



amies II - Scenario development
for sustainable land use
in the Greater Caucasus, Georgia



AMIES II – Midterm Meeting 2016

18.05.2016

B: Soil functions for sustainable land use

**T. Hanauer, P. Felix-Henningsen, B. Kalandadze, T. Urushadze,
I. Diehl, T. Grzelachowski, C. Pohlenz, B. Späker, B. Vashev**

Characteristics, distribution and agricultural potential of soils in the Kazbegi region



Agricultural University
of Georgia



Ilia State
University



Ivane Javakhishvili
Tbilisi State University



Justus-Liebig-University
Giessen



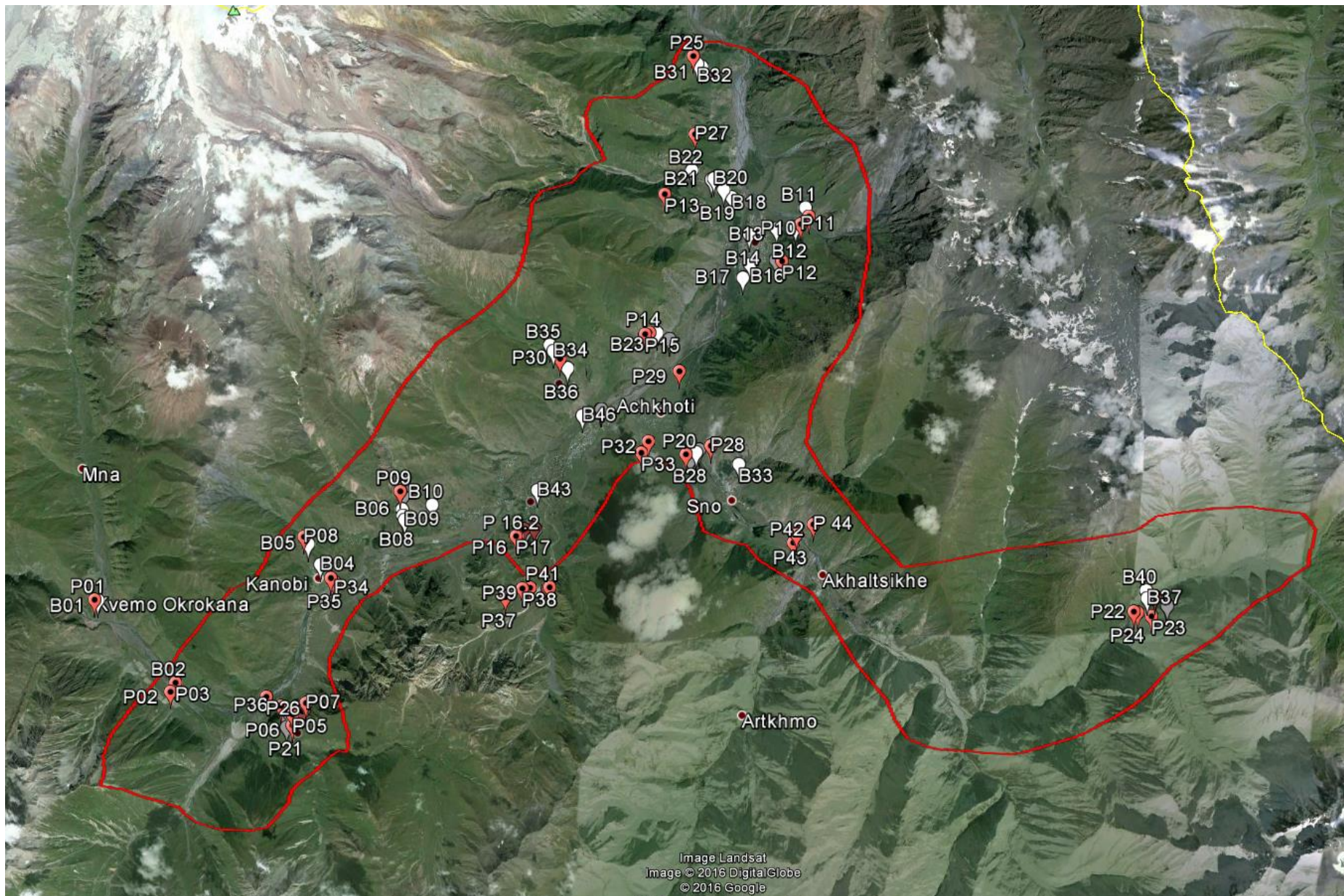
Center for international
Development and
Environmental Research

Objektives of part B

Creation of **spatial soil resource database** on:

- Spatial distribution of soil substrates
- Dominating soils
- Soil functions in the ecosystems
- Soil quality and yield potential
- Suitability for agriculture
- Vulnerability to degradation

Research Area





Field Seasons 2014/15

- Soil profiles
 - Characterization due to KA5/WRB
 - Sampling (each horizon)
 - Soil Quality Rating (SQR)
- Augers
 - Characterization due to KA5/WRB
 - Partly SQR
 - Partly sampling

Catenae, characterization of geological and geomorphological units, Soil properties and agricultural potential

- Sampling of top soils and(former) Green houses
- Sampling of survey water and drinking water

→ Persistent organic pollutants (Global Distillation)

→ Mineralization of catchment basin (water safety)

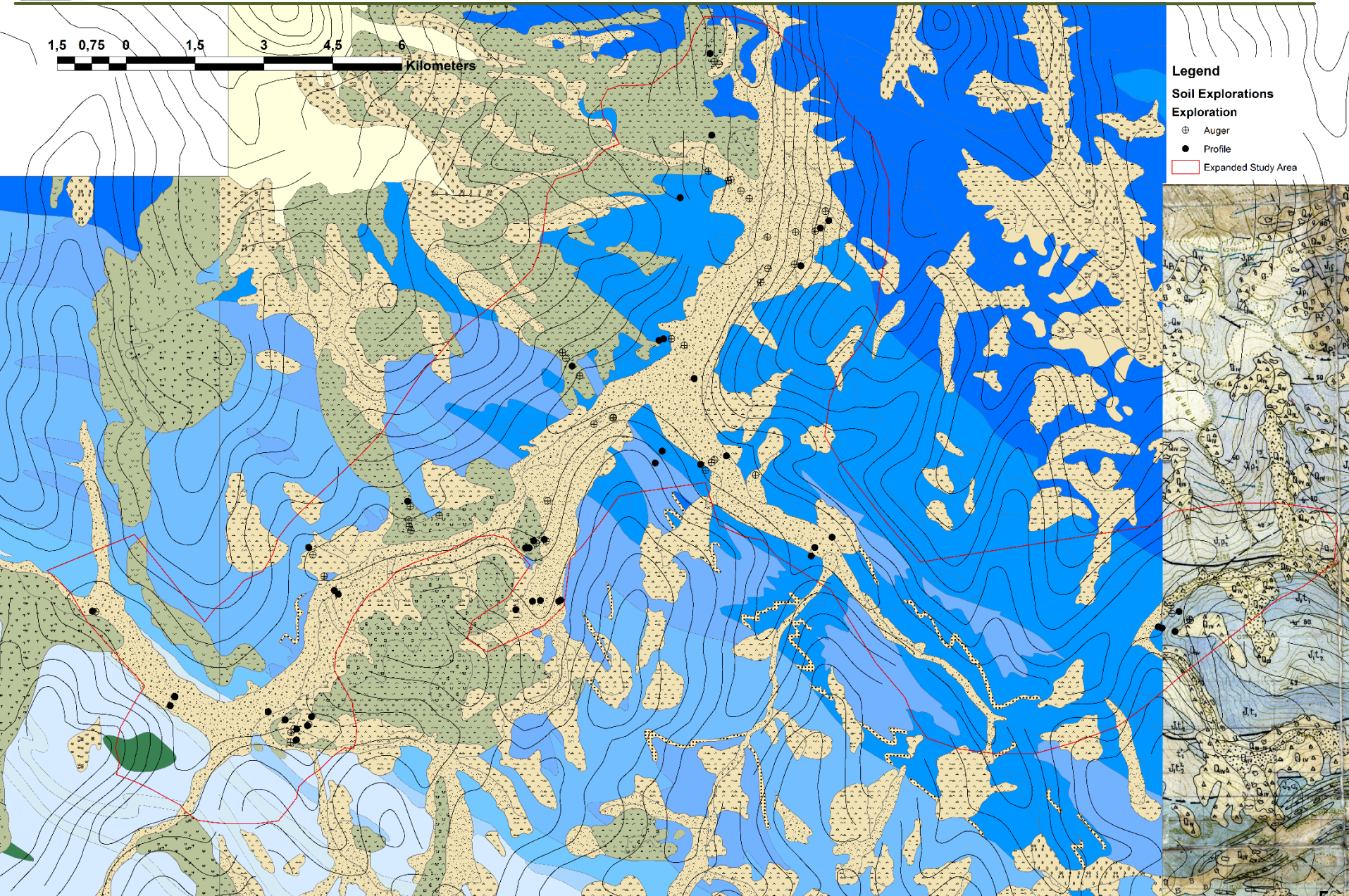


Analyses (accomplished)

Soil:

- Total element content (Aqua regia)
- Medium term available elements (EDTA)
- Plant available elements (NH_4NO_3)
- Persistent organic pollutants (POP)
- CAL-P, CAL-K, $\text{N}_{\min}$, $\text{S}_{\min}$
- P-sorption
- CNS
- EC, pH
- CaCO_3
- Cation exchange capacity
- Texture
- Bulk density
- Coarse fraction
- Iron, aluminum, silica oxides
- RDA (mineralogy)
- RFA (elemental analysis)

Geology



Synthetic Soil Map

1,5 0,75 0 1,5 3 4,5 6 Kilometers

Legend

Soil Explorations

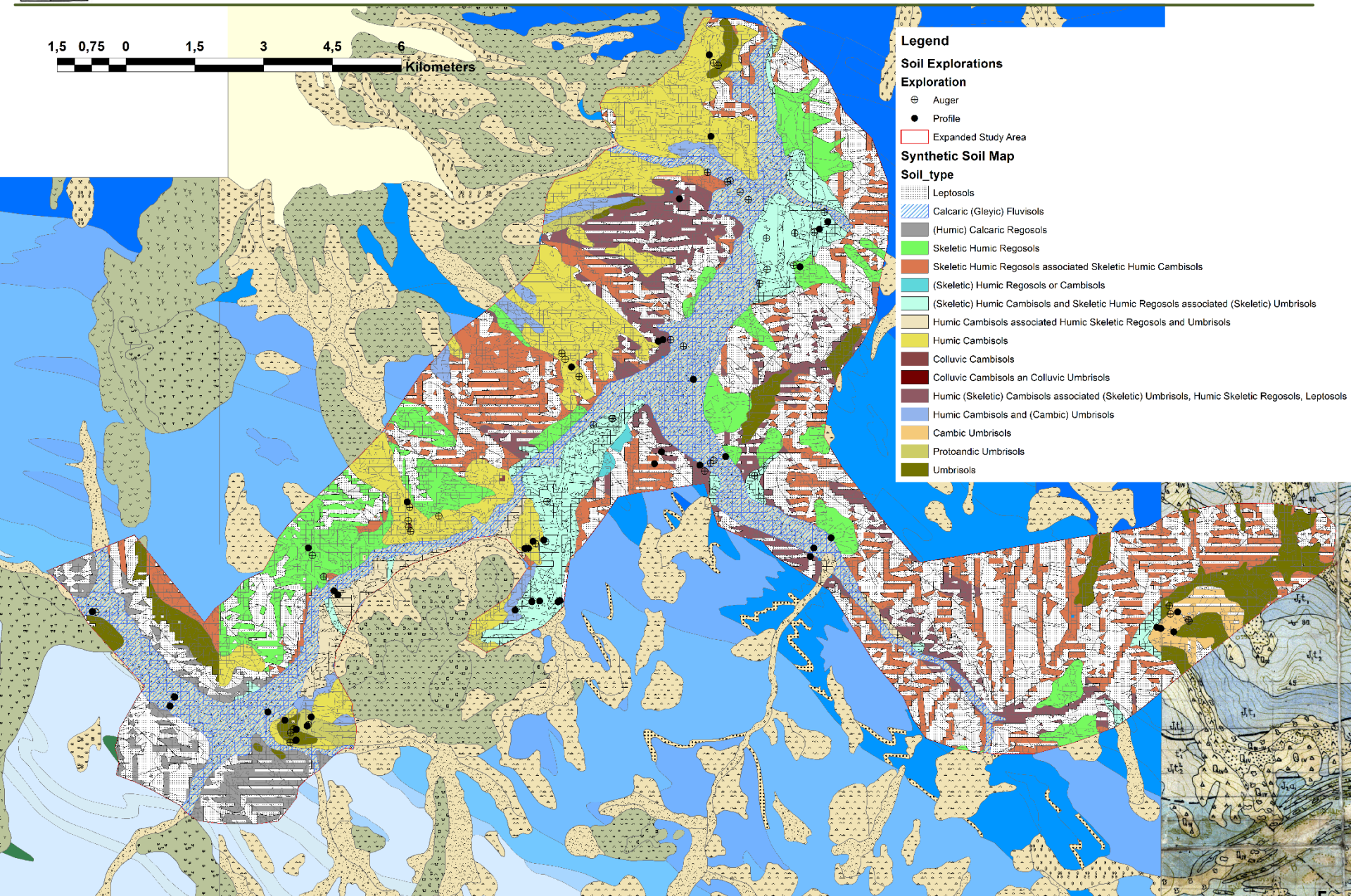
Exploration

- ⊕ Auger
- Profile
- Expanded Study Area

Synthetic Soil Map

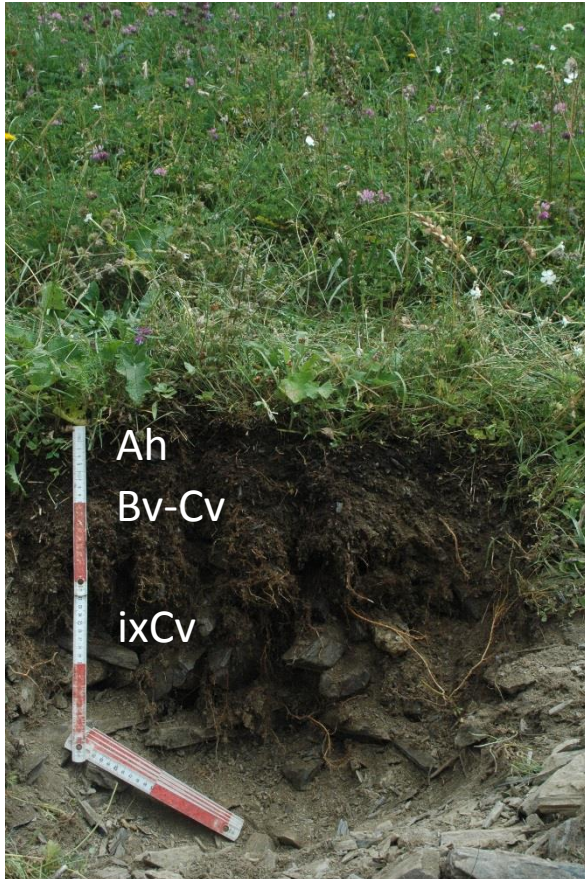
Soil_type

- Leptosols
- Calcaric (Gleyic) Fluvisols
- (Humic) Calcaric Regosols
- Skeletal Humic Regosols
- Skeletal Humic Regosols associated Skeletal Humic Cambisols
- (Skeletal) Humic Regosols or Cambisols
- (Skeletal) Humic Cambisols and Skeletal Humic Regosols associated (Skeletal) Umbrisols
- Humic Cambisols associated Humic Skeletal Regosols and Umbrisols
- Humic Cambisols
- Colluvic Cambisols
- Colluvic Cambisols on Colluvic Umbrisols
- Humic (Skeletal) Cambisols associated (Skeletal) Umbrisols, Humic Skeletal Regosols, Leptosols
- Humic Cambisols and (Cambic) Umbrisols
- Cambic Umbrisols
- Protoandic Umbrisols
- Umbrisols



Leptosols

P44 Skeletic Mollic Leptosol on Debris/Hard rock

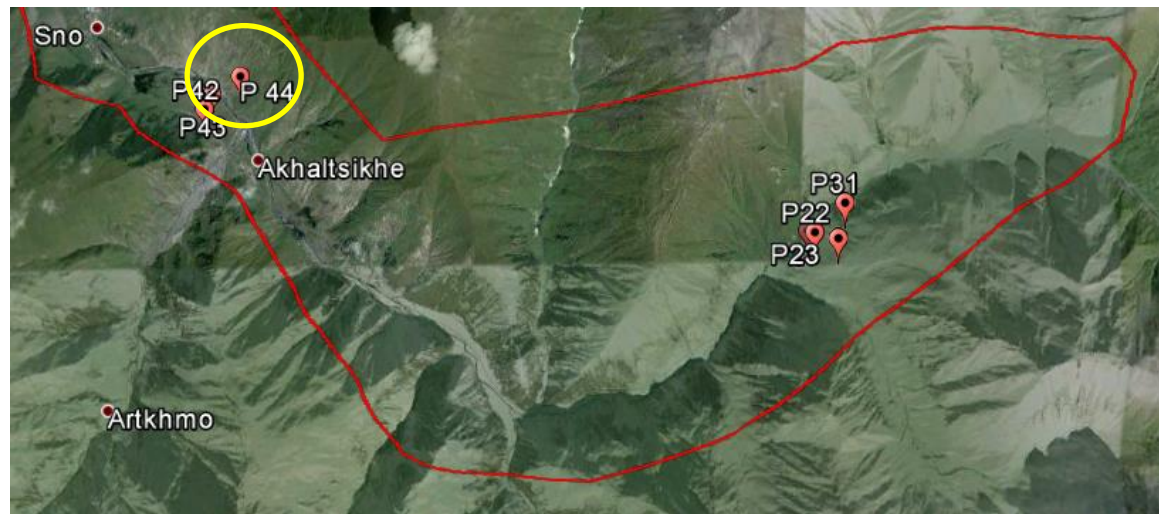


- (Top) slopes and Exposed areas
- Shallow soils
- High proportion of Coarse fraction, increases with depth

Land use:

- Pasture

Agricultural potential: very low

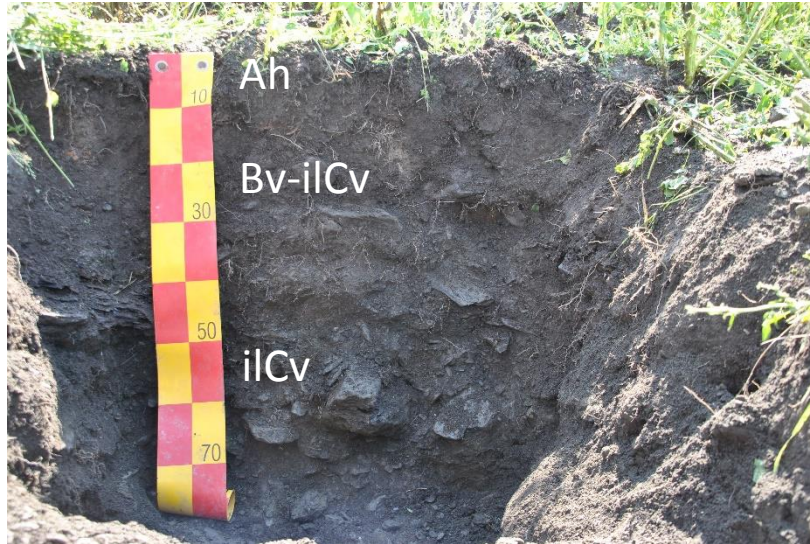


Skeletal Cambisols / Regosols



Skeletal Cambisols/ Regosols

P10 Skeletic Cambisol on Debris

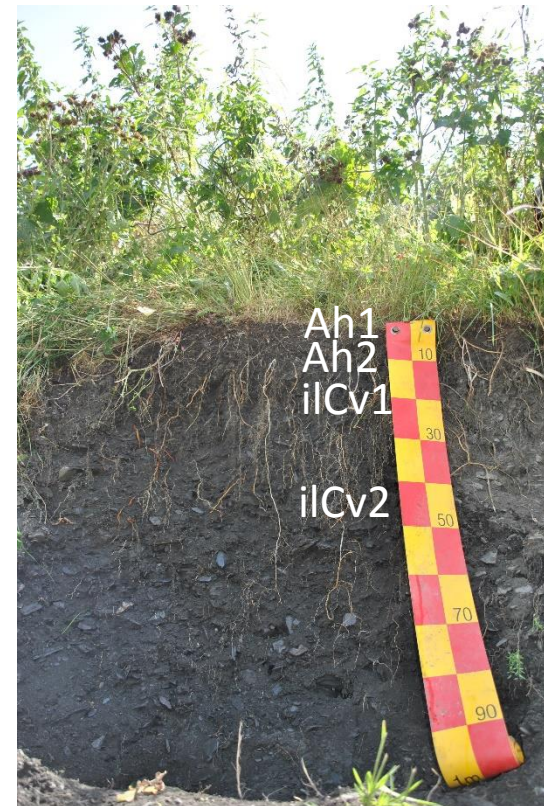


- Dominating soil type of Talus fans
- Low-moderate depth
- Loamy Top Soil, sandy sub soil
- High proportion of coarse fraction, increases with depth
- Low soil depth, but grave-pure underground

Land use:

- Grassland / Pasture
- (Potatoes, Gardening)

P12 Regosol on Debris

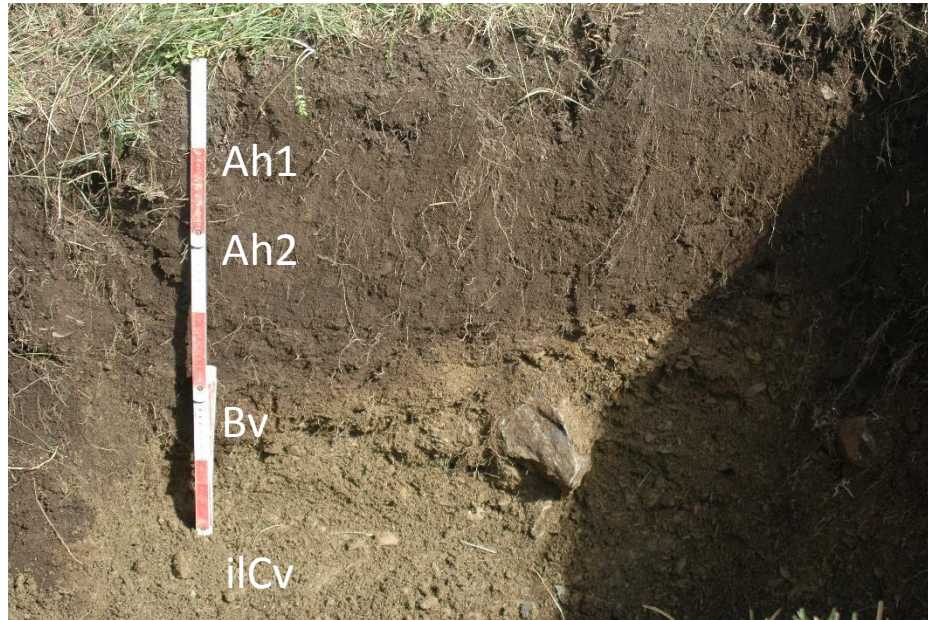


Agricultural potential: (very) low - moderate

	pH	C _{org} [%]	CEC [cmol _c kg ⁻¹]
Top Soil	5,8 ±0,5	6,8 ±3,2	24,7 ±9,4
Sub Soil	5,0 ±0,3	2,1 ±1,5	9,8 ±6,0

Cambisols

P23 Cambisol on Glacial deposits

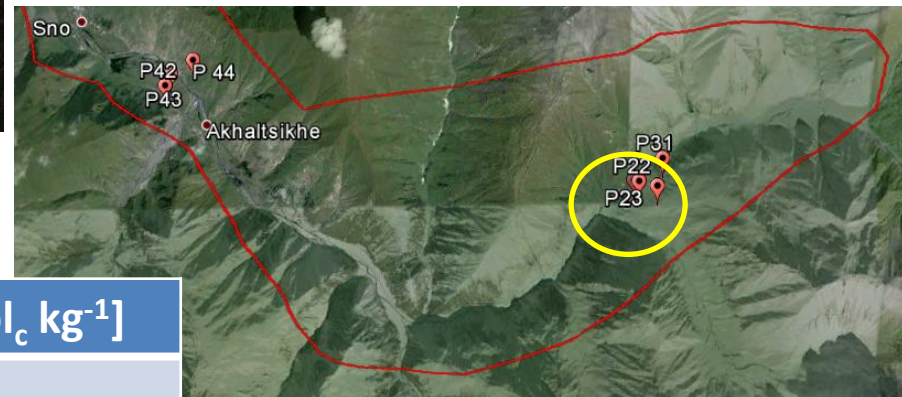


- Moderate depth
- Sandy-loamy texture
- Moderate coarse fraction, increases with depth

Land use:

- Grassland / Pasture

Agricultural potential: low - moderate



	pH	C _{org} [%]	CEC [cmol _c kg ⁻¹]
Top Soil	4,7 ±0,9	9,7 ±5,3	14,1 ±5,5
Sub Soil	5,3 ±0,8	2,5 ±1,5	9,5 ±4,9

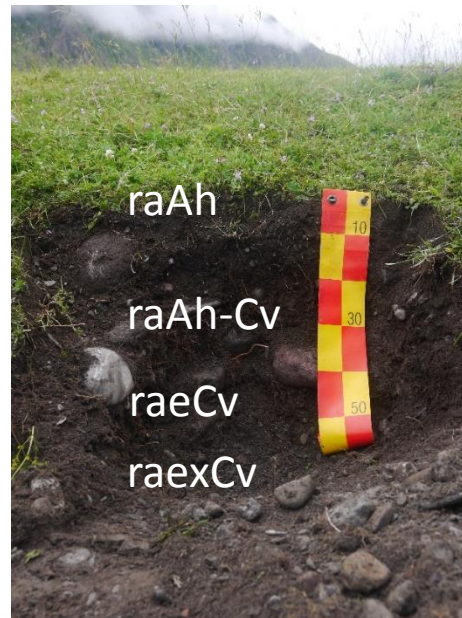


Soils in flood plains

P3 Calcaric Fluvisol on alluvial sediments (loam over debris)



P29 Fluvic Calcaric Regosol on alluvial sediments (gravel)



P26 Gleyic Fluvisol on alluvial sediments (loam over gravel)



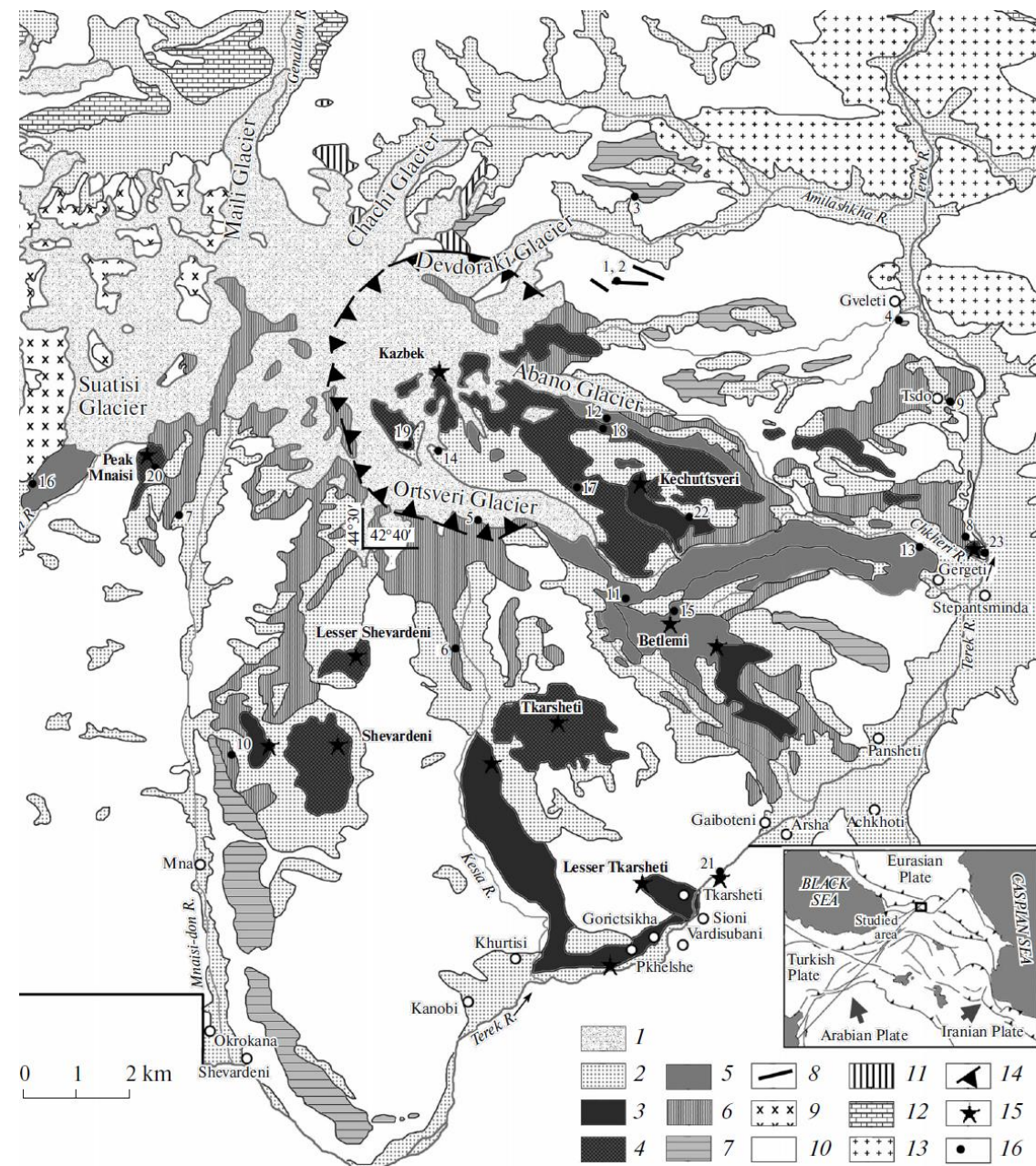
- Soil depth and texture depends on underground: Loam or gravel?
- Enriched in CaCO_3

Land use:

- Grassland / Pasture
- (Potatoes)

Agricultural potential: low - moderate

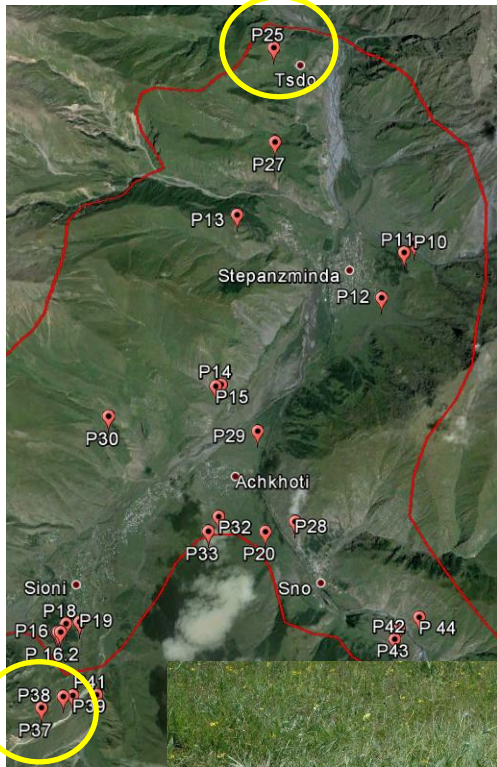
Geology



- 1) Glaciers
- 2) Quaternary fluvial sediments and talus
- Volcanic rocks of Kazbek (IV phases)
 - 3) IV <50 ka
 - 4) III Beginning of phase 90-120 ka
 - 5) III End of phase 90-120 ka
 - 6) II 200-250 ka
 - 7) I 395-433 ka
- 8) Late Quaternary andesite dikes and necks of copper deposits
- 9) Pliocene granodiorite and quartz diorite
- 10) (early-middle) Jurassic sedimentary and volcanic rocks
- 11) Jurassic gabbroic rocks
- 12) Late Paleozoic metamorphic and volcanic rocks
- 13) Carboniferous granitic rocks
- 14) Ledge of caldera (paleo-Kazbek)
- 15) Quaternary volcanic apparatuses

Lebedev et. al, 2014 (modified)

Protoandic Umbrisols



- Slope loam of / colluvium on Andesit-Dacit
- Bulk density $< 0,8 \text{ g/m}^3$
- Soil depth up to $> 15 \text{ cm}$
- (sandy-) loamy soil texture
- K well supplied top soil, heterogeneous in sub soil
- P deficiency / partly high P-sorption

Land use:

- Grassland / Pasture
- (Potatoes)

Agricultural potential: low - good

	pH	C _{org} [%]	CEC [cmol _c kg ⁻¹]
Top Soil	5,8 ± 0,7	8,8 ± 4,1	35,3 ± 11,8
Sub Soil	4,8 ± 0,5	3,2 ± 1,3	16,3 ± 10,3



Soil Quality Rating (SQR)¹

Basic soil indicators

1. Substrate (3)
2. A horizon depth (1)
3. Topsoil structure (1)
4. Subsoil compaction (1)
5. Rooting depth (3)
6. Profile available water (3)
7. Wetness and ponding (3)
8. Slope and relief (2)

Soil hazard indicators

1. Contamination
2. Salinisation
3. Sodification
4. Acidification
5. Low total nutrient status
6. Soil depth above hard rock
7. Drought
8. Flooding and extreme waterlogging
9. Steep slope
10. Rock at the surface
11. High percentage of coarse soil texture fragments
12. Unsuitable soil thermal regime
13. Miscellaneous hazards

Step
1

Basic soil score of 0...34 based on 8 indicators (weighted of 1...3)

Step
2

Hazard multipliers of 0.1...3,
(Lowest = valid multiplier)
If no hazard factor,
multiplier = 3 (2.94)

Step
3

Soil score (SQR score) of 0...100 under
- Cropping
- Permanent grassland



B19 Haplic Cambisol
on Loamy slope
deposits (over till)
[Gergeti]

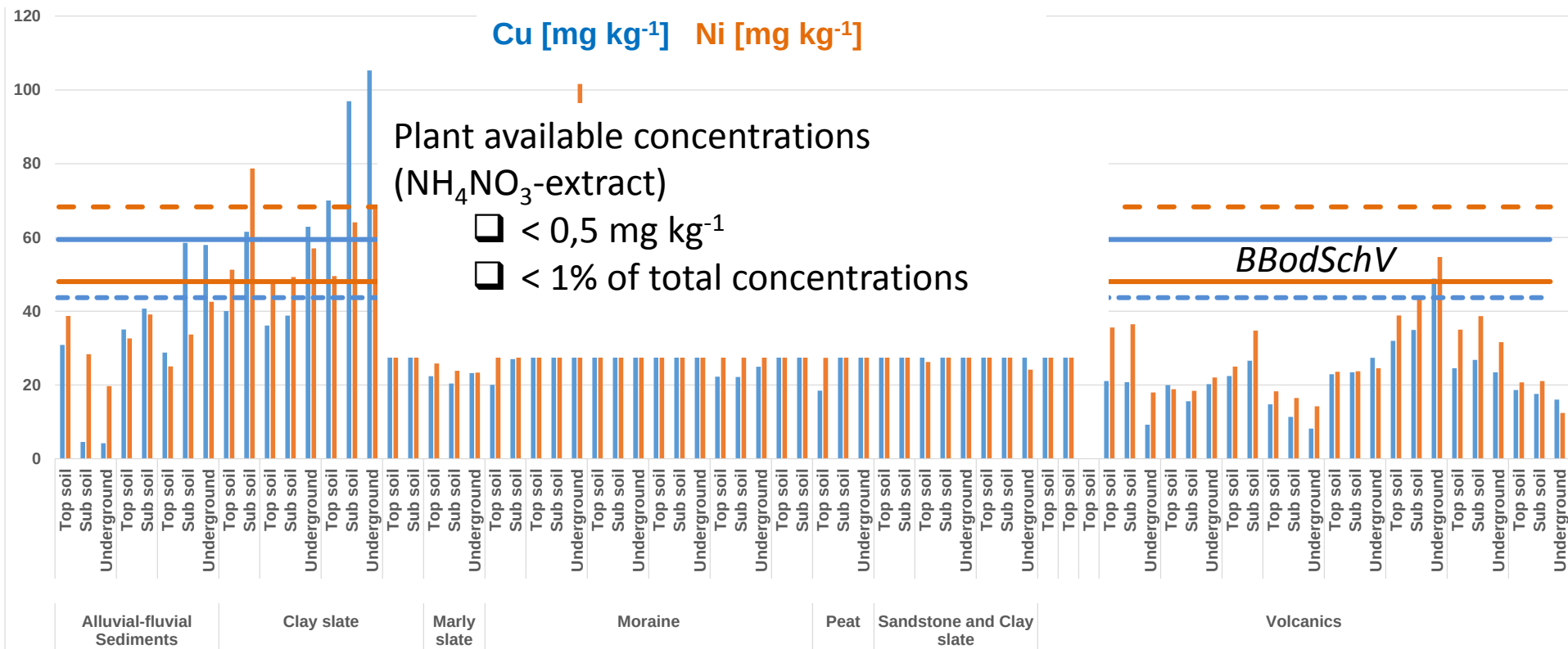


P10 Skeletic Cambisol
on
Debris
[Stepansminda]

Classes of SQ are < 20 = **Very poor**, 20 - 40 = **Poor**, 40 - 60 = **Moderate**, 60 - 80 **Good**,
> 80 = **Very good**.



Hazards - Trace metals

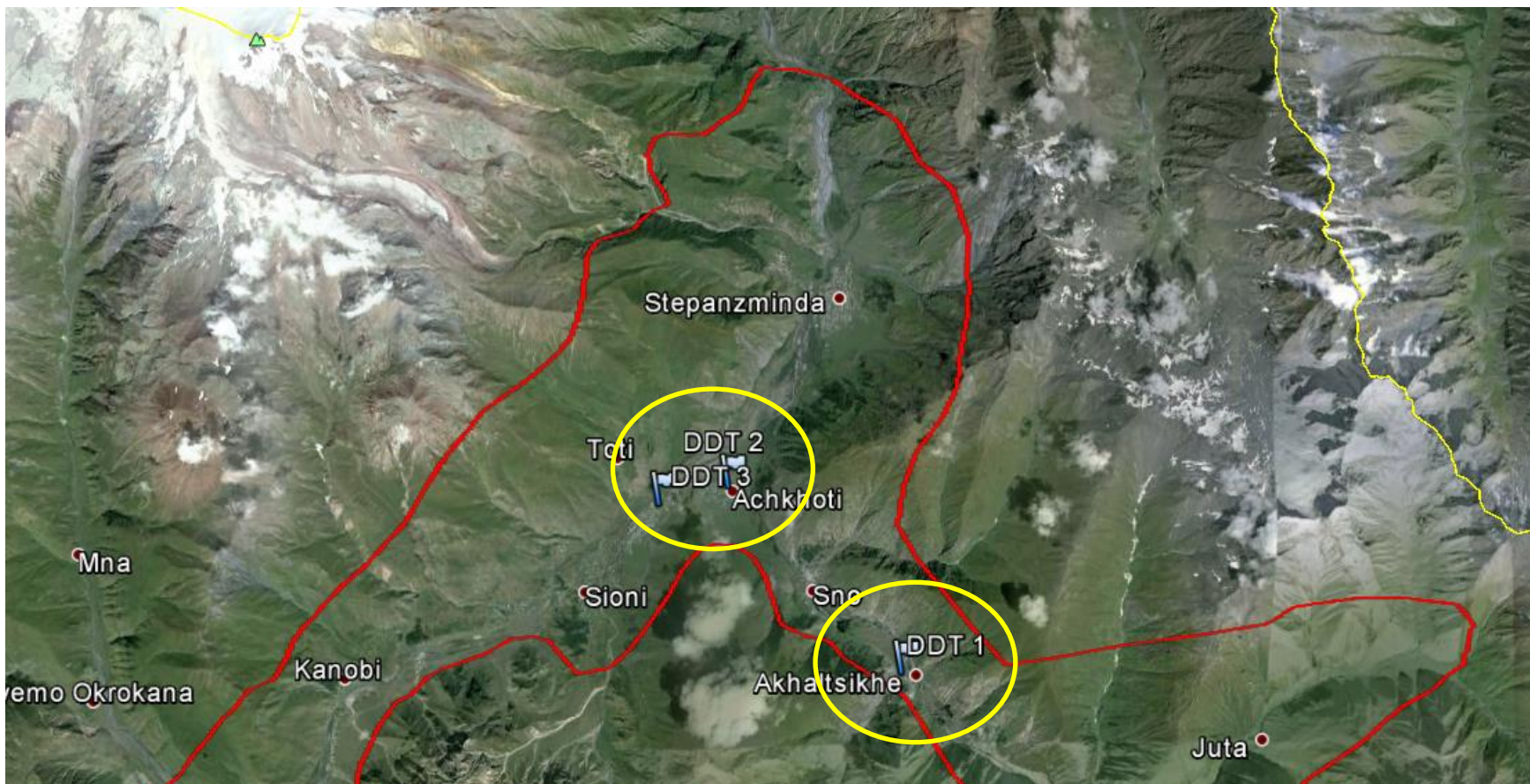




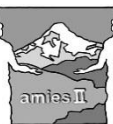
Hazards - Persistent Organic Pollutants (POP)

Profile	Location	Soil type	Trifluralin	HCH	HCB	DDx	Corg %
P3	Truso valley	Calcaric Gleyic Fluvisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	2,6
P8	Kanobi	Skeletal Humic Regosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	3,8
P9	Pkhelsche	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	6,9
P10	Stepansminda	Skeletal Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	9,9
P11	Stepansminda	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	7,7
P13	Gergeti Trinity Church	Leptosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	8,9
P14	Pansheti	Skeletal Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	7,4
P18	Sioni	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	10,4
P20	Sno	Histosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	28,6
P23	Juta	Cambic Hyperhumic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	17,7
P25	Tsdo	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	6,9
P26	Kobi	Calcaric Gleyic Fluvisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	4,3
BB-KAZ	below Kazbeg glacier	Cambic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	8,6
P29	Achkhoti	Fluvic Calcaric Regosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	5,6
P30	Toti	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	8,9
P31	Juta	Cambic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	11,8
P33	Achkhoti	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	16,7
P34	Kanobi	Gleyic Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	7,4
P36	Ukhati	Cambic Hyperhumic Protoandic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	11,3
P37	Sioni	Hyperhumic Abruptic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	7,5
P38	Sioni	Mollic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	6,0
P43	Akhaltsikhe	Fluvic Calcaric Regosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	6,8

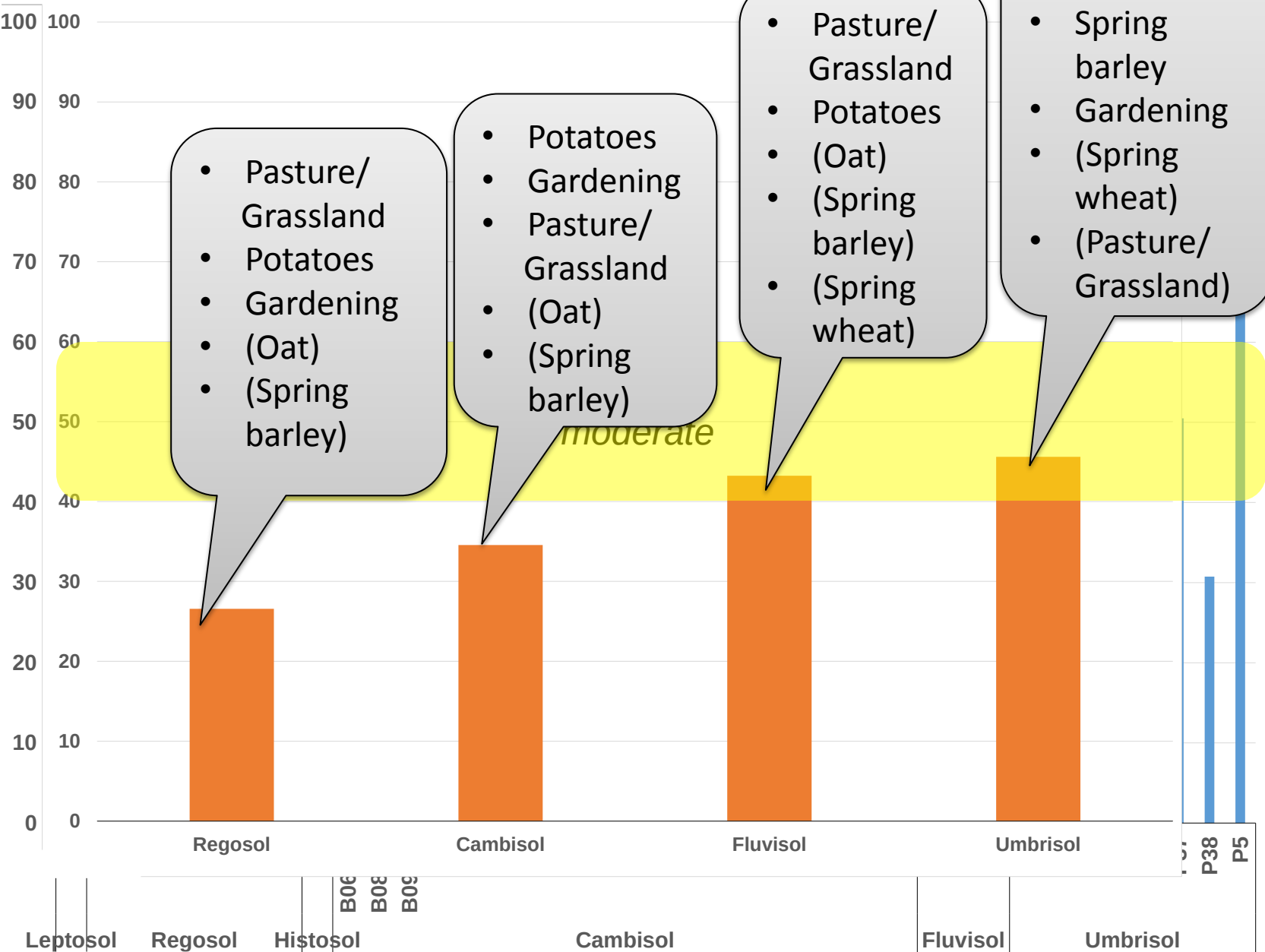
Hazards - Persistent Organic Pollutants (POP)



2.4'-DDD	2.4'-DDT	4.4'-DDD	4.4'-DDT	2.4'-DDE	4.4'-DDE	α -HCH	β -HCH	γ -HCH	Δ -HCH	
		5,09	4,18		10,56	6,82				$\mu\text{g/kg}$
4,52	16,34	17,27	20,97	1,86	178,12	6,95				$\mu\text{g/kg}$
			3,82		4,68	7,72				$\mu\text{g/kg}$



Soil Quality Rating (SQR)





Summary

- High diversity of substrates and soil forming processes
- (Relatively) deep soils on volcanic parent material as well as fluvial and glacial sediments
- SQR : *Poor – moderate (seldom good)* rating
- Best soils on slope sediments of weathered Andesite-Dacite: *(Protoandic) Umbrisols*; suitable for farming
- Trace metals partly increased but not available!
- No increased POP concentrations outside greening houses!

Discussion!

