Black soils in the south side of the Alps: large C stocks, strong weathering degree, genetic issues

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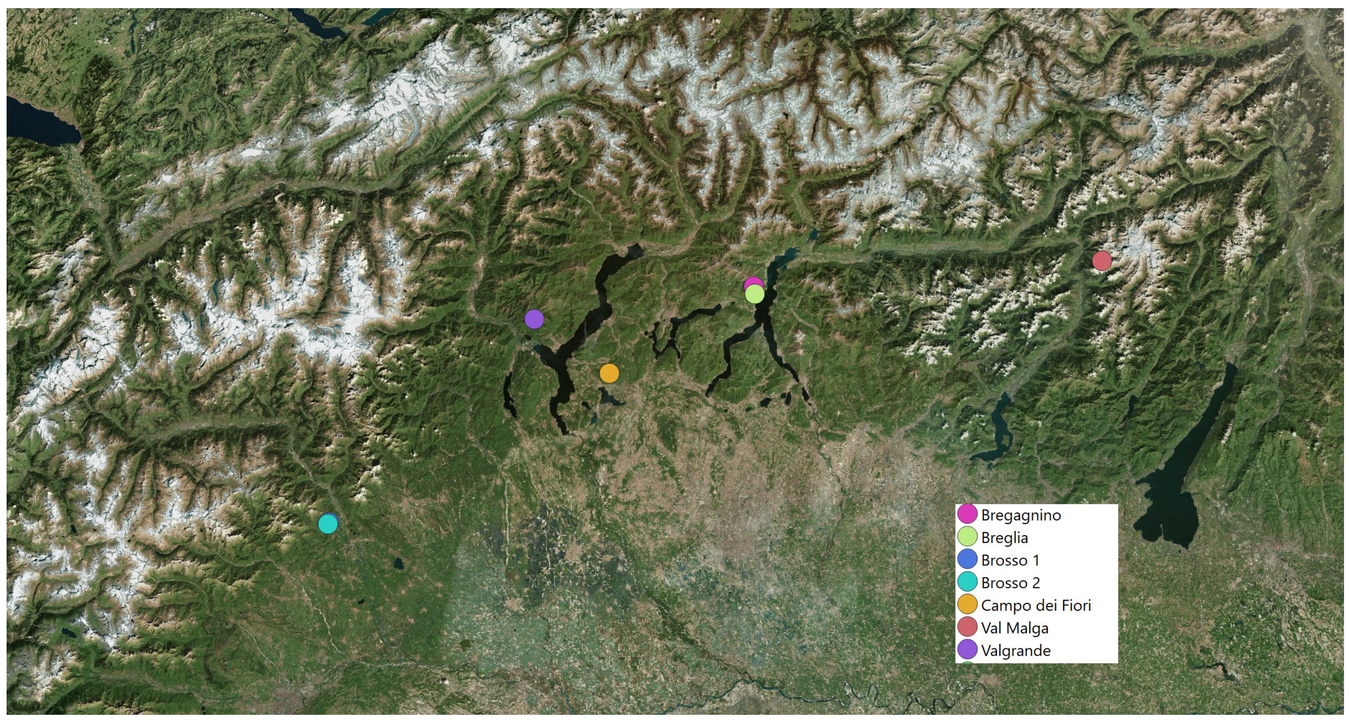
Introduction

Umbrisols are the most common soil type in the Southern side of the Alps, between Piedmont and the Lake District in Lombardy (NW-Italy) and Switzerland, particularly on sialic substrates and glacial till but also on carbonates, if the soil is sufficiently deep. They are best developed on southward aspects, and below chestnut, beech forests or anthropogenic grasslands, at montane elevations. Many of these soils, particularly if developed on stable surfaces above the LGM trimline (i.e., the upper limit reached by glaciers), have 20-40 cm thick A horizons, with fine granular structure and abundant roots, overlying black horizons (80-120 cm of depth) lacking biogenic aggregation, containing very few roots and characterized by very low bulk densities, even <0.5 g/cm^3.

Their genesis has been characterized in some works but with different conclusions: the black horizons were found to be rich in charcoal (Egli et al. 2008), or were interpreted as spodic horizons dominated by Al and organic matter (OM), and lacking Fe (Blaser et al., 1997). Some of their properties, however, were not considered and their pedogenic interpretation is sometime dubious.



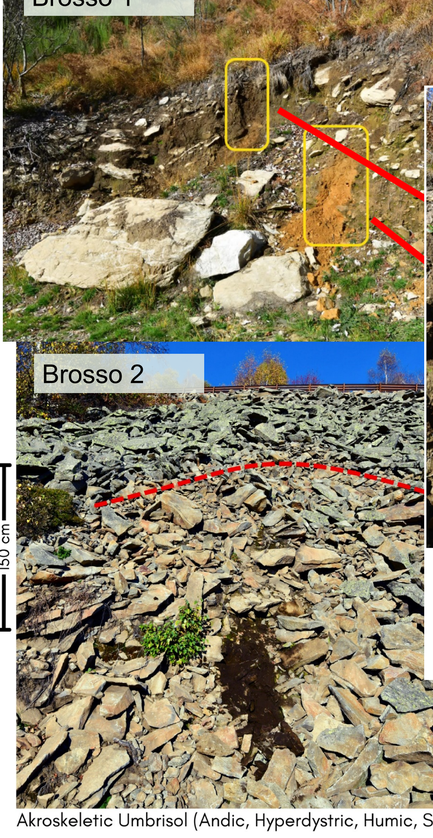
Study sites

Site	Parent material	Land cover	Elevation (m)	MAP (mm)
Brosso 1 (TO)	Gneiss	Open birch and chestnut woodland	1220	1500
Brosso 2 (TO)	Gneiss	Fossil blockstream	1150	1500
Valgrande (VB)	Gneiss and mafic granulite	Chestnut forest	900	2000
Campo dei Fiori (VA)	Cherty limestone and dolostone with loess inputs	Coniferous plantation	1150	1800
Breglia (CO)	Gneiss	Chestnut forest	950	1800
Bregagnino (CO)	Gneiss	Abandoned pasture	1500	1800
Val Malga (BS)	Tonalite	Spruce forest	1500	1300

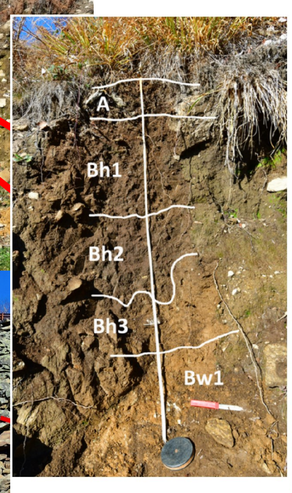
Methods

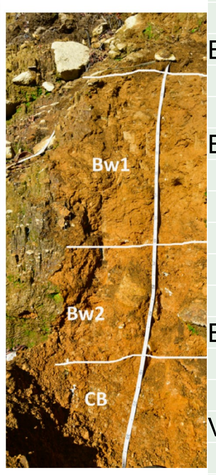
7 soils with extremely well developed Umbric (Ah-Bh) horizons were sampled in different locations in N-Italy, between Torino metropolitan area (west) and Adamello Regional Park in the East (Brescia), to understand their age, stability, chemical recalcitrance to decomposition, and the mineral stabilizing factors.

- Standard chemical analysis
- Bulk density measurement
- Carbon stock calculation
- 14C dating (no results yet)
- Thin section for micro-structures characterization (under preparation)
- Mineralogical analysis (not ready yet)
- Oxalate extractable Fe, Al , Si
- OM density fractionation and charcoal separation; chemical recalcitrance



Akroskeletic Umbrisol (Andic, Hyperdystric, Humic, Sombric)





Results

- In all sites, under biologically active Umbric horizons, thick Bhs were observed;
- Their structure is coarse blocky subangular, with few roots and weak signs of biological activity;
- The weathering degree is very high, with most stones destroyed and soft;
- Alox and Feox are very high (up to ca. 2.2%) in most horizons (andic properties)
- Siox is high only in brown Bw, not in black Bh (silandic properties in Bw and aluandic in Bh)

- Carbon stocks are very high, up to > 47 kg/m^2.
- Quite high charcoal contents are also detected

Profile	sample	Thick	SK	BD	pH	pHNaF	Corg	Sio	Feo	Alo	IS	S	Silt	Clay
		cm	%	g/cm^3			%	%	%	%	%	%	%	%
Bregagnino	A	28	25		4.34	7	8.05	0.06	0.77	0.59	0.98	50.0	42.9	7.0
	Bh	54	10		4.16	7	6.88	0.08	1.37	1.07	1.75	20.8	76.3	2.9
	Bwh	14	20		4.24	7		0.21	0.83	0.99	1.40	53.5	32.4	14.1
	Bw	40	30		4.22	10	1.88	0.23	1.05	0.81	1.34	47.0	36.9	16.1
	BC	40	40		4.64	10.5	0.82	0.28	0.58	0.70	0.99	63.6	28.0	8.4
Breglia	A	24	25		4.2	7		0.06	0.38	0.44	0.63	52.3	41.3	5.4
	Bh	43	2		3.93	7		0.05	1.28	1.22	1.86	32.0	61.5	6.6
	Bw	60	20		4.35	10		0.30	1.40	1.15	1.85	47.8	39.0	13.2
Brosso 1	A	22	50	0.58	4.4	7	6.21	0.00	0.81	0.40	0.80	73.1	22.3	4.7
	Bh1	30	10	0.65	4.6	11.5	4.8	0.00	1.08	0.54	1.08	72	23.3	4.8
	Bh2	80	5	0.82	4.5	11	4.25	0.00	1.21	0.87	1.47	74.9	21.1	4.0
	Bh3	35	25	0.89	4.9	12	2.41	0.05	0.75	0.61	0.99	61.8	34.1	4.1
	Bw	80	40	1.24	4.7	11	1.04	0.13	0.55	0.54	0.81	68.7	28.5	2.8
	BC	80	70	1.31	5	12	0.41	0.08	0.39	0.31	0.51	72.7	25.5	1.8
Brosso 2	A?	5	80		4.7	12	1.58	0.29	0.36	1.01	1.20	76.6	22.3	1.1
	Bh1	15	50		4.6	12	3.69	0.40	0.60	1.46	1.76	75.8	23.2	1.0
	Bh2	15	50		4.5	12	4.53	0.29	0.63	1.30	1.61	72.5	26.4	1.1
Valgrande	A/OH	5	0	0.42	4.1	8.5	11.28	0.05	0.80	0.68	1.07	54.2	41.0	4.8
	A2	15	0	0.51	4.3	10	7.34	0.06	0.70	0.72	1.07	51.3	43.7	5.0
	Bh	55	5	0.56	4.7	12	7.21	0.07	0.54	0.75	1.02	55.7	38.1	6.3
	Bw	40	20	1.02	5	11.5	2.32	0.33	0.50	0.85	1.10	60.1	30.3	9.6
Campo dei Fiori	A	18	10	0.46	3.41	7		0.00	0.48	0.15	0.39	44.2	40.3	15.6
	Bh1	22	10	0.67	3.59	7		0.00	0.56	0.25	0.53	43.2	41.9	14.9
	Bh2	25	20	0.75	3.71	7		0.00	0.56	0.33	0.61	44.7	39.9	15.4
	Bh3	35	40	0.91	3.78	7		0.00	0.48	0.34	0.58	44.1	39.7	16.2
Val Malga	A	16	60	0.52	3.94	7		0.00	0.42	0.26	0.47	60.3	34.0	5.7
	Bh	55	5	0.56	4.11	8		0.14	0.97	1.28	1.77	55.6	36.5	7.9
	Bhs	40	30	0.92	4.28	10.5		0.68	0.56	2.09	2.37	82.3	14.0	3.7

Conclusion

- Podzolization is not a primary pedogenic process;
- Strong mineral weathering and release of Al and Fe fix large quantities of illuvial organic matter in thick Bh horizons;
- The wet and temperate climate leads to the strong weathering and an Andosolization-like process;
- This organic matter is highly stabilized (demonstrated by the presence of black horizons under LGM blockstreams, Brosso 2)
- These soils are highly resistant to erosion thanks to their high porosity;
- Their extreme C storing capacity makes them worth of protection
- Their WRB classification is not univocal