

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



VolkswagenStiftung

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Soil distribution and soil properties in the subalpine region of Kazbegi; Greater Caucasus



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Ilia State
University



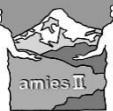
Ivane Javakhishvili
Tbilisi State University



JUSTUS-LIEBIG-
UNIVERSITÄT
GIESSEN



Center for international
Development and
Environmental Research 1



Research Area

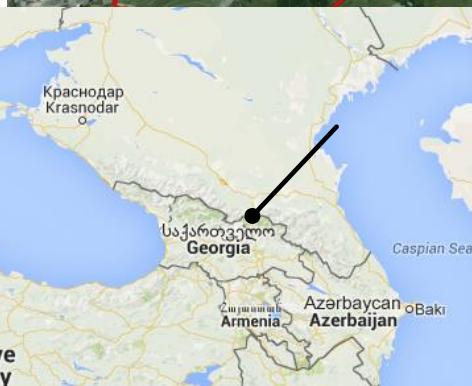
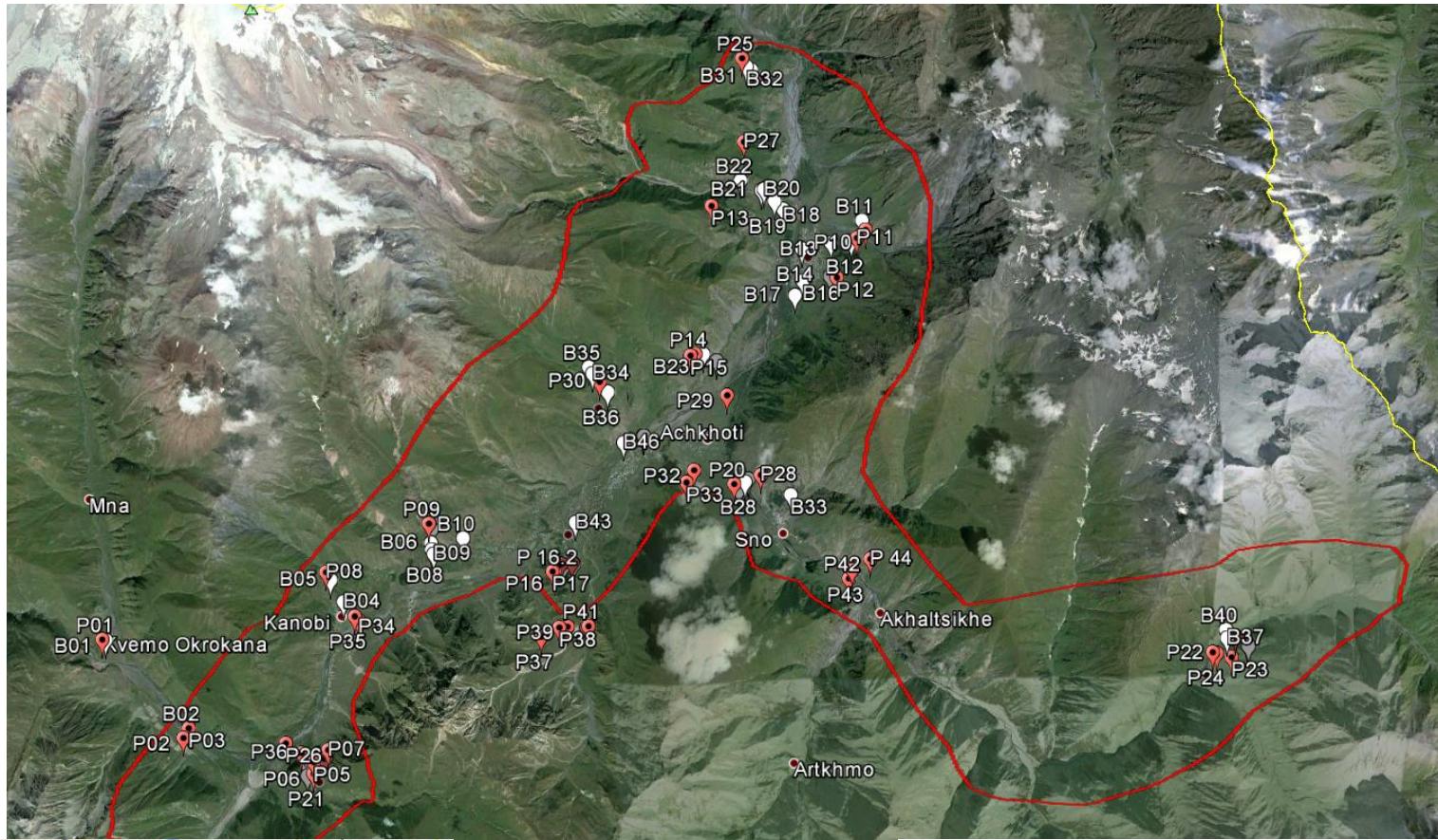
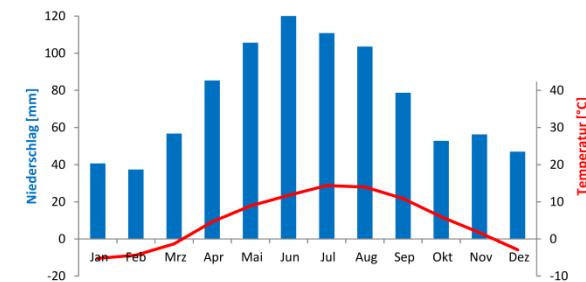
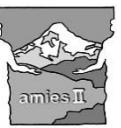


Image Landsat
Image © 2016 DigitalGlobe
© 2016 Google

Stepanzminda, Georgien, 1961-90
1744 m ü. NN, 42°39'50"N, 44°38'00"E
+4,9°C
897 mm





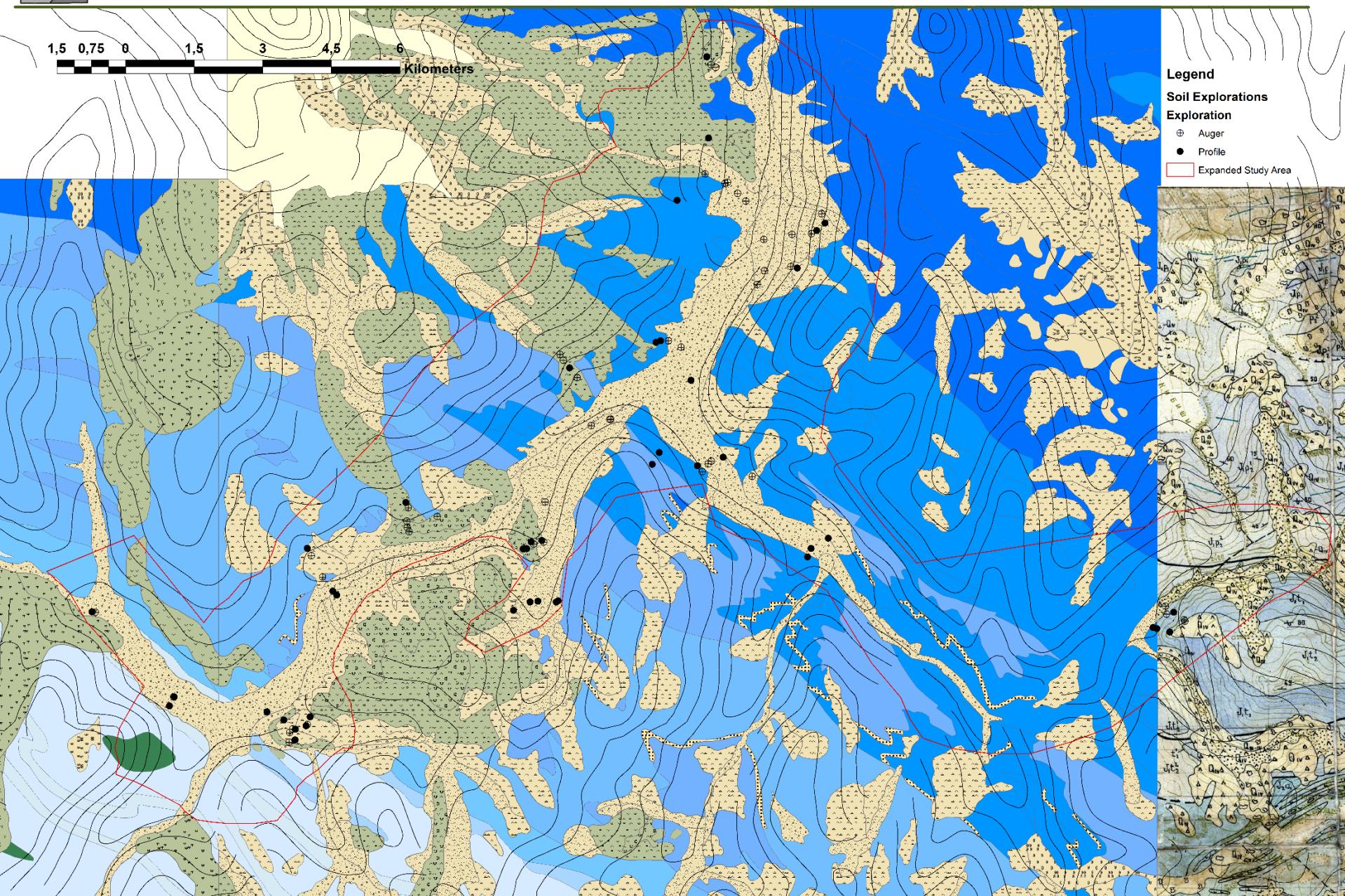
Objektives of part B

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

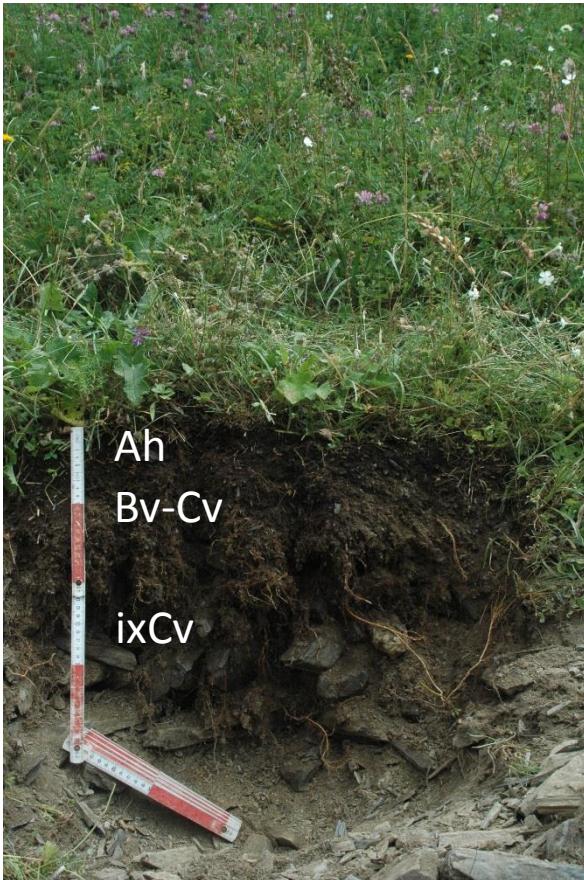


Geology



Leptosols

P44 Skeletic Mollic Leptosol on Debris/Hard rock

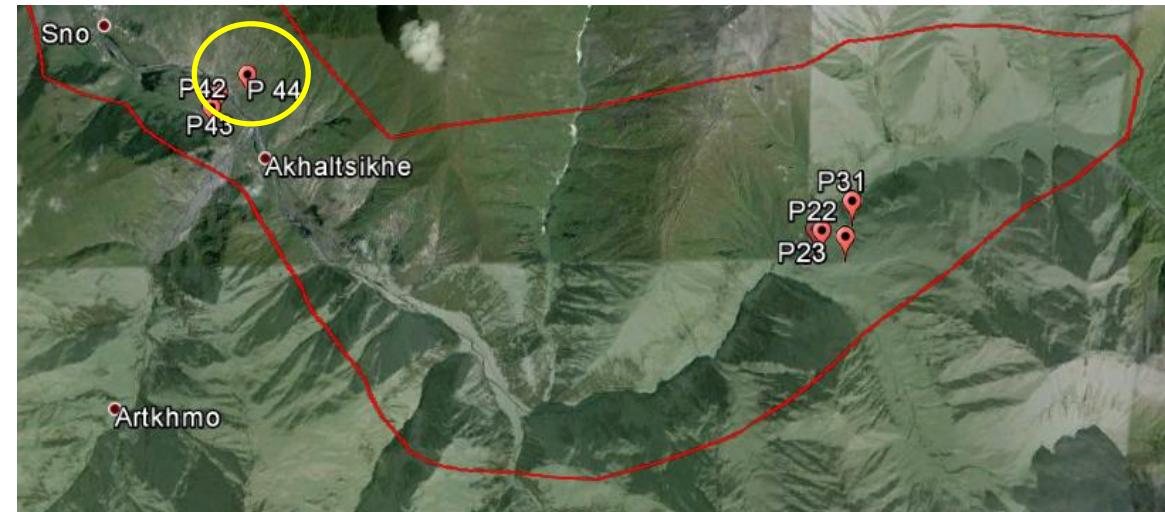


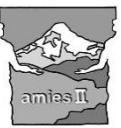
- (Top) slopes and Exposed areas
- Shallow soils
- High proportion of Coarse fraction, increases with depth

Land use:

- Pasture

Agricultural potential: very low



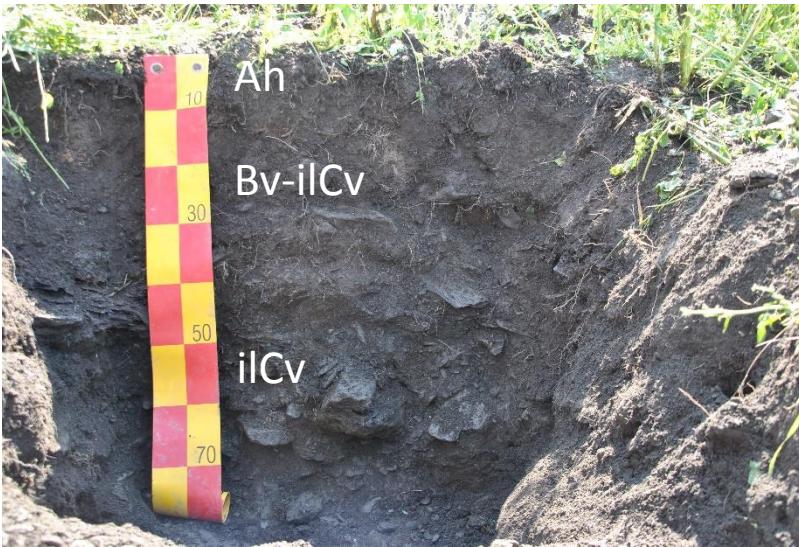


Skeletic Cambisols / Regosols



Skeletic 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

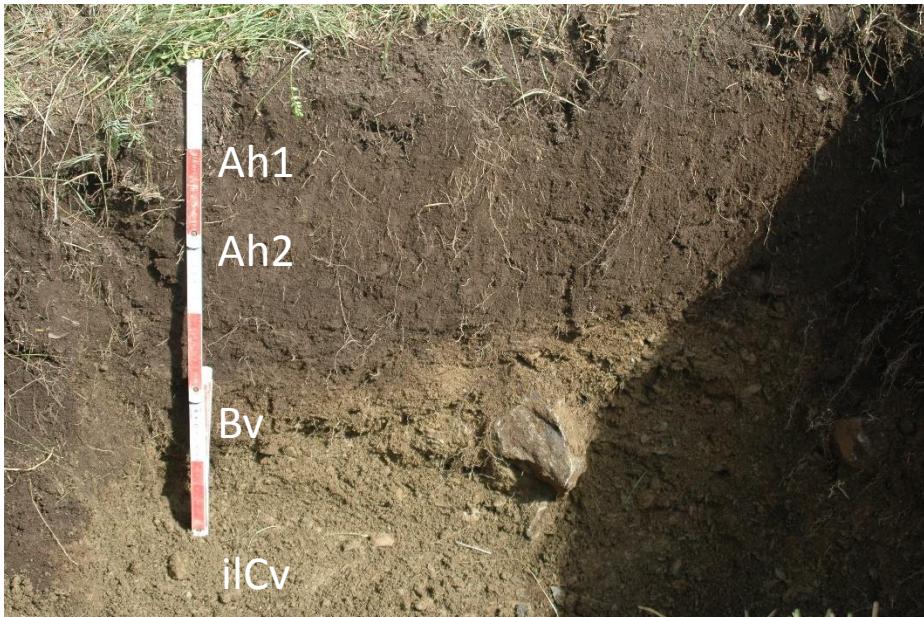


Agricultural potential: (very) low - moderate

	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



Agricultural potential: low - moderate

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

Land use:

- Grassland / Pasture



	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

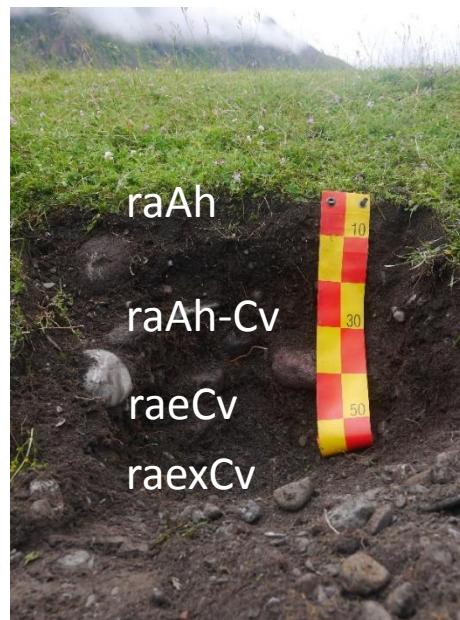


Soils in flood plains

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

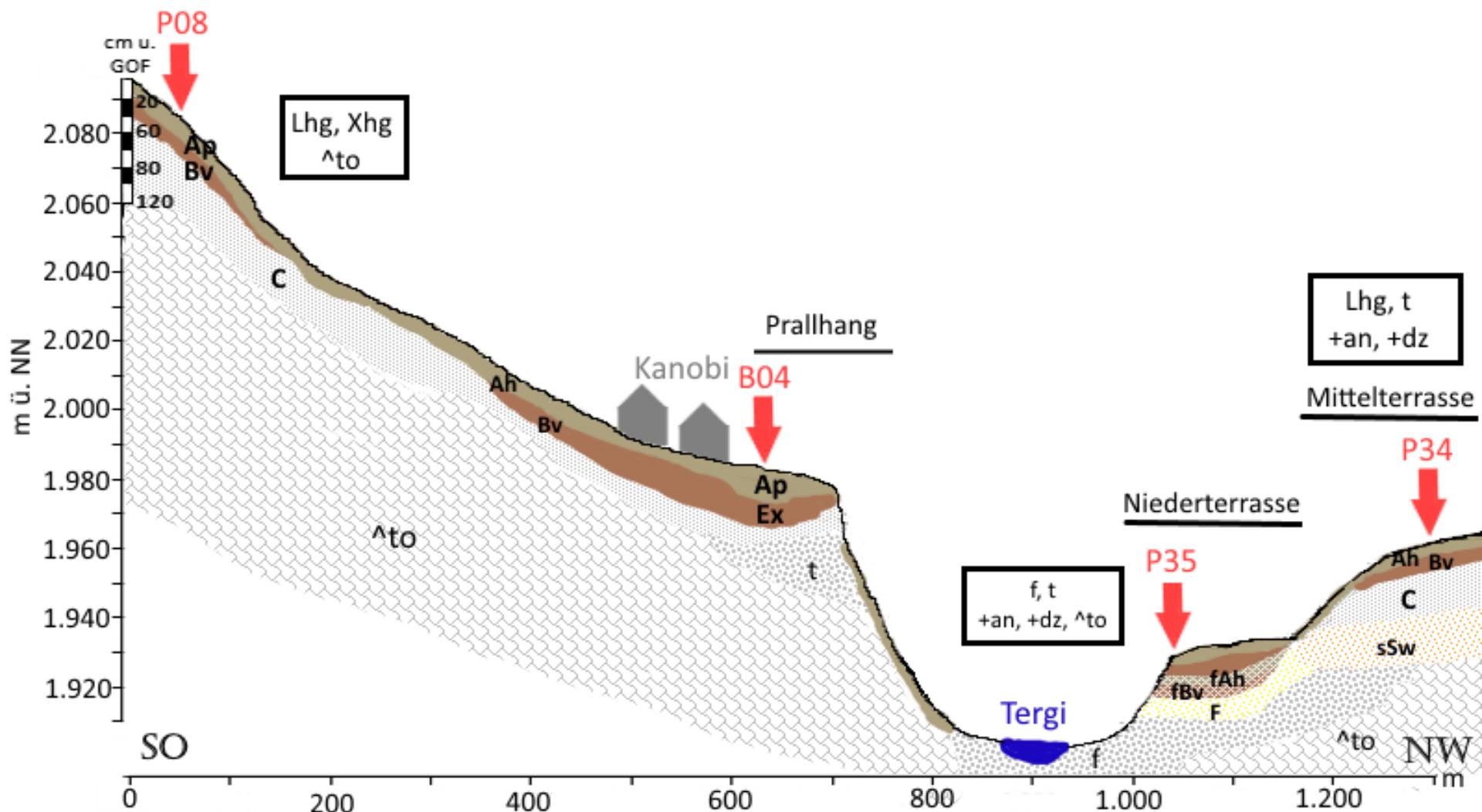
Land use:

- Grassland / Pasture
- (Potatoes)

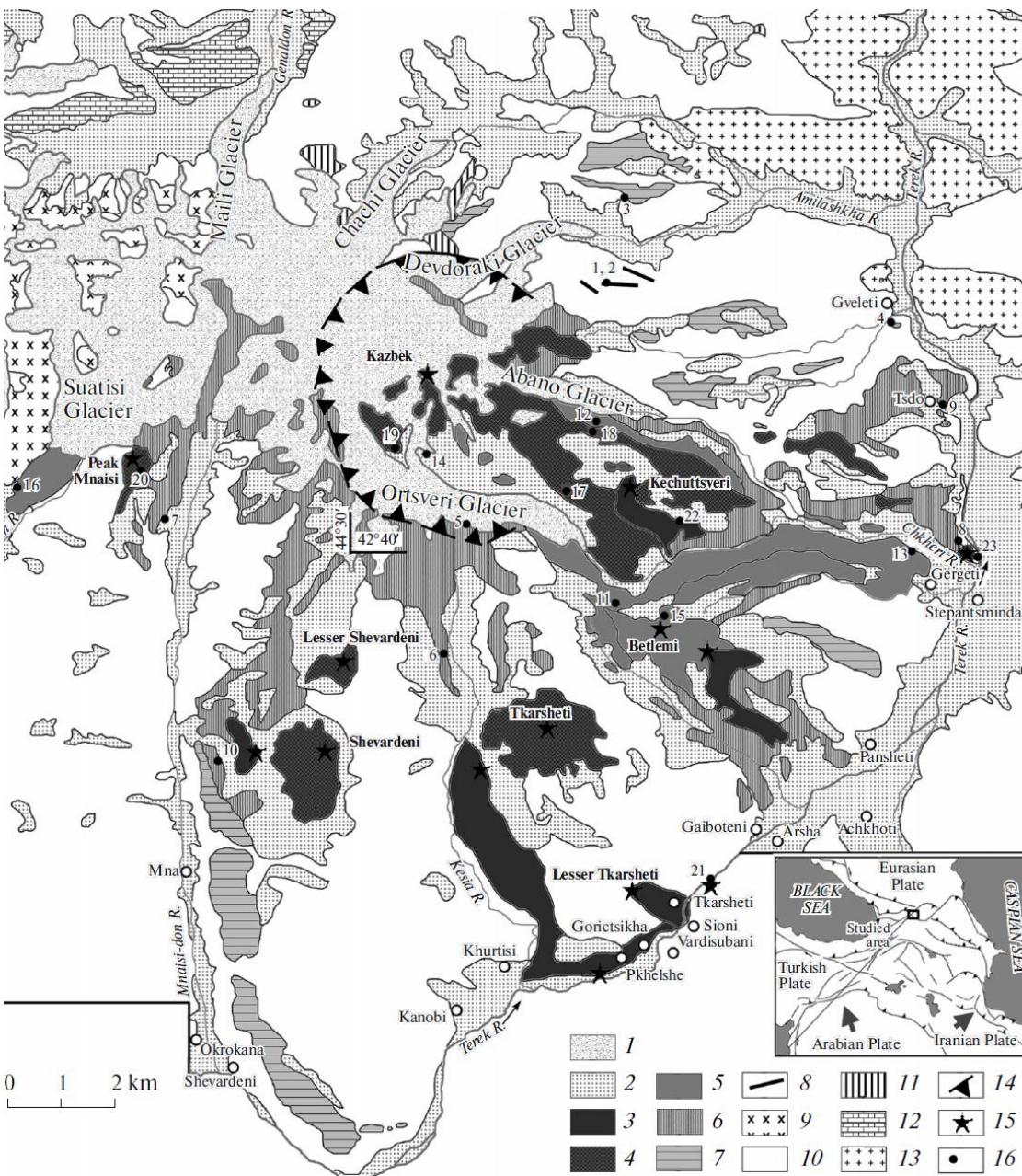
Agricultural potential: low - moderate



Catena



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

Protoandic Umbrisols



- Slope loam of / colluvium on Andesitic Dacit
 - Bulk density <0,8 g/m³
 - Soil depth up to >150 cm
 - (sandy-) loamy soil texture
 - K well supplied - top soil, heterogeneous in sub soil
 - P deficiency / partly high P-sorption capacity
- Best soils!**

Land use:

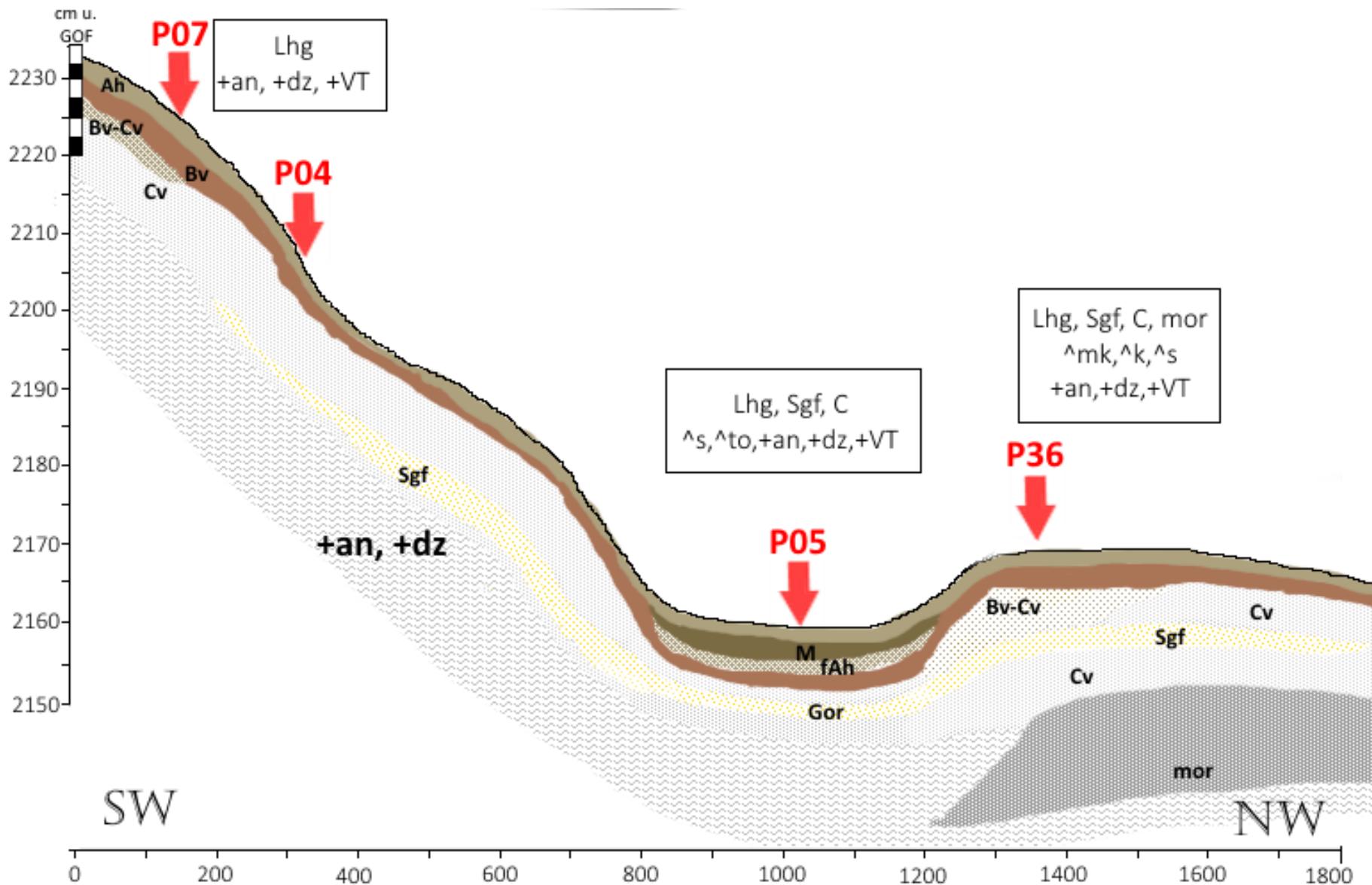
- Grassland / Pasture
- (Potatoes)

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

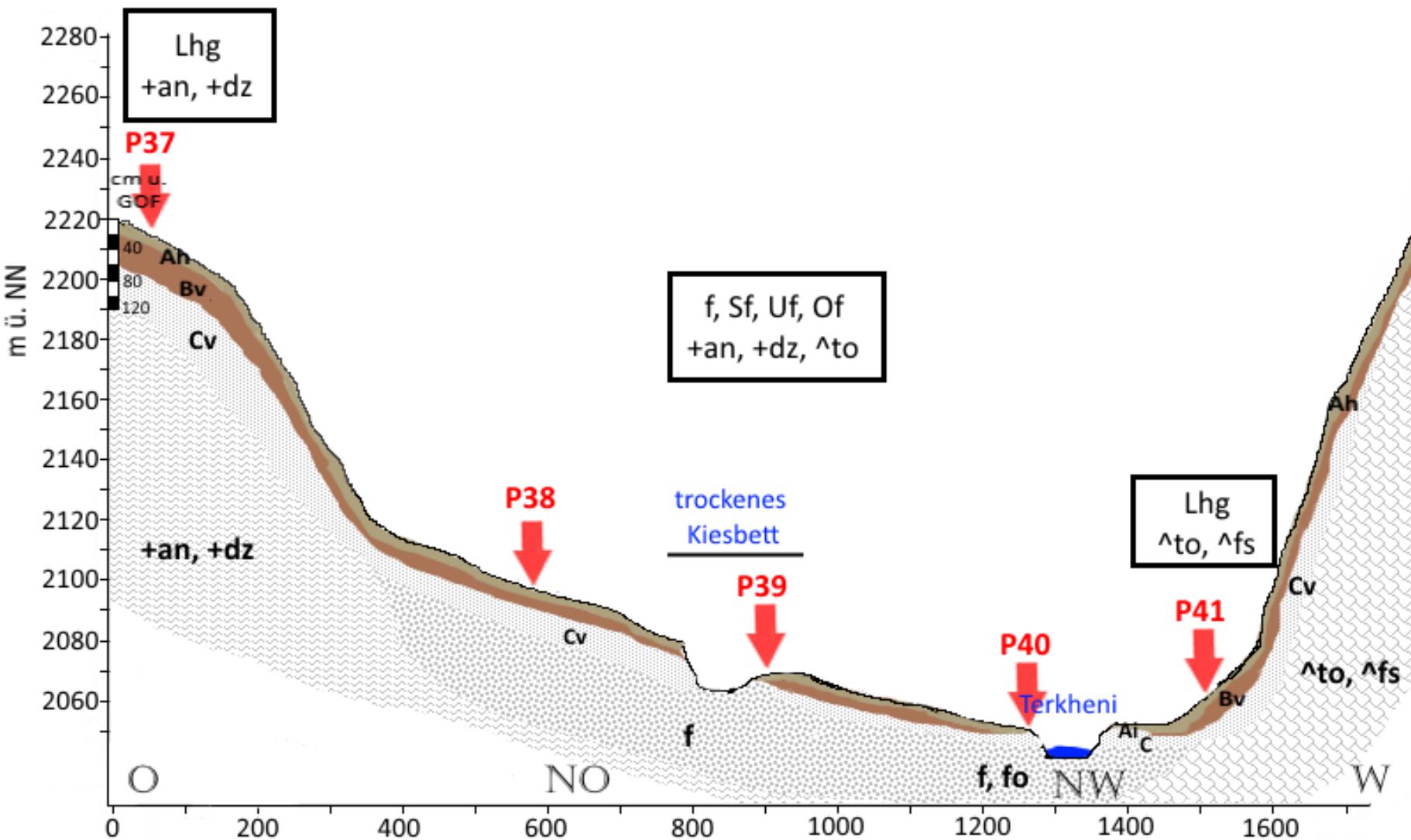


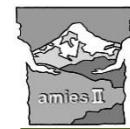
Catena





Catena



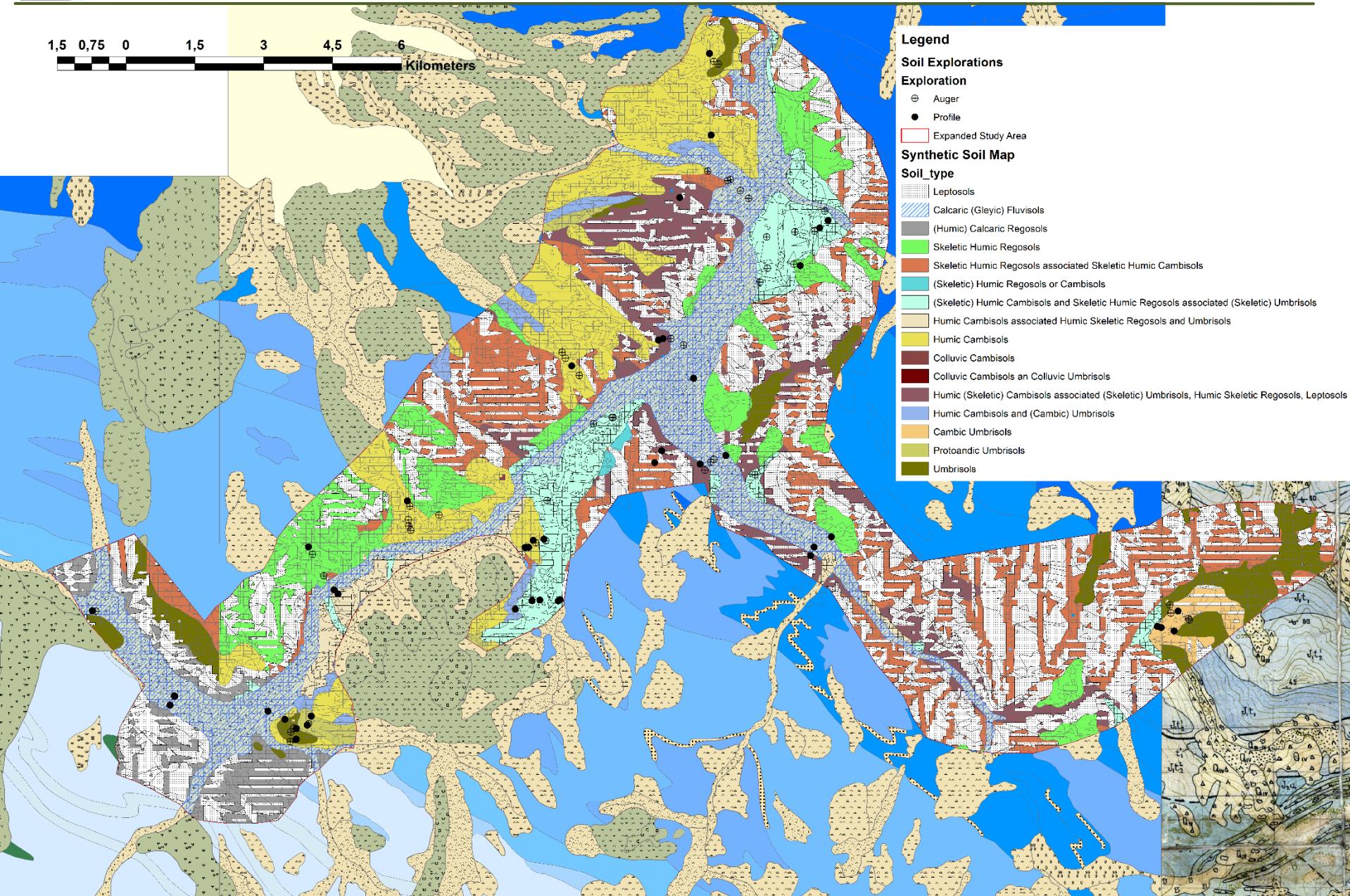


Synthetic Soil Map

1,5 0,75 0 1,5

3 4,5 6

Kilometers





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)

Step

1

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

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



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

Step

2

Step

2

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

Step

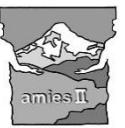
3

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

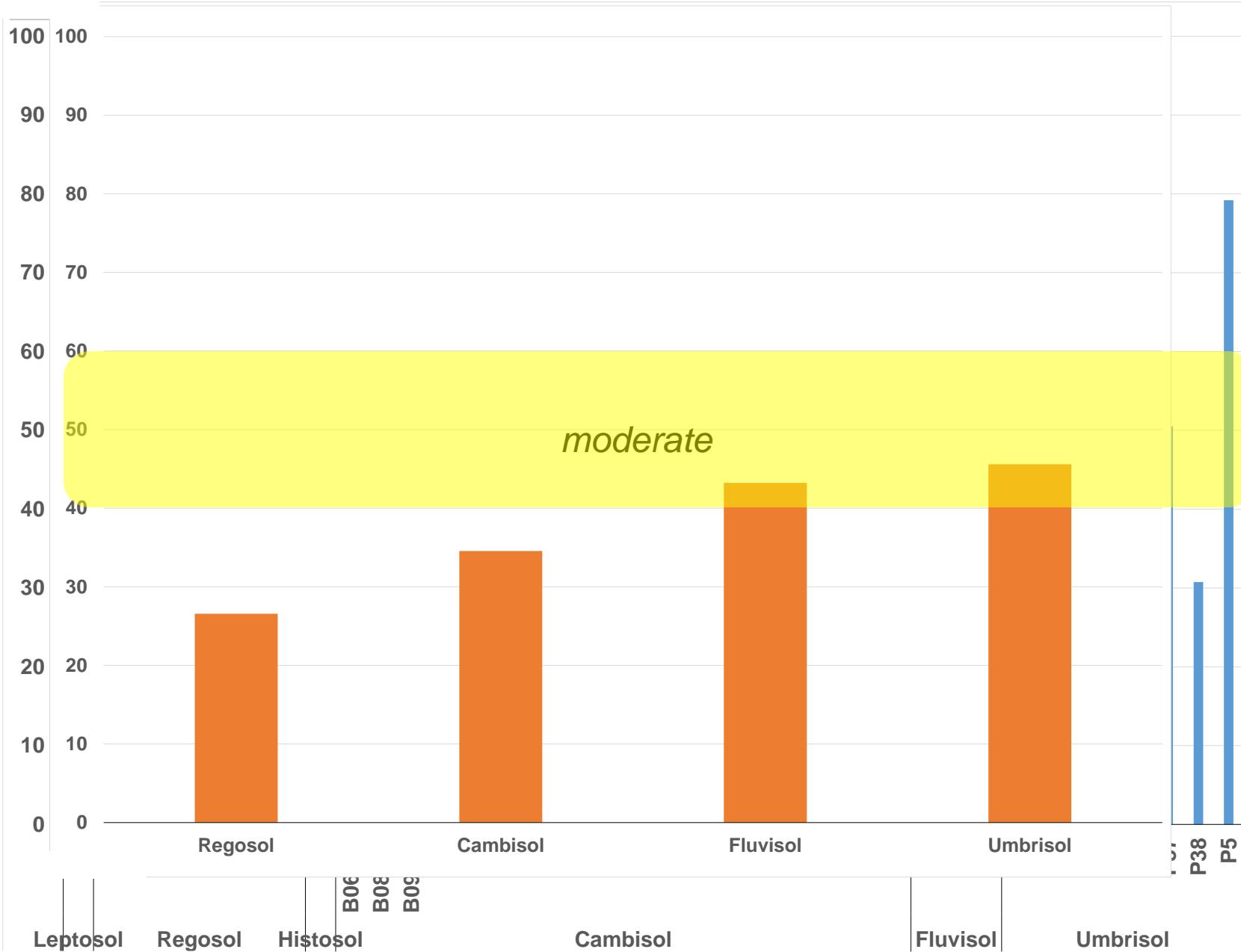


**P10
Skeletal Cambisol
on
Debris
[Stepansminda]**

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

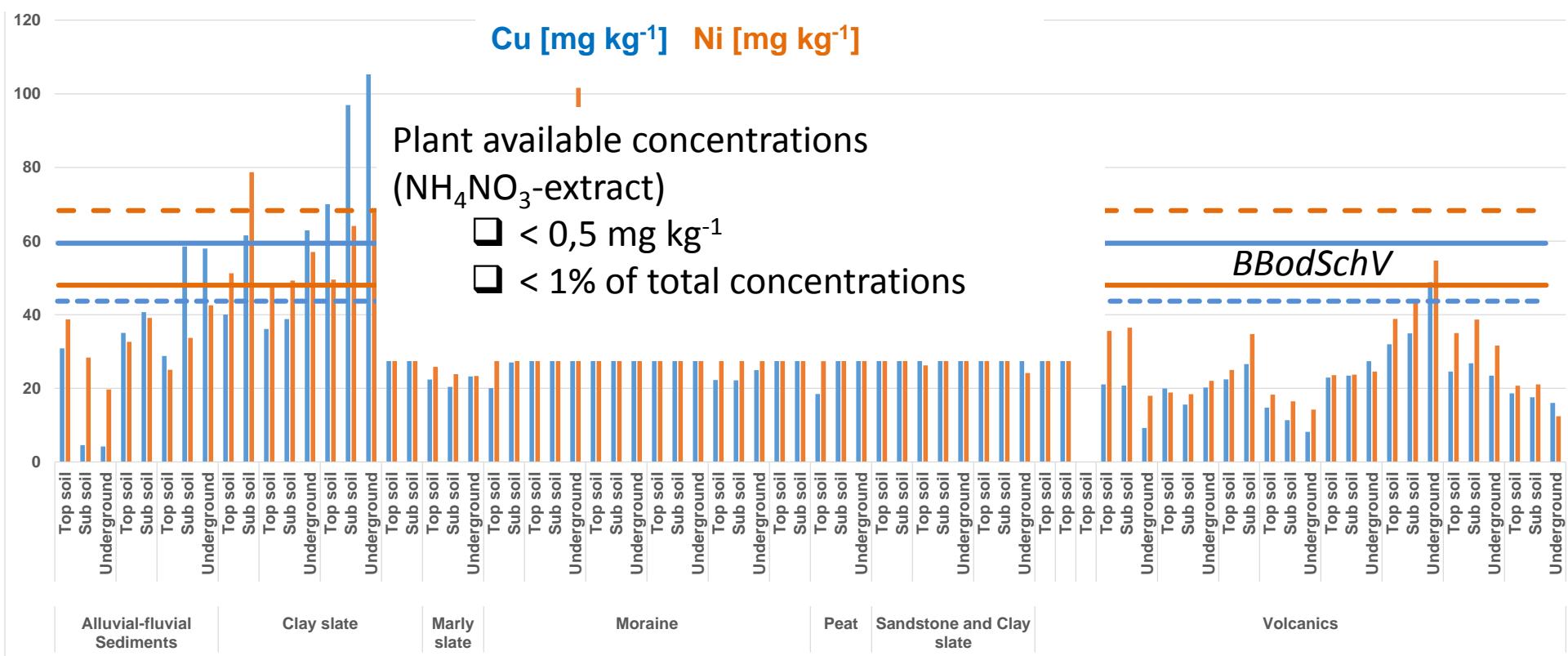


Soil Quality Rating (SQR)





Hazards - Trace metals



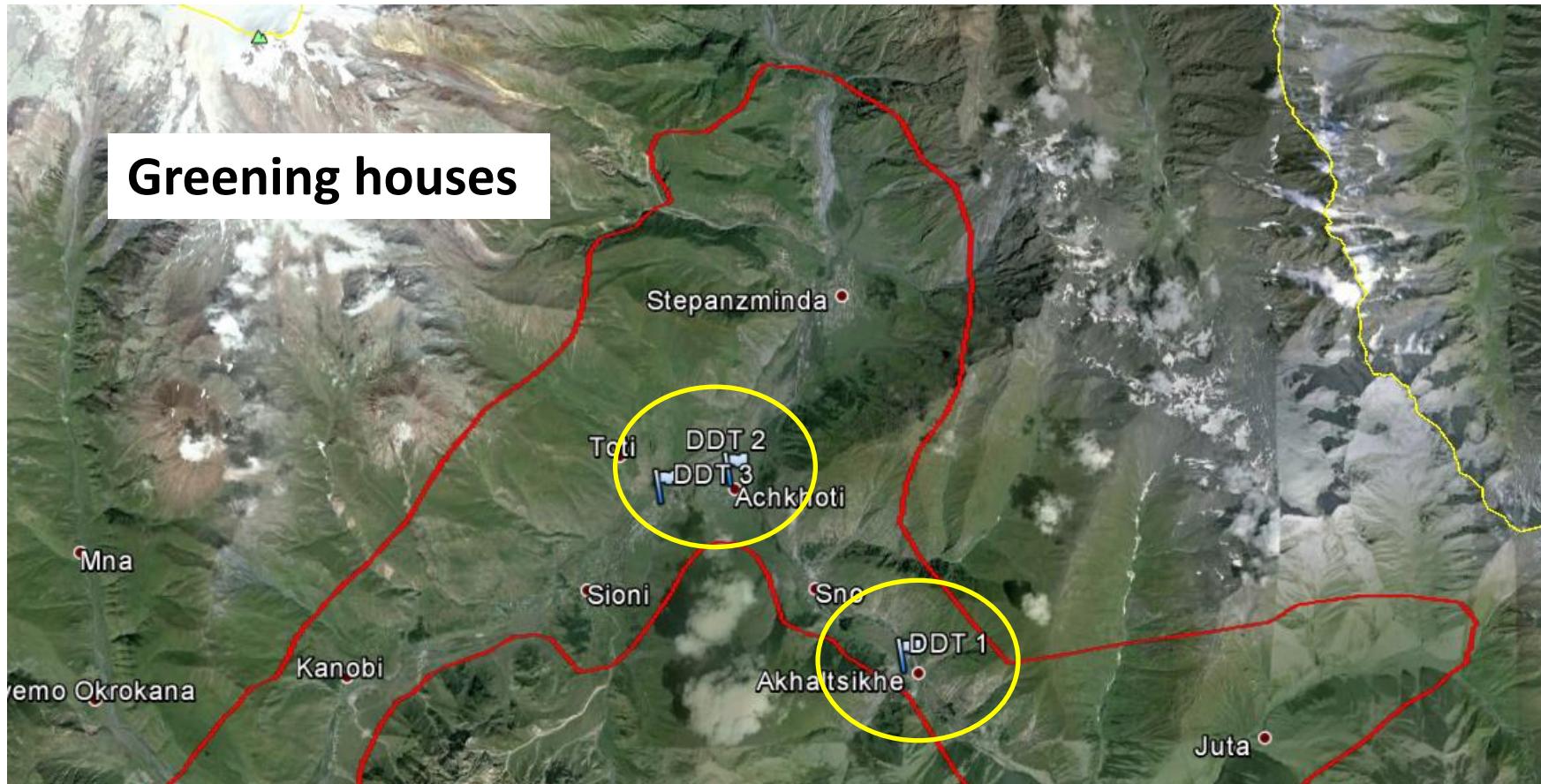


Hazards - Persistent Organic Pollutants (POP)

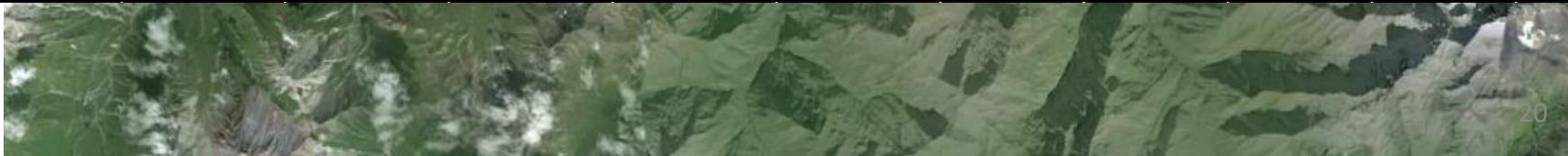
Profile	Location	Soil type	Trifluralin	HCH	HCB	DDx	Corg %
P3	Truso valley	Calcaric Gleyic Fluvisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	2,6
P8	Kanobi	Skeletal Humic Regosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	3,8
P9	Pkhelsche	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	6,9
P10	Stepansminda	Skeletal Umbrisol	b.d.l.	b.d.l.	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
	Gergeti Trinity Church	Leptosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	8,9
P13	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
	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
	below Kazbeg glacier	Cambic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	8,6
BB-KAZ	Achkhoti	Fluvic Calcaric Regosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	5,6
P29	Toti	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	8,9
P30	Juta	Cambic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	11,8
P31	Achkhoti	Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	16,7
P33	Kanobi	Gleyic Humic Cambisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	7,4
	Ukhati	Cambic Hyperhumic Protoandic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	11,3
P36		Hyperhumic Abruptic Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	
P37	Sioni	Mollis Umbrisol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	7,5
P38	Sioni	Fluvic Calcaric Regosol	b.d.l.	b.d.l.	b.d.l.	b.d.l.	6,0
P43	Akhaltsikhe		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	
4,52	16,34	5,09	4,18	1,86	10,56	6,82				$\mu\text{g}/\text{kg}$
		17,27	20,97	3,82	178,12	6,95				$\mu\text{g}/\text{kg}$
					4,68	7,72				$\mu\text{g}/\text{kg}$

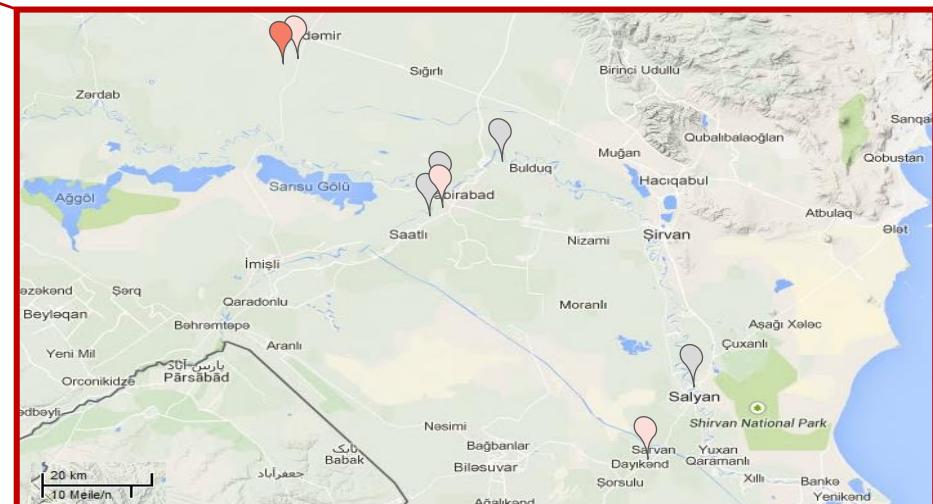
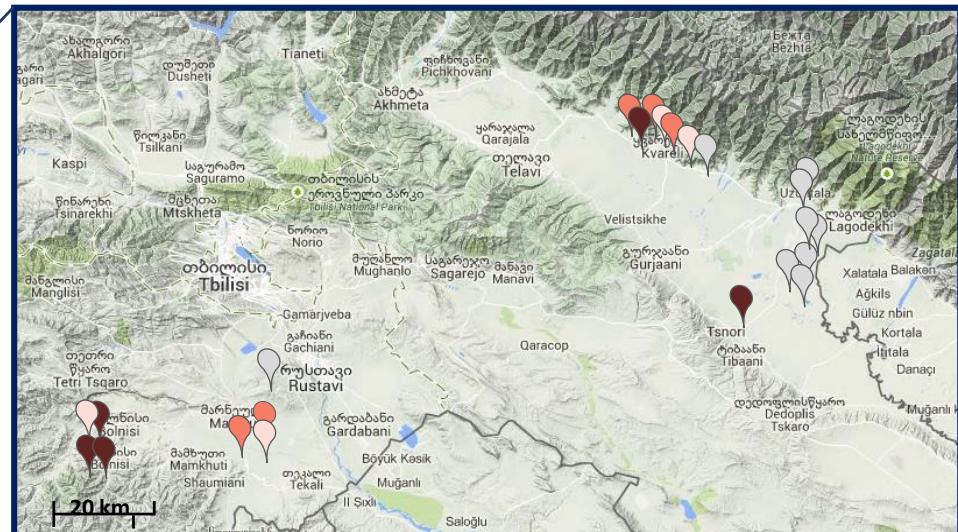
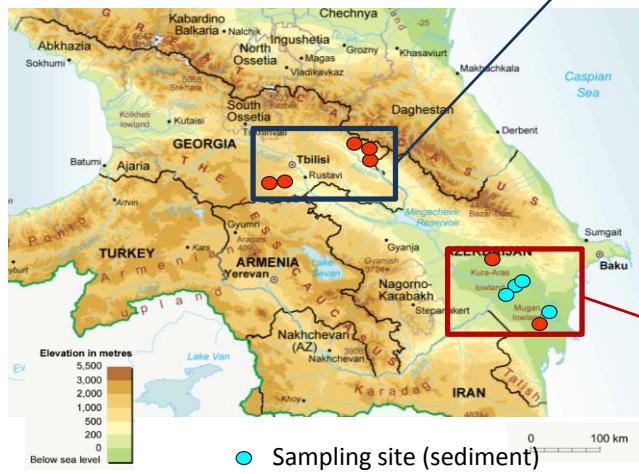


Persistence: obsolete Pesticides in regions of the former sovjet union



- Identification and prioritization of contaminated sites
- Development and strategies for risk minimization
- Environmentally sound disposal of organochlorinated pesticides (OCPs)

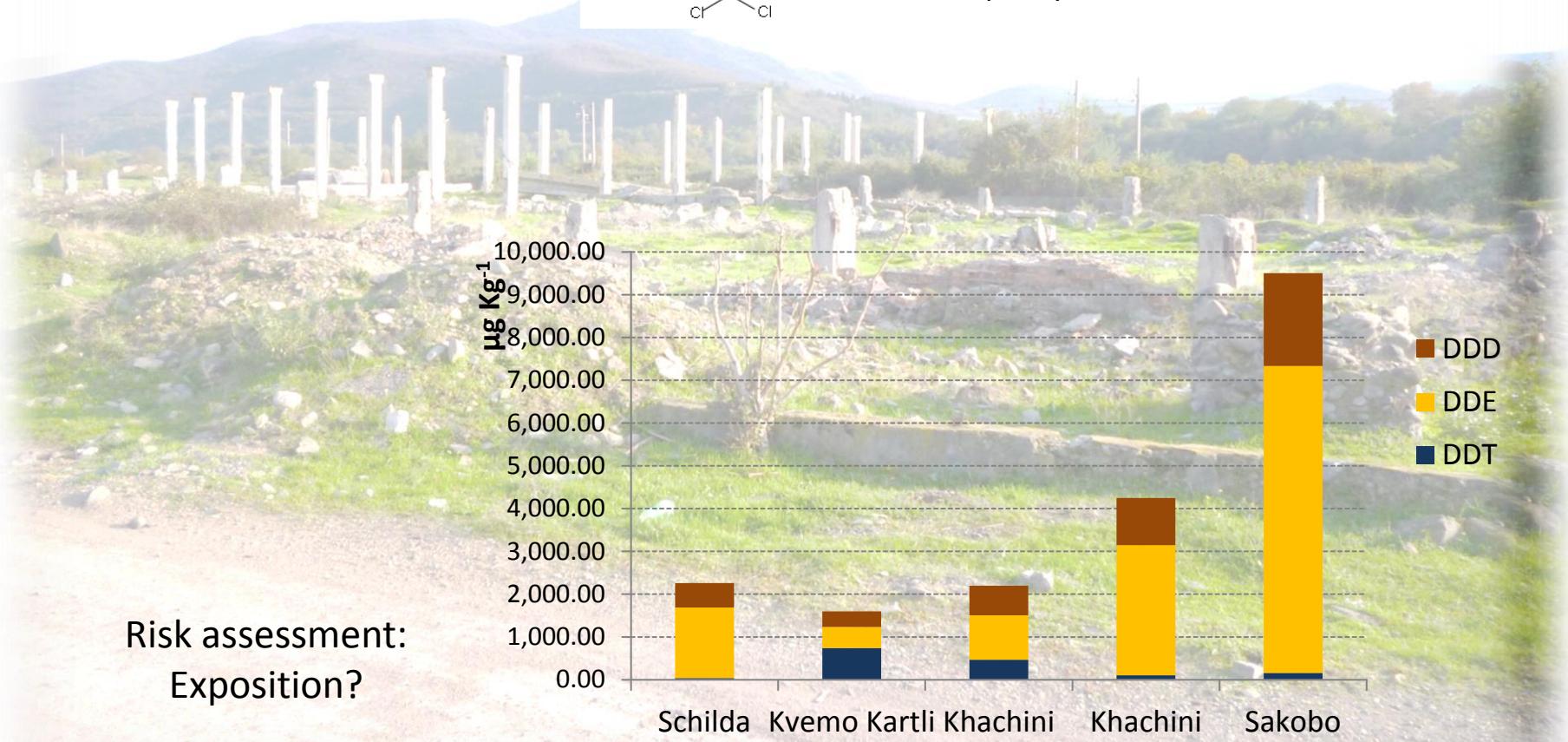
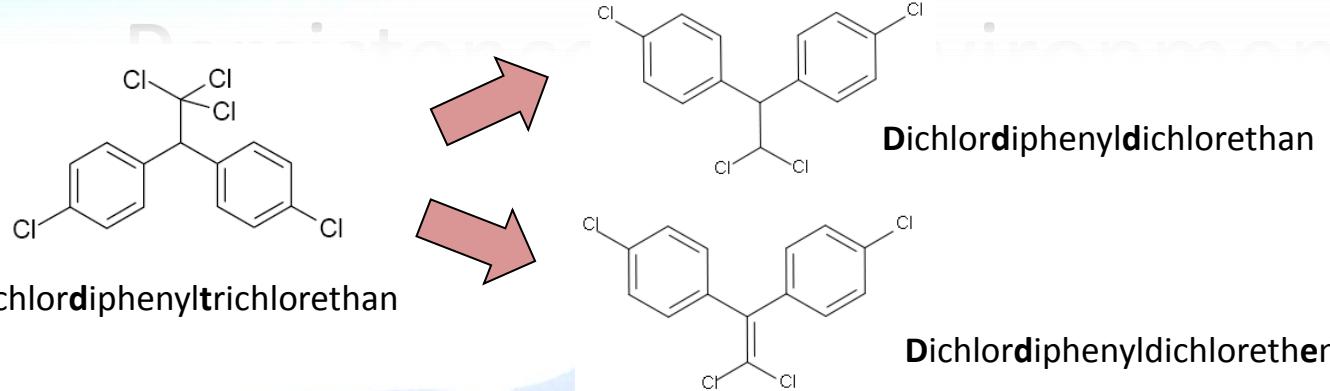
OCPs and transformation products in Caucasian soil



ΣDDX [$\mu\text{g kg}^{-1}$]

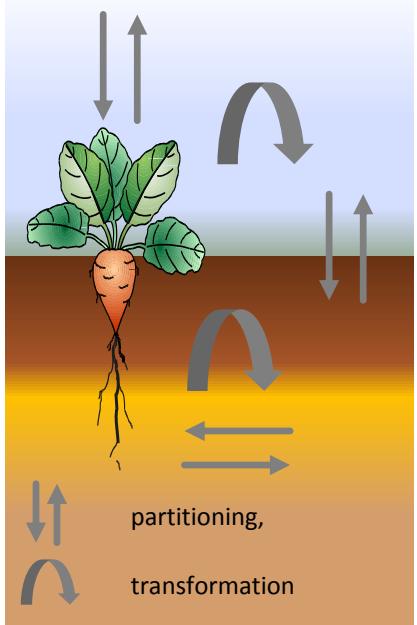
- 1000 - 10 000
- 100-1000
- 10-100
- 0.5-10







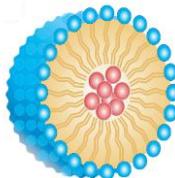
Health risks due to soil contamination with POPs in the Southern Caucasus: monitoring and mitigation strategies



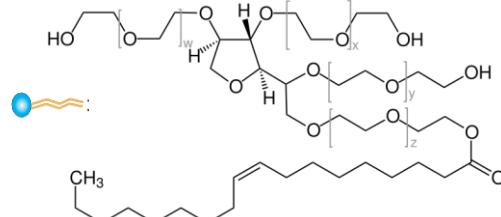
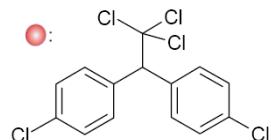
- Integration of regional knowledge
- Characteristics of sites and soils
- Suitable plant species for phytoremediation
- Remobilization of contaminants by surfactants

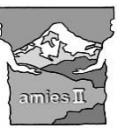
$$S_W^*/S_W = 1 + X_{mn}K_{mn} + X_{mc}K_{mc}$$

Zeng et al., 2012



Adopted from
Takai et al., 2013





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!

