World Soil of the Year 2025

Gleysol from the Carpathian Basin

Hydromorphic soils supporting forest growth in the steppe region

Soil formation

The soil forming environment is a fluvial landscape with depositional features in the middle of the Carpathian Basin. The area is a typical backwater area, a closed depression bordered by the natural levees of abandoned river channels, creating a unique soil association with Gleysol, Solonetz and Chernozem soils. The area was drained in the second half of the 19th century and its rivers lost their water supplies or were transformed to drainage or irrigation channels. This is a beautiful polygenetic soil profile having several different soil formation stages and changing soil development accordingly, inheriting the properties and changing them to adapt to the current environment. It has a buried soil layer at 145-155 cm depth representing an older surface with heavy clay texture of fluvio-lacustrine origin. It was later covered with coarser textured fluvio-aeolian sediment with increasing amounts of aeolian deposits mixed into the clayey material. The buried soil with very fine clay sediments show beautiful vertic properties and slickensides. Due to its low lying position and its closed basin nature, the soil shows stagnic and gleyic properties at the same time (uterqic). It was developed under the influence of shallow, salty groundwater, and frequent, seasonal water-stagnation at the soil surface at the same time, accompanied with some slights salt accumulation in the deeper horizon. From the buried soil to the recent soil and its actual development (after water regulations) the influence of the groundwater is decreasing, but it still supports forest growth in relatively dry climatic conditions.

Functional relevance of these soils for humans and environment

This soil association and soil-landscape developed in this environment created a special and unique cultural landscape dominated by grasslands and salt effected pastures in the Hungarian Plain. Its unique folklore and culture was recognized by the UNESCO World Heritage committee and was dedicated as World heritage site and a Biosphere Reserve area. It is also part of the Hortobagy National Park. The actual soil profile is located within the Püspökladány (Farkasszíget) Salinization Experimental Yard that was founded on 1 October 1924, 100 years ago to elaborate methods of afforestation on less fertile, low productivity lowland areas with relatively dry climatic conditions and salt affected saline soil. The major research areas focus on the selection of tree and shrub species for afforestation and forest management that are based on natural processes and can be applied to forest steppe climate. The aim is to improve the ecological stability, game bearing capacity, and the economic value of these forests by combining knowledge from different fields of sciences focusing on the biosphere, hydrosphere, lithosphere, pedosphere and atmosphere, for sustainability, carbon sequestration and climate change adaptation. These soils maintain natural and planted forest patches and provides diverse research, experimental, recreational and educational functions. These soils store and supply water and serve as refugium for plant and animal species preferring forested habitats.

Soil threats

These soils are exposed to further drying due to decreasing groundwater level and increasing salinity. Climate change will decrease the duration and spatial extent of water saturation in the topsoil by stagnic water. These soils supposingly turn into steppe formation in the future, while forest thinning - which is already showing on these soils - generates positive feedback regulation. Under forest cover

the deep root system of trees restricts the capillary rise to the subsoil, and the more balanced temperature and moisture regime below the forest prevents the accumulation of sodium and the salinization of topsoil layers. The decline of forest supports increased evaporation of the soil, which is bringing the sodium and water-soluble salts closer to the soil surface, generating further decline of the forest.

Location of this soil

Gleysoils with significant remarks of environmental changes, such as salinization of groundwater, decreasing groundwater level and alternation of sediment influx as it is shown by buried soil, can be found frequently, but to a small extent in the Plains of the Carpathian Basin. They are located in abandoned river channels, and backswamp areas of the alluvial plains, which are no more directly connected with active fluvial landscape processes. The represented soil profile is in Püspökladány Experimental Station and Arboretum University of Sopron Forest Research Institute (SOE-ERTI).

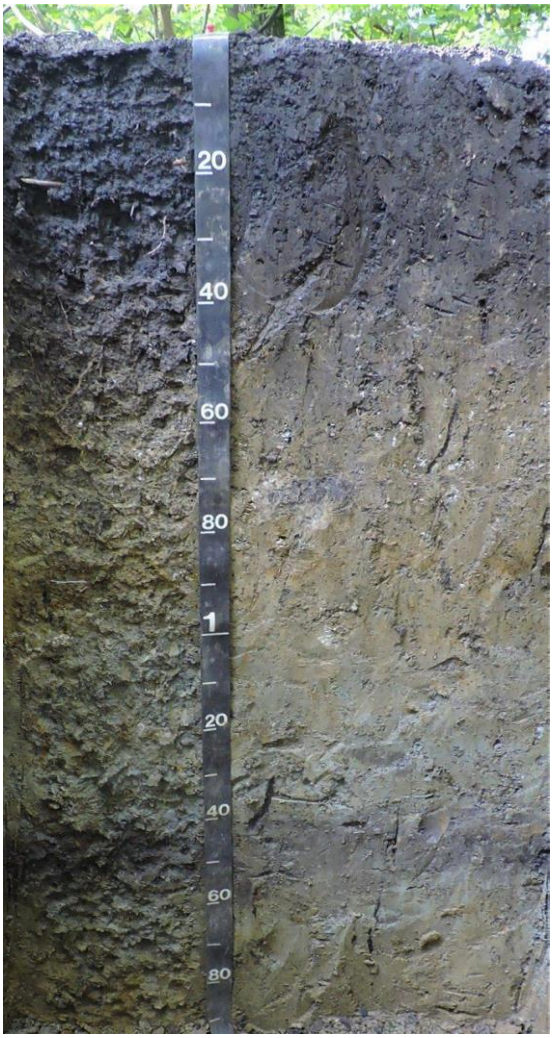
Classification WRB

Oxygleyic Chernic GLEYSOL (Loamic, Uterquic, Protocalcic, Bathyraptic, Bathyreductic, Bathyprotosalic, Thaptovertic)

Hungarian classification

Mélyen eltemetett talajrétegű, közepes humuszos rétegű, mélyben karbonátos, mélyben sós réti talaj (Buried soil layer in the deeper horizon, with medium deep humus rich top horizon, calcareous and salty in the deeper horizon, Meadow (gley) soil).

Profile environment				
Coordinates (WGS 84):	É. sz.:	*47°20'17.49"*	EOV X	*804709*
	K.h.:	*21° 5'40.47"*	EOV Y	*223608*
Elevationa.s.l.		*86.1 m*	Soil climate	*mesic*
			Soil moisture regime	*ustic*
			Land cover:	*forest*
			Land use:	*forest, protected,Natura 2000*
			Parent material:	*fluvial-aeolian sediment above 120 cm depth* *fluvial aleurit, clay below 120 cm depth*
			Ground water	
			Further information:	*Püspökladány 24/F /60/*

Profile description	**Horizon**	**Depth (cm)**	**Description**
	Ah1	*0-20*	*Black (2.5Y 2.5/1-m) strong, fine – medium blocky subangular and polyhedric structure, clay loam, many fine roots*
	Ah2	*20-40*	*Very dark gray (2.5Y 3/1-m) strong fine- medium polyhedric structure, clay loam, moderately compacted, humus coatings*
	AB	*40-60*	*Very dark grayish brown (2.5Y 3/2-m) clay loam, moderately compacted, moderately-strongly carbonated, fine calcretes, slightly gleyic, humus coatings, very fine soft and hard iron-manganese concentrations*
	Bk	*60-80*	*Mottled (gleyic &stagnic)(2.5Y 4/2-m, 2.5Y 5/3-m, 10YR 5/6-m) clay loam, strongly carbonated, oxidized iron concentrations, few clay coatings*
	CBg	*80-95*	*Mottled (gleyic & stagnic))(10YR 5/6-m, 2.5Y 5/3-m) clay loam, moderately carbonated, oximorphic gleyic color pattern (reddish iron concentrations)*
	Cl	*95-120*	*Olive gray (5Y 5/2-m) clay loam, moderately-strongly carbonatic, coarse calcretes*
	2Crlssz	*120-145*	*Dark greenish gray (10Y 4/1-m) clay, slickensides, iron concentrations*
	3Alzb	*145-155*	*Dark gray (2.5Y 4/1-m) clay, carbonate free,*
	3Crlz	*155-175*	*Gray (5Y 5/1-m) clay, carbonate free*
	4Clz2	*175-*	*Mottled (10YR 4/6-m, 2.5Y 5/4-m, 5Y 5/3-m) silty clay, slightly carbonated, many iron concentrations*

Taxonomy	
WRB 2022	Oxygleyic Chernic **GLEYSOL** (Loamic, Uterqic, Protocalcic, Thaptovertic, Bathyraptic, Bathyreductic, Bathyprotosalic)
Soil Taxonomy (2014)	*Aquic Haplustoll*

Soil physics data

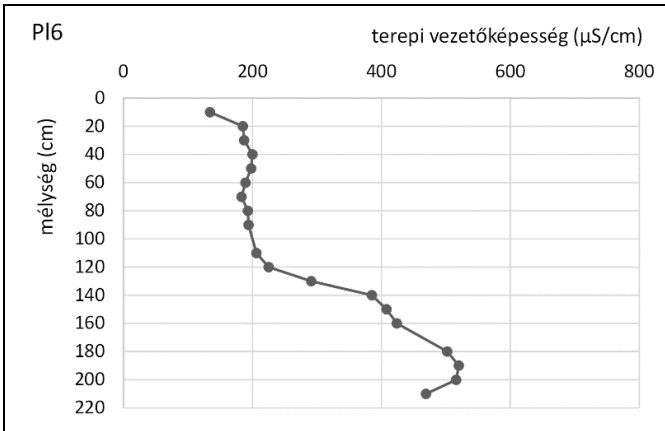
Horizons	Depth (cm)	Sand >0,05 mm	Silt 0,05-0,002 mm	Clay <0,002 mm	Texture class	K_{A*}
Ah1	0-20	22.39	40.31	37.30	clay loam	47
Ah2	20-40	21.07	40.26	38.67	clay loam	43
AB	40-60	21.81	42.17	36.02	clay loam	49
Bk	60-80	23.66	41.59	34.75	clay loam	51
CBg	80-95	25.06	37.32	37.62	clay loam	48
Cl	95-120	25.05	37.85	37.10	clay loam	55
2Crlssz	120-145	10.87	19.05	70.08	clay	56
3Alzb	145-155	18.87	29.71	50.42	clay	54
3Crlz	155-175	11.06	34.27	54.67	clay	56
4Clz2	175-	17.83	39.53	42.64	silty clay	60

*$K_A \approx 0.85 \times WC_{SP}$ (WC_{SP} =water content of saturation paste in g / 100 g soil)

Soil chemistry data

Horizons	Depth	$pH_{(1:2,5)}$	Salts	EC_{SE}**	$CaCO_3$	Soil Organic Matter	C_{org}	Exchangeable cations		
								Ca^{2+}	Na^{+}	ESP
	(cm)	(H_2O)	m/m%	dS/m	m/m%			cmol/kg		%
Ah1	0-20	7.20	0.06	1.33	<0.1	2.7	1.6	23.9	<0.02	<0.01
Ah2	20-40	6.87	0.06	1.46	<0.1	1.8	1.0	20.5	<0.02	<0.01
AB	40-60	7.90	0.06	1.28	3.2	1.1	0.6	21.4	0.03	0.11
Bk	60-80	8.35	0.04	0.82	13.7	0.4	0.2	19.7	0.08	0.35
CBg	80-95	8.33	0.06	1.31	6.1	0.4	0.2	20.1	0.16	0.64
Cl	95-120	8.22	0.09	1.71	2.5	0.3	0.2	18.2	0.25	1.11
2Crlssz	120-145	7.83	0.26	4.85	0.6	0.3	0.2	27.0	0.95	2.67
3Alzb	145-155	7.79	0.25	4.84	0.5	0.5	0.3	23.4	1.44	4.67
3Crlz	155-175	7.86	0.32	5.97	1.1	0.2	0.1	24.3	1.93	5.88
4Clz2	175-	7.96	0.31	5.40	4.0	0.2	0.1	20.7	3.62	12.1

**calculated according (*Filep – Wafi, 1993*) from total salt content



Electrical conductivity measured in field (left), slickensides and gleyic color pattern from 2Crlrssz horizon (right).