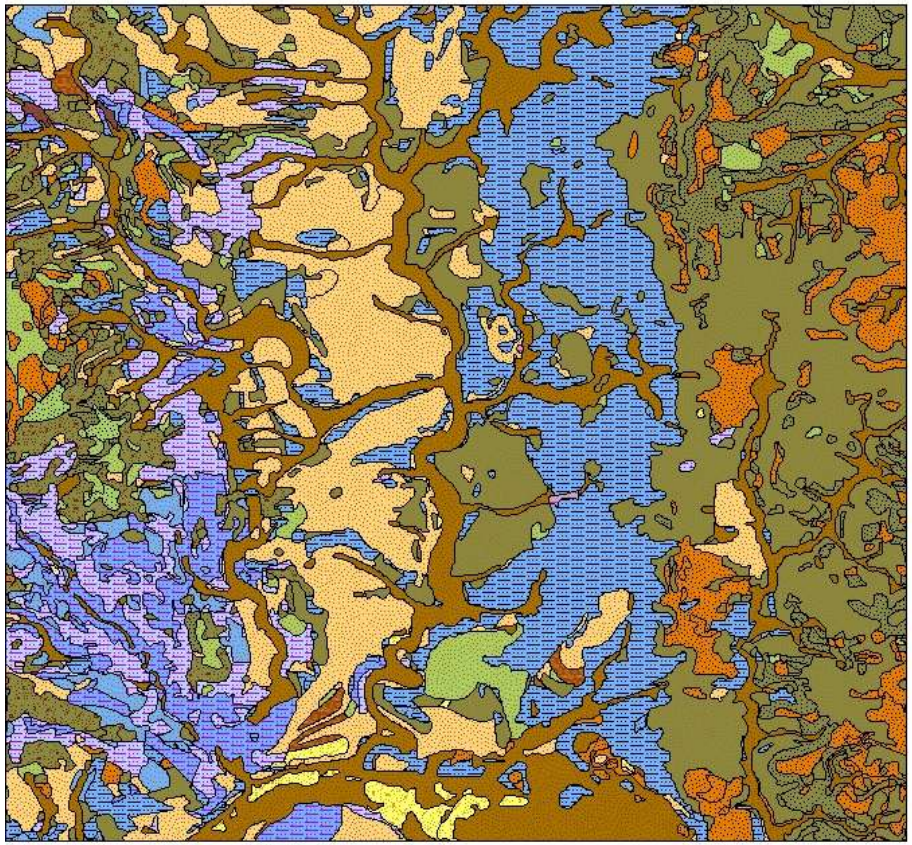
PM classification based on a geological map 1: 200 000



Willer, 2012

Example: Refined soil substrate

Disaggregation of the PM map into soil substrates



Soil Substrate

surface substrate

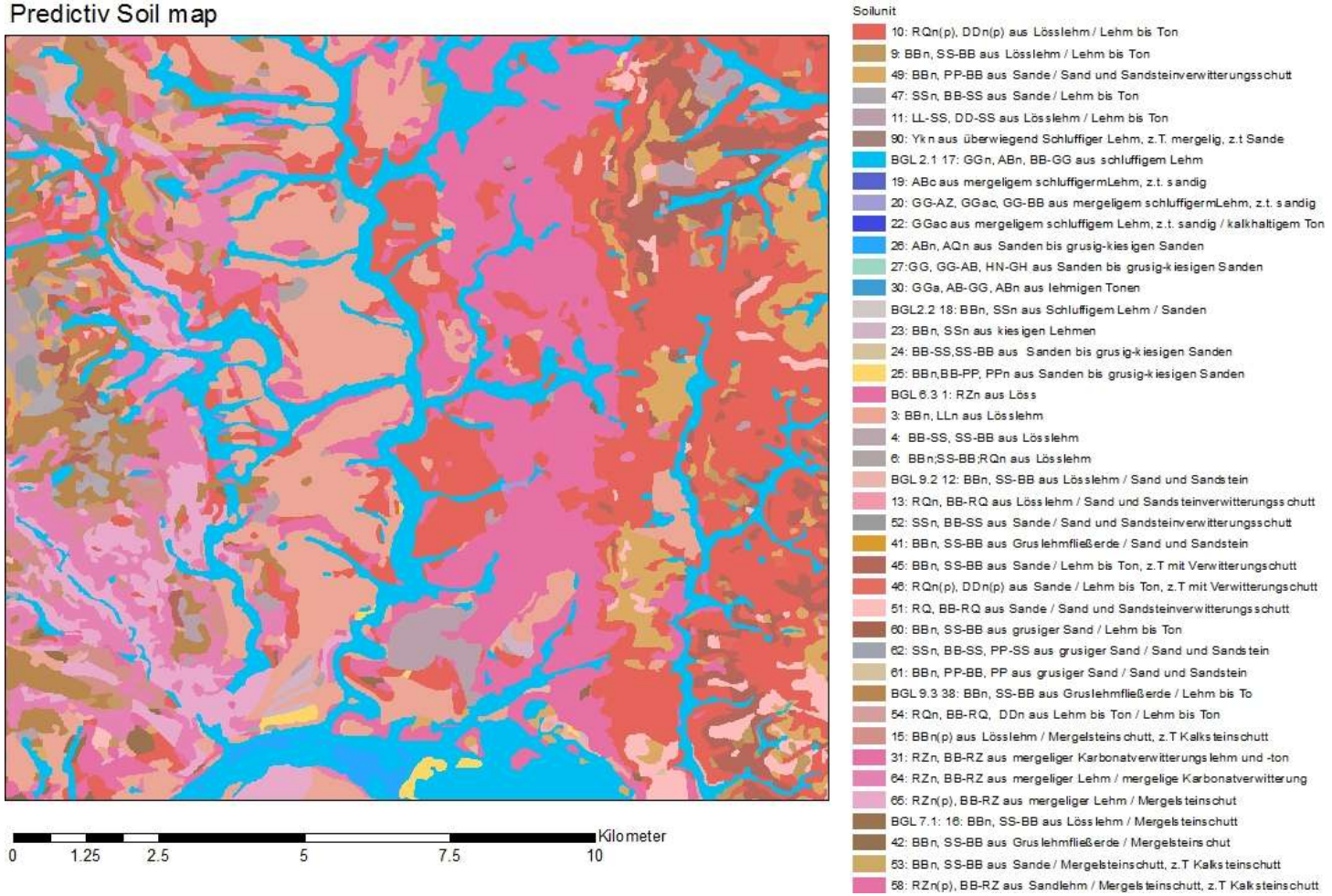
- 1: Kolluvien
- 4: Löss
- 5: Lösslehm
- 15: Schluffiger Lehm
- 16: mergeliger schluffiger Lehm, z.t. sandig
- 20: kiesige Lehme
- 22: Sande bis grusige, kiesige Sande
- 32: lehmige Tone
- 55: Sande
- 61: grusiger Sand
- 58: Sandlehm
- 44: Gruslehm; 46:Gruslehmfließerde
- 56: Lehm bis Ton
- 65: mergeliger Lehm
- 37: mergeliger Karbonatverwitterungslehm und -ton

subsoil substrate

- 4: Löss
- 5: Lösslehm
- -998 Kulluvien (überwiegend Schluffiger Lehm, z.T. mergelig)
- 27:Schluffiger Lehm
- 21: kiesige Lehme
- 22: Sande bis grusige, kiesige Sande
- 57: Sand und Sandsteinverwitterungsschutt
- 56: Lehm bis Ton
- 54: Lehm bis Ton, z.T mit Verwitterungschutt
- 32: lehmige Tone
- 31: kalkhaltige Tone
- 16: mergeliger schluffiger Lehm, z.t. sandig
- 37: mergeliger Karbonatverwitterungslehm und -ton
- 59: Mergelsteinschutt, z.T Kalksteinschutt

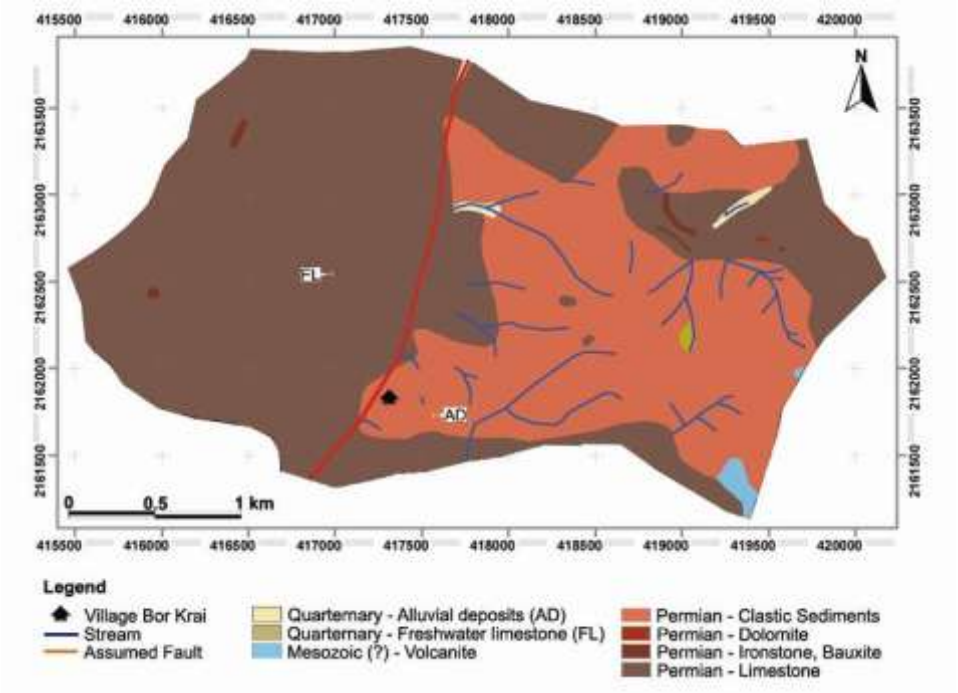
Willer, 2012

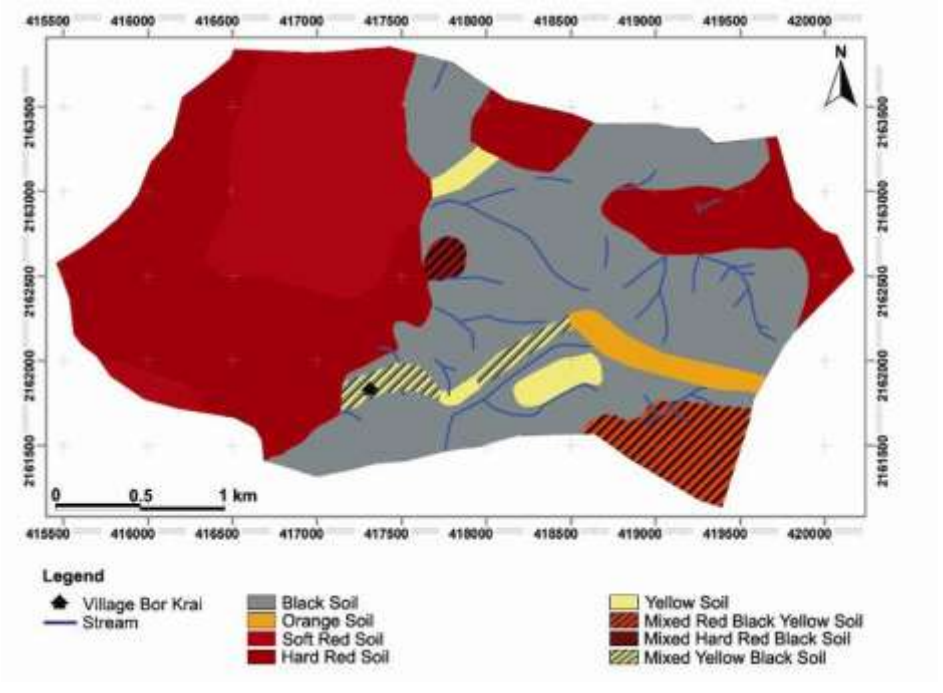
Example: Predictive soil map



Willer, 2012

Example: Indigenous soil knowlege (Thailand)

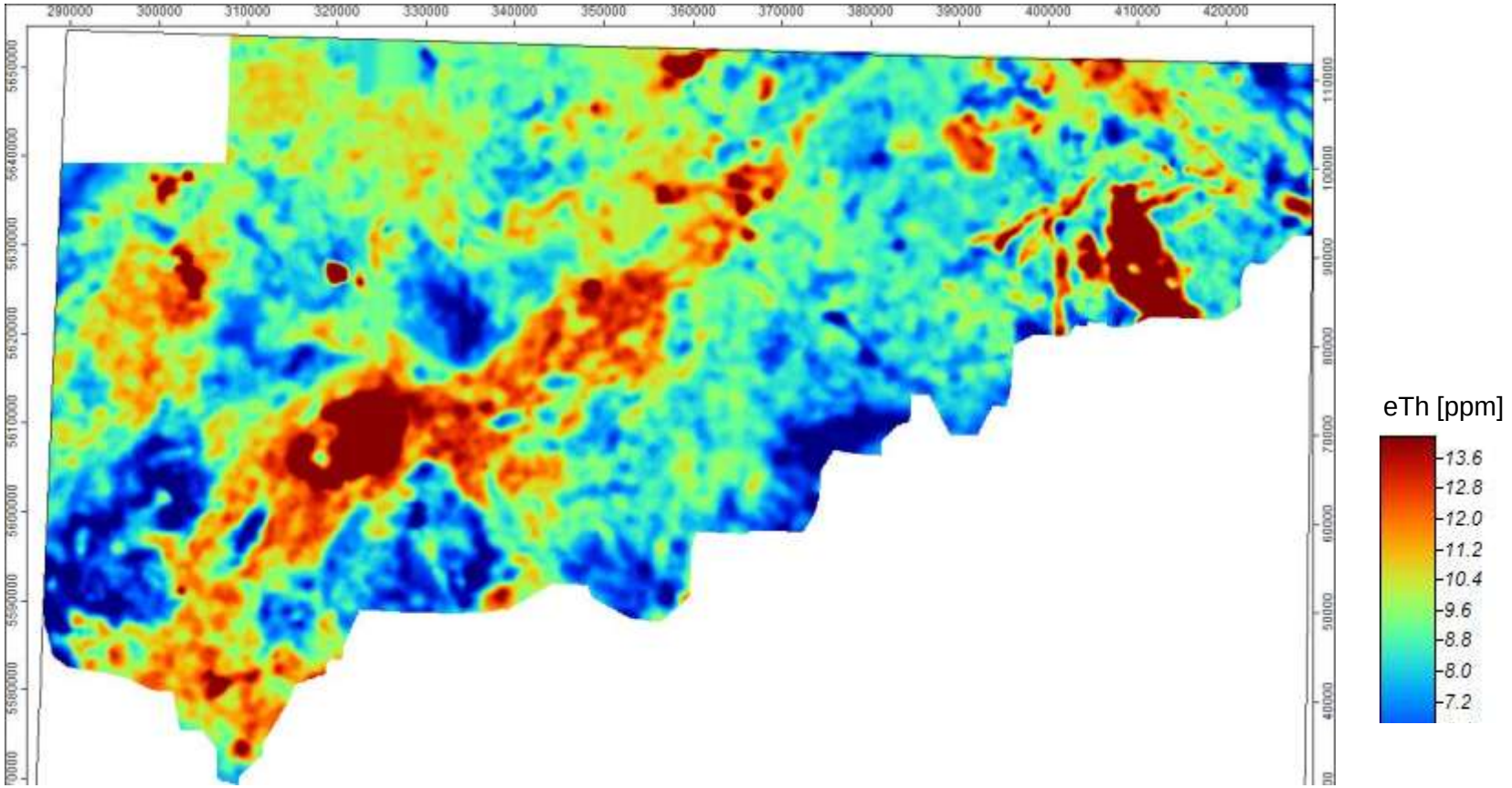




Schuler et al., 2006

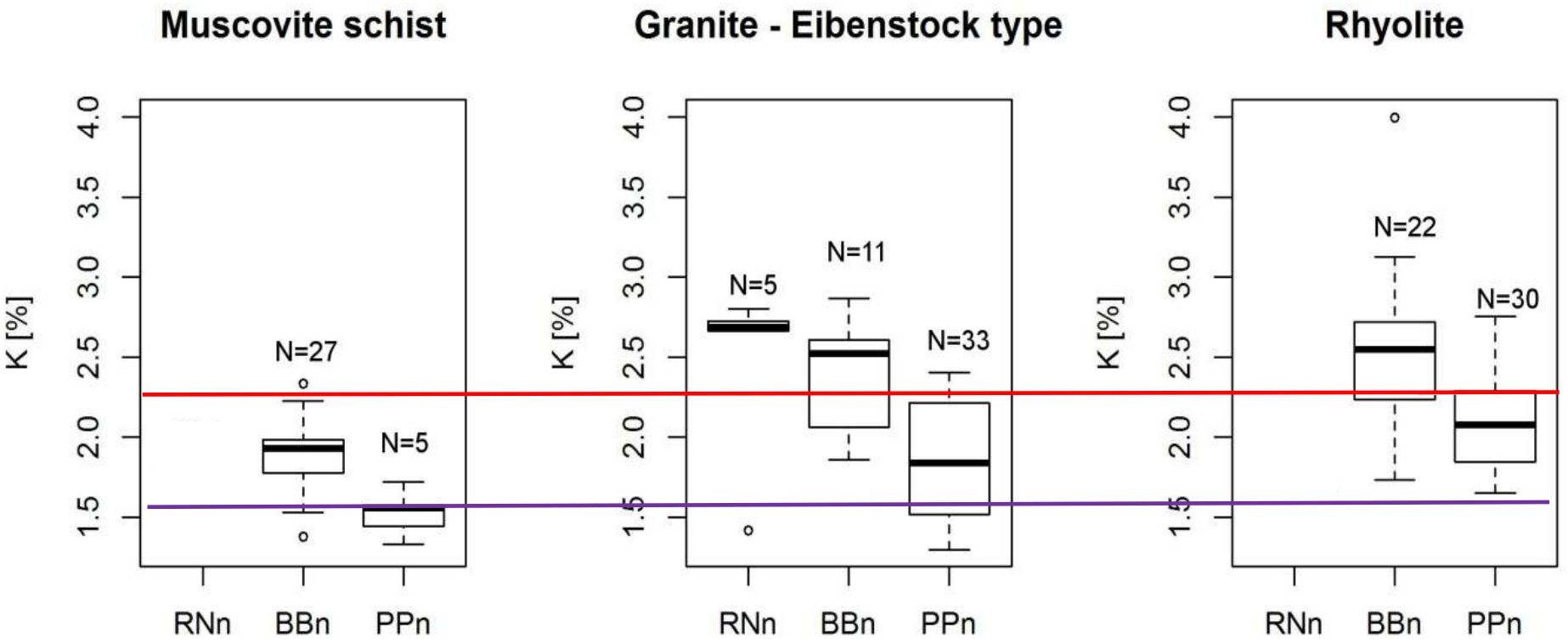
Block II

4. Soil mapping using gamma spectrometry



Block II

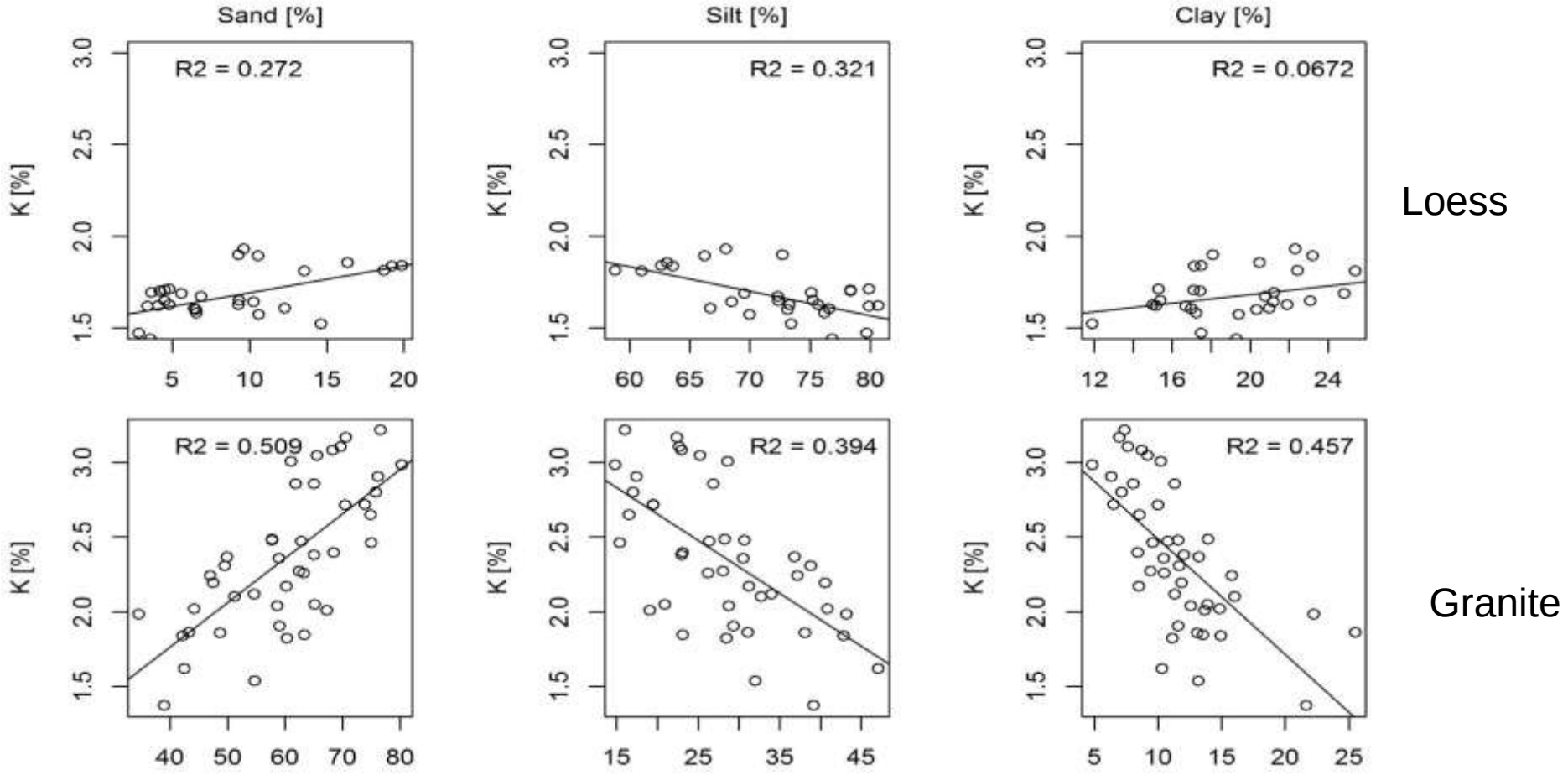
4. Soil mapping using gamma spectrometry



RRn = Leptosols
BBn = Cambisols
PPn = Podzols

Block II

4. Soil mapping using gamma spectrometry



4. Soil mapping using gamma spectrometry

Conclusions

- Radiometric data gives evidence for the influence of PM on soil properties, despite loess coverage
- Soil mapping using gamma spectrometry of larger areas can not be done without consideration of parent material.

Outlook

- Potential for developing a globl PM layer for SOTER: utilize OneGeology by applying the revised FAO PM classification

- Parent material mapping in Europe: Task Force Superficial deposits (EuroGeoSurveys, EGS) → Re-generalize geological information under increased consideration of superficial deposits

- For Europe: investigate the usability of lithology layer contained in the 1:1.5M hydrogeological map of Europe (BGR, 2012 in development)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Thank
you!
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