Deriving WRB soil types using
National German Soil Survey
Guidelines

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Interpreting the German inventory for international use

- German “soil systematics” is based on morphogenetic horizonation
  → no diagnostics independent of horizonation described

- international context → WRB
  → derive diagnostics from soil database data

- automated tool
First approach – German pedogenetic system to WRB

<table>
<thead>
<tr>
<th>Type</th>
<th>Terrestrial soils</th>
<th>Semi-terrestrial soils</th>
<th>(Semi-)Submerged soils</th>
<th>Fens and Bogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classes</td>
<td>13</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtypes</td>
<td></td>
<td></td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Varieties + Criteria</td>
<td></td>
<td></td>
<td>2794 varieties + 22 criteria for sub-varieties</td>
<td></td>
</tr>
</tbody>
</table>

BUT: translation possible for 50% of all systematical units only

(25 core classes, 30 deviating, 83 transitional)

(16 core classes, 30 deviating, 24 transitional)
German pedogenetic system + substrate

**pedogenesis**
- geogenesis, coarse/fine texture, carbonate/lithogenic C content, rock type

**soil type**
- *Bodenform = "soil form"

**substrate**
- *brown earth* from calcareous aeolian sand

**substrate type**
Data – German Soil Mapping Guideline 5th ed.

Germany: Data obtained and coded according to German soil survey guideline, 5th ed.

- 40 site and profile parameters
- 87 horizon-related parameters
  many multiple-entry
  incl. data on distribution, share, size, intensity

49 different kinds of distribution of phenomena, e.g. lenses, on aggregates, in pockets, etc.

9 classes [%]

| f1  | <1   |
| f2  | 1-<2 |
| ... |      |
| f8  | 70-<90 |
| f9  | ≥90   |

<table>
<thead>
<tr>
<th>micro</th>
<th>medium</th>
<th>macro</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;0.5</td>
<td>&lt;50</td>
</tr>
<tr>
<td>2</td>
<td>..&lt;1</td>
<td>..&lt;5</td>
</tr>
<tr>
<td>3</td>
<td>..&lt;2</td>
<td>..&lt;20</td>
</tr>
<tr>
<td>4</td>
<td>..&lt;5</td>
<td>..&lt;50</td>
</tr>
<tr>
<td>5</td>
<td>≥5</td>
<td>≥50</td>
</tr>
</tbody>
</table>

5 classes

- g1 very weak
- g2 weak
- g3 medium
- g4 strong
- g5 very strong

• additionally using lab data if available
WRB

- 32 Reference Soil Groups (RSG)
- 171 Qualifier, incl. pseudo-specified qualifiers (plus 46 explicitly defined combinations with specifiers)
  - 70 encode presence of a diagnostic within a certain depth range
  - 31 add further criteria to a diagnostic
  - 67 encode non-diagnostics-related information
  - 2 encode absence of diagnostics
  - 1 encodes absence of relevant diagnostics

based on
- 39 diagnostic horizons
- 14 diagnostic properties  
  \[ \text{65 diagnostics} \]
- 12 diagnostic materials
Algorithm Calcic horizon

1. **Carbonate Content ≥ 15%?**
   - Yes: Go to 3.
   - No: Go to 2.

2. **Carbonate Content Class “c[4-7]”?**
   - Yes: Go to 3.
   - No: No Calcic horizon.

3. **Check secondary carbonates, ”f[4-9]”?**
   - Yes: Thickness ≥ 15 cm?
     - Yes: Calcic horizon.
     - No: No Calcic horizon.
   - No: No Calcic horizon.

   **Horizon Notation “([A,H,B,T,S,G,M]c...)”?**
   - Yes: Calcic horizon.
   - No: No Calcic horizon.

   **Thickness ≥ 15 cm?**
   - Yes: Calcic horizon.
   - No: No Calcic horizon.
Challenges identified

- Morpho-genetic horizonation may hide diagnostics
- How depth information is stored in databases and affects identification of diagnostics
- Determination of start and end depth of diagnostics
- Definition of classes of descriptive parameters – e.g. textural classes
Classification in the field vs. with database data

- Cambic hor.
  - Ah-Bsv → Bw
  - Ael-Bv → Bw
  - Abrupt Textural Change

- Albic hor.

- Argic hor.

- Calcaric material
Horizonation, horizon notations, horizon description affect detection of Albeluvic tonguing

Definition:
Albeluvic tongues
1. colour of an albic horizon; and
2. greater depth than width, ...
3. occupy 10 percent or more of the volume in the first 10 cm of the argic horizon ... ; and
4. have a particle-size distribution matching that of the coarser textured horizon overlying the argic horizon.
Albeluvic tonguing and shape of lower horizon boundary

- Plane
- Wavy
- Pocket-like
- Tongue-like
- Cleft-like
- Drop-like
- Mottled

NCSS conference, Asheville, NC, May 22-26, 2011

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Albeluvic tonguing and “combination horizons”

Ael [E]

Ael+Bt [BtE]

Bt [Bt]

→ no information on shape and share of the pale domain...

← "combination horizon"
Data recording affects identification of diagnostics

Example: Abrupt textural change

Definition:
“8 percent or more clay in the underlying layer and:
1. doubling of the clay content within 7.5 cm if the overlying layer has less than 20 percent clay; or
2. 20 percent (absolute) increase in clay content within 7.5 cm if the overlying layer has 20 percent or more clay.”
Abrupt textural change – sharpness of horizon boundary

Clay content

Clay content ratio A : B is 1 : 2

Clay content ratio A : B is 1 : 3

Abrupt
Clear
Diffuse

clearly abrupt text. change  maybe – maybe not

clearly abrupt text. change  maybe – maybe not
Performance – are *Fahlerden* Albeluvisols?

because of no tongues, tongues lithologically determined, mottles instead of tongues, ...
Performance of algorithms

Albic Cutanic Lamellic Luvisol (Ruptic, Arenic)

Albic Cutanic Alisol (Ruptic, Alumic, Greyic, Arenic → Epiarenic)

Albic Cutanic Luvisol (Abruptic, Ruptic, Arenic → Epiarenic)

Albic Cutanic Luvisol (Anthric → not enough org. C, Abruptic, Ruptic, Epidystric, Greyic, Epiarenic → Arenic)

Albic Cutanic Luvisol (Abruptic, Ruptic, Arenic)

→ Albic Cutanic Albeluvisol → Luvisol (Abruptic, Ruptic, Dystric → Epidystric, Greyic, Epiarenic)

correct not correct correct (with no-data assumption) correct with horizon symbol interpretation → change
Challenges for database data evaluation - Determination of start and end depth

A **Salic horizon** has:

1. **averaged over its depth** ... an electrical conductivity ... (ECe) of 15 dS·m$^{-1}$ or more ... or an ECe of 8 dS·m$^{-1}$ or more ... if the pH (H$_2$O) of the saturation extract is 8.5 or more; and

2. **averaged over its depth** ... a product of thickness (in centimetres) and ECe (in dS·m$^{-1}$) of 450 or more; and

3. a thickness of 15 cm or more.

→ no hard criterion for upper and lower depth given – which (parts of) morphogenetic horizons should be included?
Further challenges

• some criteria difficult
  (e.g. micromorphological findings in operational form)

• “minor” parameters are often helpful (e.g. “further pedogenic properties” – bleached sand grains, etc.), but might often contain no data

• horizon notation as integrating parameter often used, but quality hardly to estimate
Conclusions

... do we have to improve the data?
- more detailed description of horizons does not necessarily result in better evaluable data
- improve profile description:
  e.g. when to distinguish a further horizon?
- always note “best guess” instead of scientifically correct understatement (e.g. boundary depths)

... or the classification?
- Definition of diagnostics should always include an absolute criterion
- Robustness of classification against data and data storage artefacts (e.g. Albeluvisol detection needs a soil pit
  → size importance down from RSG to qualifier level?
  → Glossalbic Luvisol/Alisol/etc.?)
Thank you ...

... for your attention

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