Classification of geological types according to the radon potential

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   proposed classification scheme

Purpose & procedure

- Purpose: assign “classes” to geological types
- First stage of the European Geogenic Radon Map (EGRM)
- Questions:
  1) How to define classes ?
  2) How to assign geological types to the classes ?
- Procedure:
  1) geological units → geological types
  2) algorithm: geological types → classes

step 1: Geological units → types

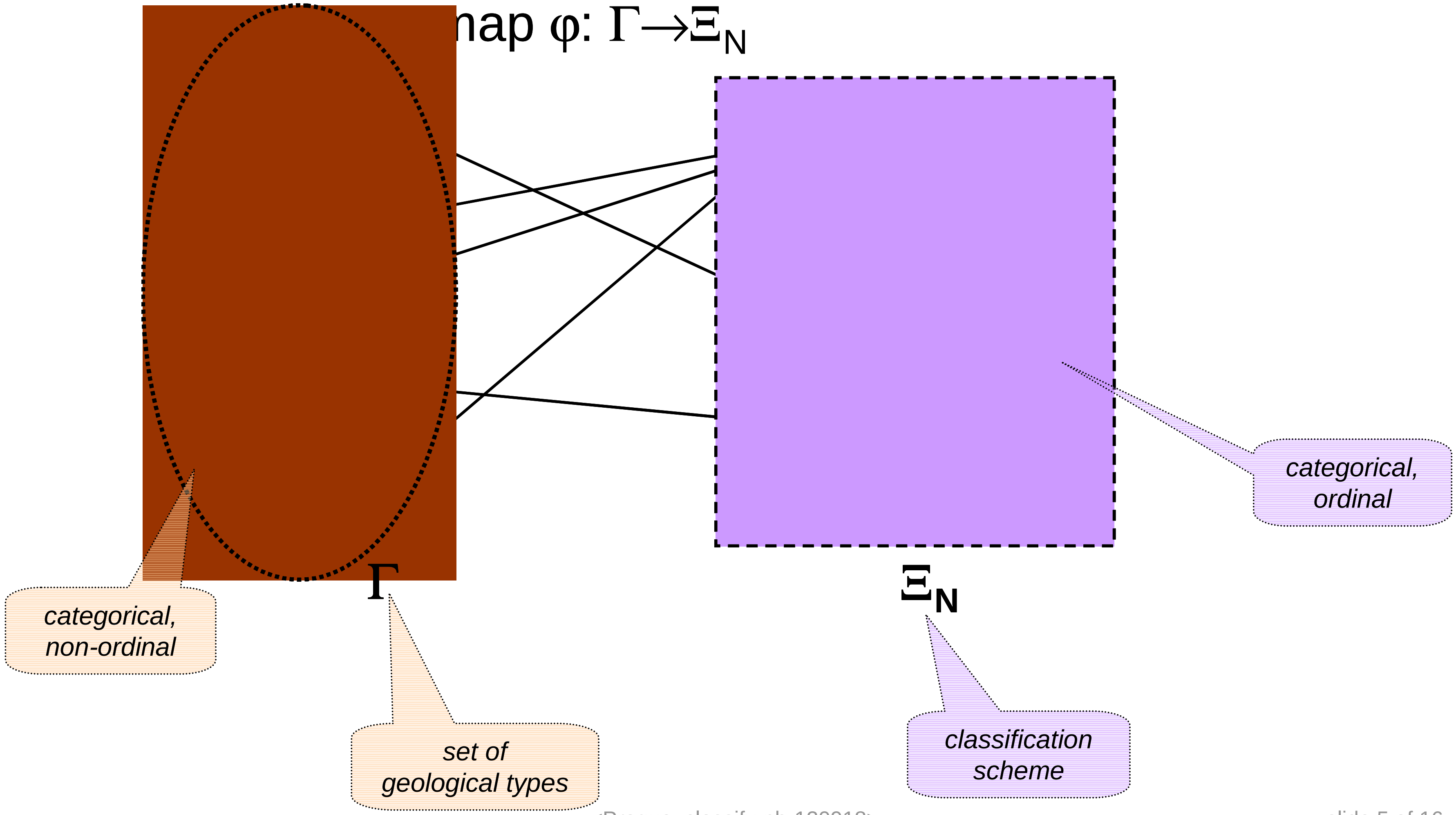
- each sampling point lies in a geological unit, defined by the 1:1M and 1:200k geological maps of the German geol. service. Attributed to the points by GIS.
- Kemski et al. distilled a set of simplified types according to soil Rn concentration.
- I modified this scheme a bit ⇒ finally 56 geo-types; codes assigned only for computational reasons, nothing official!

sedimentites

code no.	GM(RP)	stratigraphy		genesis	lithology	class_rad	class_geo
210	24.3	Neoproterozoic - Cambrian		sediment, marine, partly metamorphic	slate, Bündner schist, sandstone, phyllitic schist, quartzite, greywacke	2	3
221	26.5	Ordovician		sediment, marine	slate, quartzite, Geröllquarzit	2	3
223	41.8	Ordovician		sediment, marine, oolithic	clayey schist, Gräfenthal group	4	4
230	46.7	Ord - Silurian – lower Dev		sediment, marine	slate, fibrous schist, greywacke, limestone, alum shale	4	4
240	18.6	Devonian		sediment, marine	slate, sand stone, greywacke, quartzite, limestone	1	2
251	29.1	carboniferous	lower, dinantian = Viseum + Tournaisium	marine sediment	greywacke, slate, Plattenkalk, siliceous limestone, Kieselschiefer, alum shale	2	3
252	20.4	carboniferous	upper, namur = ca. Serpukhovium		quartzite, greywacke, clayey shale	1	3
253	36.8	carboniferous	lower	olithostrome		2	4
254	16.0	carboniferous	upper, namur, westphal. (= ca. Pennsylvanium) and other		slate, sandstone, conglomerate,, siltstone, claystone, limestone, black coal	1	2
261	16.8	Permian	Rotliegend = ca. Cisuralium + Guadalupium	sediment, fluvatile, fanglomeratic	shale clay, sand stone, conglomerate, black coal, porphyric breccia, tuff	1	2
262	29.8	Permian	Zechstein = ca. Lopingium	sediment, marine-saline	dolomite, clay stone with anhydrite and rock salt	2	4
311	11.8	Triassic	lower; Buntsandstein	sediment, limnic	sandstone, siltstone, clay stone, conglomerate	1	1
312	15.0	Triassic	middle-upper; Muschelkalk (= ca. Anisium)	marine sediment, biogenic	limestone, marl, dolomite, clay stone, etc.	1	2
313	9.5	Triassic	middle-upper; Keuper (=ca. Ladinium – Rhätium)	sediment, marine, limnic, fluvatile	clay stone, siltstone, quartzitic sand stone, quartzite, etc.	1	1

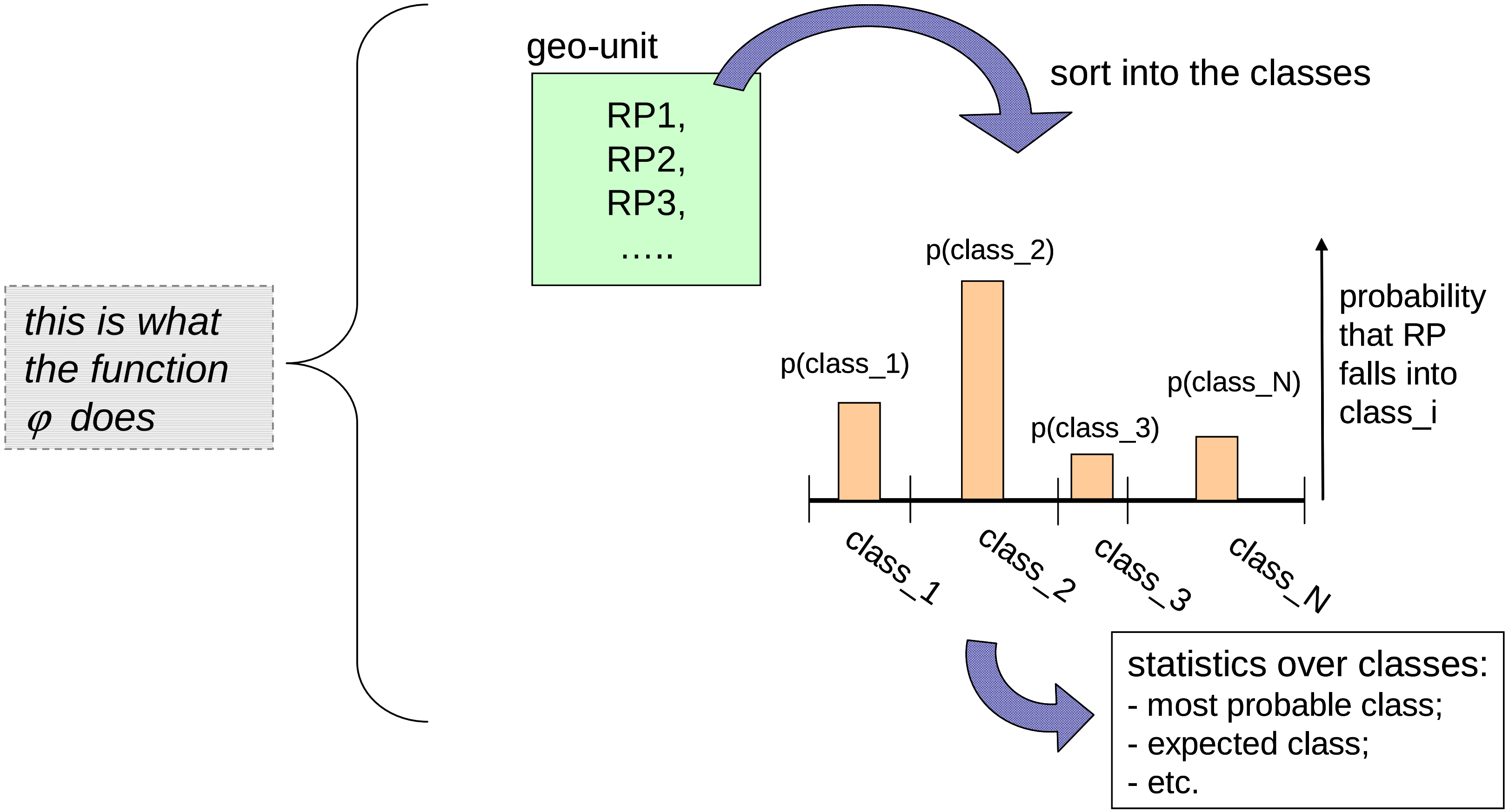
step 2: classification: formal (1)

Mapping geological types into a RP classification scheme



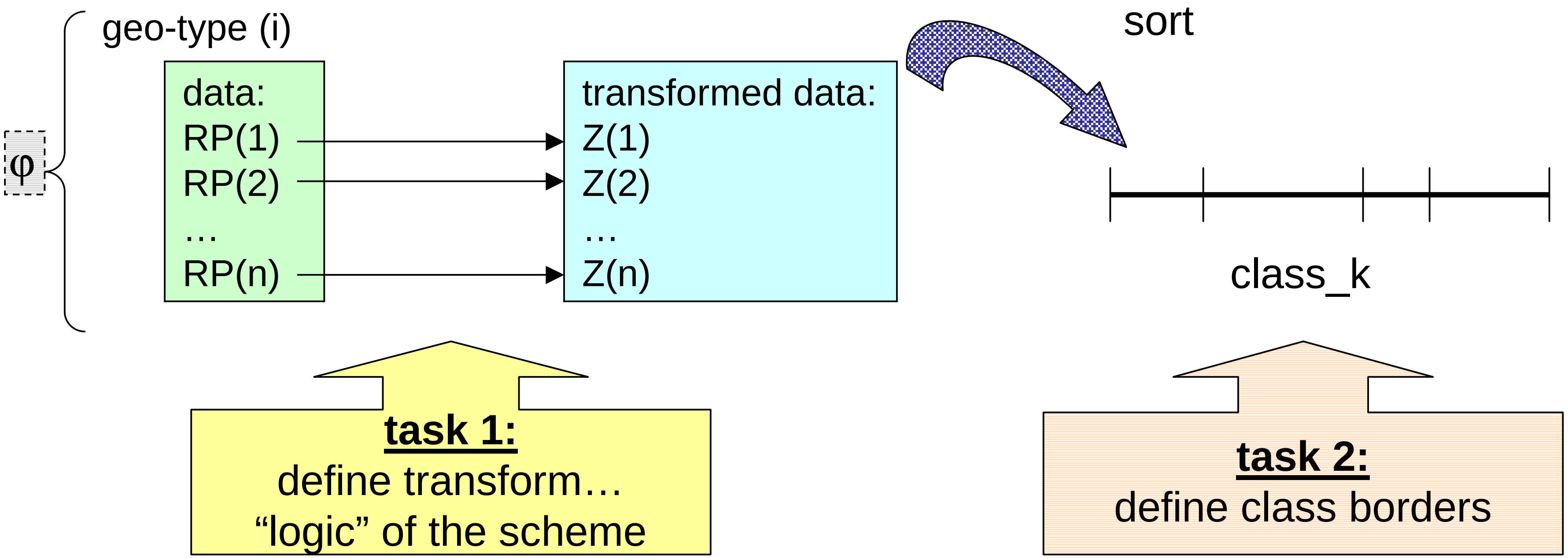
classification, formal (2)

“Fuzzy” classification of a geological type



classification, formal (3)

In more detail



2 proposals: (more are of course possible)

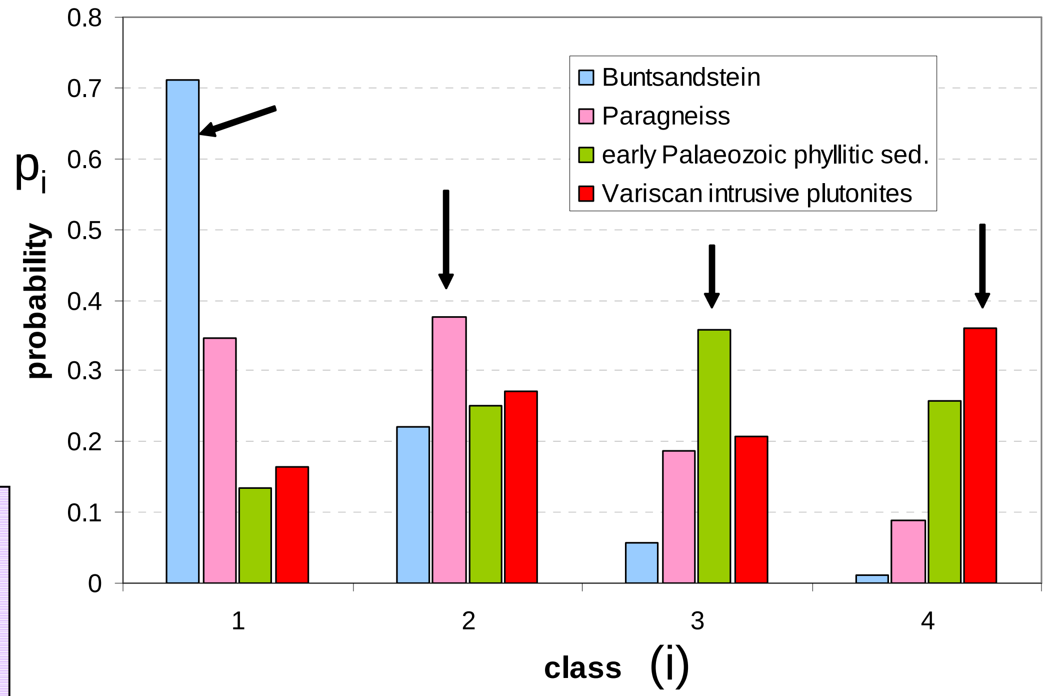
“geological”	transform = id Z(j)=RP(j)	4 classes; quartiles of distribution of $GM_{\text{(within geol. type)}}$(RP) over geol. types
“radiological”	transform: Z(j) = prob(C>100 Bq/m³ | RP(j))	4 classes; prob < 5%; <10%; <20%; >20%

the transfer model

- For the „radiological“ classification a transform RP → prob($C>c_0|RP$) is required
  (c_0 = 100 Bq/m³, long-term mean, ground floor, house with basement).
- Essentially done as follows:
  - Construct joint distribution $F_{RP,C}$ of RP and C;
  - Model $F_{RP,C}$ with copula method;
    prob($C>c_0|RP$) = $1-F_{C|RP}(c_0,RP)$
  ... conditional distribution of C, given RP
  - $f_{C|RP} = f_{RP,C} / f_{RP}$ (f = pdf = $\partial^2F/(\partial RP\ \partial c)$)
  - copula: Gumbel, parameter estimated from cross-Kendall correlation coefficient
    $\tau(h)= \tau(C(x),RP(y):|x-y|=h)$, lim $\tau(h)$ for $h \rightarrow 0$.
- more details presented 2 weeks ago, FERAS 2012, Cluj; to be published.

example

- 4 geo-types
- sorted into 4 classes after method "radiological"



⇒ **task 3:**

- given the histogram of levels Z per classes;
- which class to assign finally?

possibilities:

- assign class where p=max
- assign "mean class", $\langle class \rangle = \Sigma p_i \cdot i$ (i=class number)
- weighted mean: $WM(class) = \Sigma p_i^q \cdot i / \Sigma p_i^q$ (e.g. q=2)
- maximum of these; etc etc etc

chosen here:

maximum of "class (p=max)" and "mean class";
in some cases manual adjustment according "feeling"

comparison of schemes

advantages - drawbacks

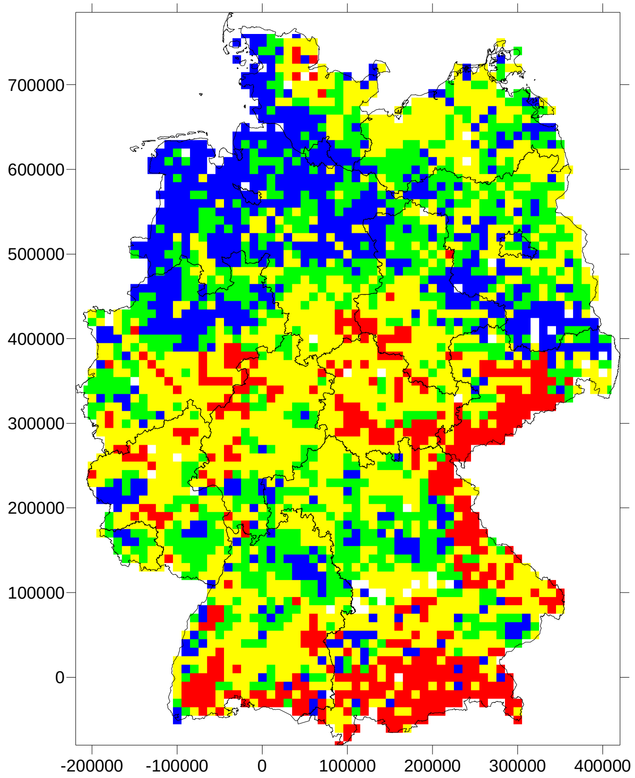
	"radiological"	"geological"
reflects what?	(+) closer to hazard	(+) closer to geological diversity
modelling	(-) includes partly tricky modelling steps	(-) depends on geological classification depth and degree of detail
temporal component?	(-) prob(C>c)>p calibrated with existing houses	(+) no!
regional component?	(-) houses used for calibration: German data, so far	(-) geological diversity: German data used, so far.

example

- this is a preliminary testing stage
- the final (so far…) version → presentation Valeria Gruber!

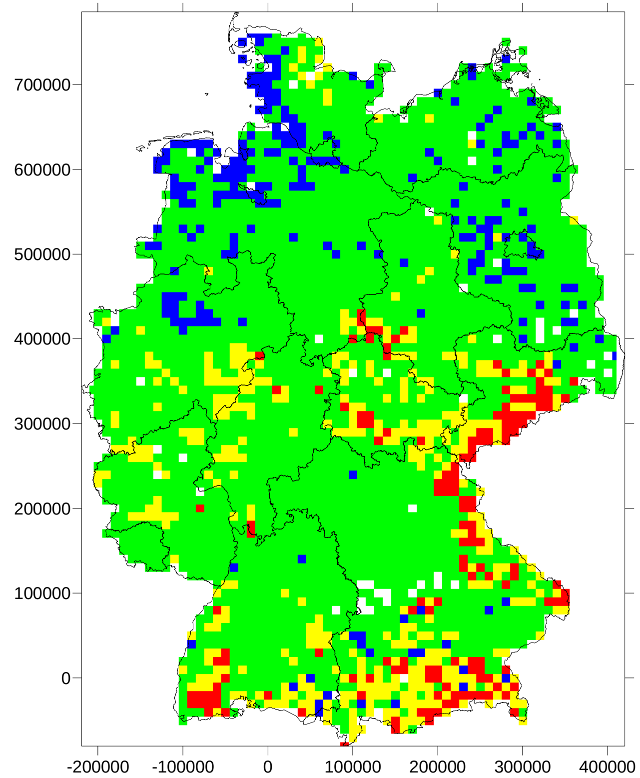
- **data:** German Rn database (ca. 3700 locations);
- **RP:** Neznal-RP; soil Rn and perm.: Kemski protocol
- **geological types:** Germany (modified Kemski scheme)
- **prob(C>100)** estimated after probabilistic transfer model, calibrated on German RP + indoor data
- not made per geological units, but per RP estimated on 10 km x 10 km pixels

"geological" classification



class_1, blue: RP < 11.8 (Q=0.22)
class_2, green: 11.8 < RP < 17.1 (Q=0.47)
class_3, yellow: 17.1 < RP < 32.2 (Q=0.77)
class_4, red: RP > 32.2

"radiological" classification



class_1, blue: prob(C>100)<5%
class_2, green: 5% <= prob(C>100) <10%
class_3, yellow: 10% <= prob(C>100) < 20%
class_4, red: prob(C>100) >= 20%

step 3: further procedure

critical steps !

- 2 schemes ("geological", "radiological") for German data;
- Valeria extracted geological types from the OneGeology lists of geological units for each country (OneGeology participants);
- I translated (as well as I could) the German geological types → OneGeology types;
- Assign classes to the types, if a German analogue or "homologue" exists;
- If no such ana- / homologue exists, or if OneGeology types are under-defined for the purpose of classifying the RP: leave blank for now;
- Valeria: GIS map of geological units with classes as attributed;
- To do: national experts verify and correct, based on their knowledge;
- E.g. Belgium: Boris Dehandschutter corrected a few types which I classified wrongly; effect shown in Valeria's presentation;
- **Iterative process! ⇒ all please contribute critically!**

geo-types left blank

- Not existing in Germany:
  e.g. the types of the Baltic shield (old granites and gneisses); types of Alpine orogeny
- Under-defined: example
  analysis of German RP, assigned German geo-legend (1:1M and 1:200 k geological maps; simplified by Kemski)
  ⇒ glacial-quaternary different RP in the N (Weichsel glac.) and S (Würm glac.) of same lithology; but this is not resolved by the German OneGeology scheme, where all is called „Upper Pleistocene; sand, gravel“ ⇒ had to be left blank for now.

example of list

tentative assignment

class_rad / class_geo according algorithm ⇐ geo type attributed by analogy

7	Rhyodacites, dacites, latiar desites: lavas and pyroclastic rocks	Permian	Permian	rhyolite			missing			
8	Rhyolites, rhyodacites, da ites, andesites: pyroclastic rocks, lavas and subvolcanic rocks	Pennsylvanian	urn:cgi:classifier:I(	rhyolite			missing			
9	Rhyolites, rhyodacites a andesites (pyroclastic rocks and lavas), alternating epiclastic deposits, with low- to	Middle Ordovician	urn:cgi:classifier:I(	rhyolite			missing			
0	Granites, granodiorites d syenites	Late/Upper Cretaceou	Miocene	Granite			missing			
1	Tonalites, quartz mon tes, monzonites, monzogabbros and monzodiorites	Late/Upper Cretaceou	Miocene	Tonalite	Quartz monzonite		Monzogabbro	Monzodiorite		
2	Diorites and gabbros	Late/Upper Cretaceou	Miocene	Diorite	Gabbro	mis	missing	missing		
3	Granites and granc s	Carboniferous	Permian	Granite	Granodiorite	missin	missing	missing		4
4	Monzonites, quar es, monzodiorites and monzogabbros	Carboniferous	Permian	Monzonite	Quartz diorite	Monzodio	Monzogabbro	missing		4
5	Diorites and gab	Carboniferous	Permian	Diorite	Gabbro	missing	sing	missing		4
6	Slates, calcare s with crystalline limestones and quartzite intercalations, and subordinate prasinites	Late/Upper Cretaceou	Miocene	Slate	Schist	Marble	zite	missing		
7	High p tes ("Calcescisti" Auct.), with associated crystalline dolostone	Late/Upper Cretaceou	Miocene	Schist	Quartzite	Marble	Ph	missing		
8	Phyllite , gneisses and marbles	Carboniferous	Permian	Phyllite	Mica schist	Quartzite	Gneis	Marble		4
9	Micasc quartzites and marbles, locally with alpine metamorphic impr	Carboniferous	Permian	Mica schist	Gneiss	urn:cgi:classifier	urn:cgi:c er:(	Marble		4
0	High p cally with alpine metamorphic imprinting	Carboniferous	Permian	Eclogite	Schist	missing	missing	missing		3
1	Gneiss nd porphyries, locally with alpine metamorphic imprinting	Carboniferous	Permian	Gneiss	Migmatite	Schist	missing	issing		3
2	High pressure: granulites and amphibolites, locally with alpine metamorphic imprinting	Carboniferous	Permian	Granulite	Amphibolite	missing	missing	m ing	2	4
3	Micaschists, gneisses and migmatites, with hercynian metamorphic imprinting	Ordovician	urn:cgi:classifier:I(	Mica schist	Gneiss	Migmatite	missing	miss	2	4
4	High pressure: eclogites and granulites, with hercynian metamorphic imprinting	Ordovician	urn:cgi:classifier:I(	Granulite	Amphibolite	missing	missing	missing	2	3

description

stratigraphy 1,2

OneGeology types

lithology 1 to 5 according OneGeology

no analogy available

summary

<u>3 Tasks:</u>

1. Define a “logic” of classification
   “radiological”, “geological”,...
2. Define the class borders
   (and also the number of classes)
3. Define algorithms for
   - sorting values into the classes and
   - for identifying the class which is finally
   assigned to a geo-type.
   (This is the more technical part)

to be continued !

Thank you !