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Pore Size Distribution and Adsorption Properties of Soils with Different Texture

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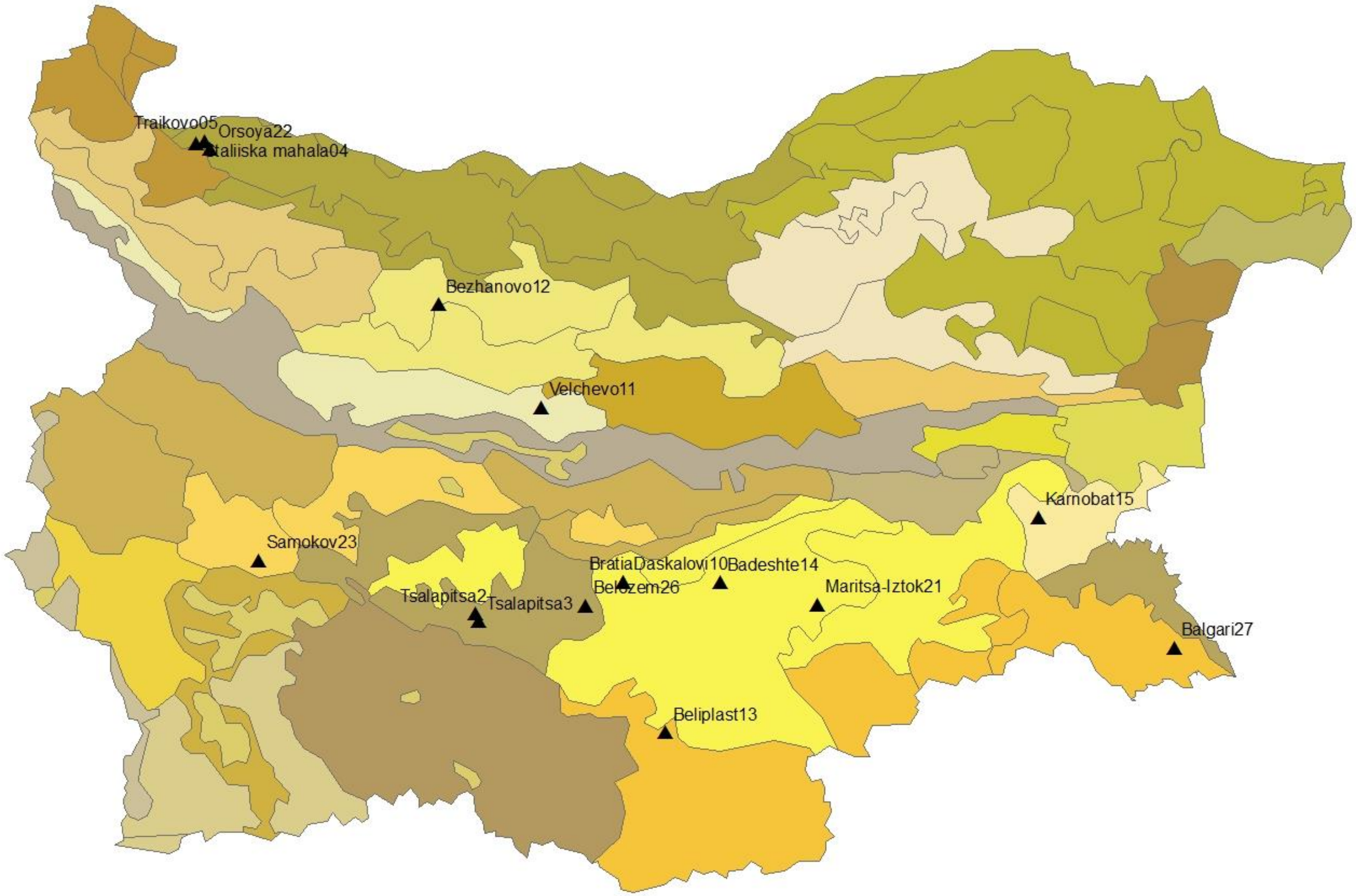
- The aim of this study is to:
  - quantify the pore size distribution and adsorption properties of genetically and texturally different Bulgarian soils;
  - encompass the information provided by different methods for assessment the structure of pore space.

Soil samples have been collected from different soil-geographic regions of Bulgaria representing variety of soil texture, organic matter and $CaCO_3$ content.

They were used for creating methodology for transforming soil texture from Katchinski classification to ISO11277 (2009) and FAO 2006 texture classification.

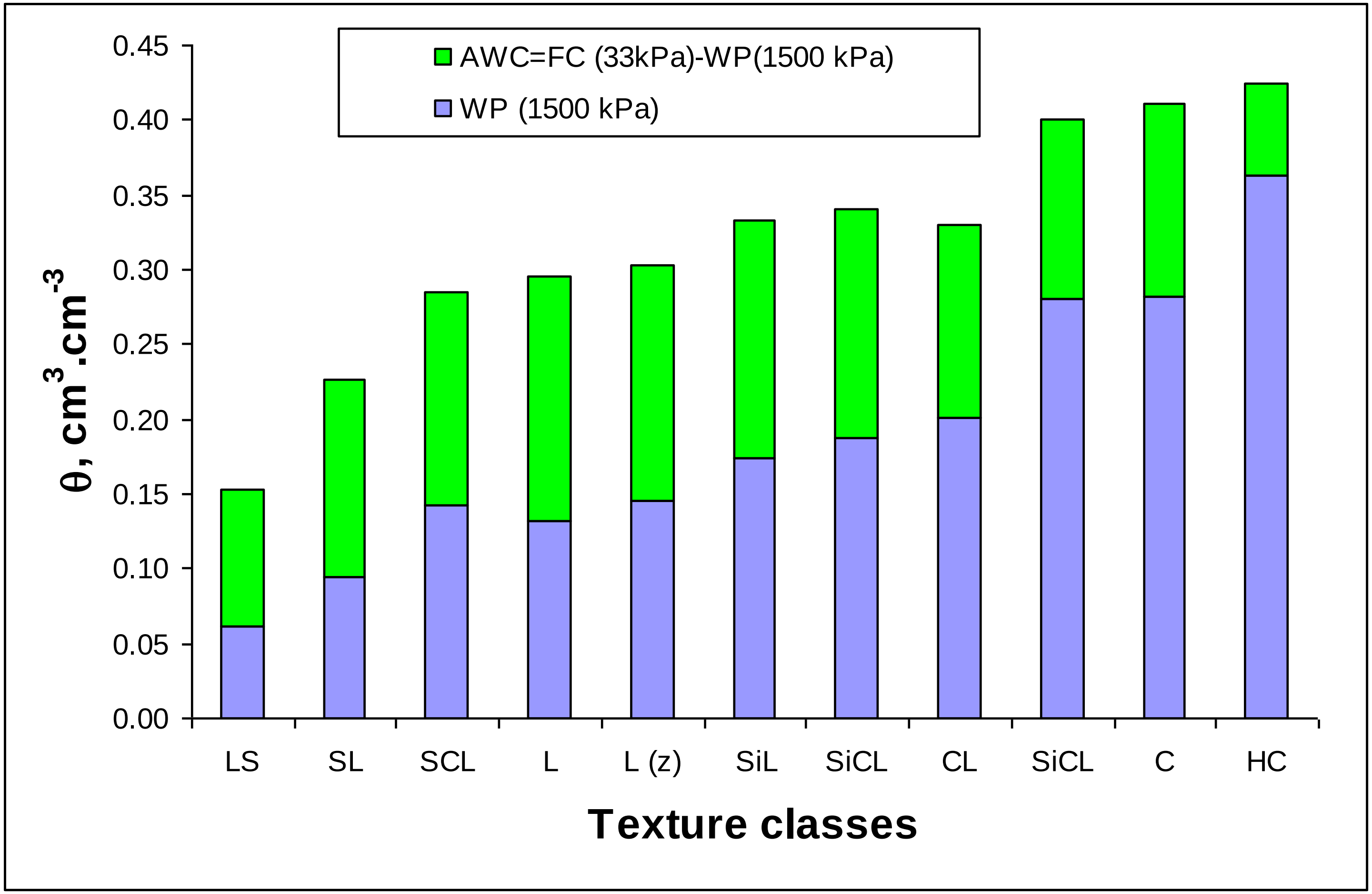


Selected soil profiles for this study and map of soil geographical regions of Bulgaria

Description of the archive soil samples used in the current study

Soil units (WRB, 2007), profile No	Landuse	Topsoil		Subsoil (s)	
		Texture	SOC,%	Texture	SOC,%
Epigleyic Phaeozem Clayic, Orsoya22	grassland	**SiC**	**2.0**	**C;SiCL/CL**	**2.0; 0.4**
Haplic Cambisol Eutric Siltic, Traikovo05	pasture	**SiL/L**	**1.0**	**L; SiIL/L**	**0.4; 0.4**
Epicalcic Chernozem Siltic, St.Mahala04	cultivated	**SiCL**	**1.4**	**SiL**	**0.8**
Endoleptic Cambisol Eutric, Karnobat15	cultivated	**CL**	**2.0**	**CL**	**1.8**
Salic Solonetz Clayic, Belozem26	cultivated	**C**	**1.5**	**C**	**0.9**
Haplic Vertisol Pellic Eutric Clayic, Bade14	cultivated	**C**	**1.5**	**C**	**1.1**
Haplic Technosol Clayic, MIztok21	cultivated	**HC**	**0.7**	**HC**	**0.3**
Epileptic Cambisol Eutric Skeletic, BeliPl13	grassland	**L**	**1.2**	**L**	**1.0**
Rendzik Leptosol Skeletic, BrDask10a	grassland	**C**	**2.9**	**CL**	**1.7**
Haplic Leptosol Calcaric Skeletic, BrDask10	grassland	**L**	**1.8**		
Epigleyic Cutanic Acrisol Albic, Balgari27	deciduous	**L**	**1.2**	**L; CL**	**0.5; 0.3**
Haplic Phaeozem (Siltic), Bezhanovo12	cultivated	**SiC**	**1.8**	**SiC; SiC/C**	**1.2; 0.7**
Haplic Cambisol, Samokov23	grassland	**L**	**1.9**	**SL;SL**	**0.9; 0.3**
Epigleyic Luvisol (Siltic), Velchevo11	grassland	**SiL**	**1.9**	**SiL;HC**	**0.8; 0.3**
Haplic Fluvisol, Tsalapitsa2	acacia	**SCL**	**1.5**	**SCL**	**0.6**
Haplic Fluvisol,Tsalapitsa3	grassland	**SiL**	**2.5**	**L; LS**	**0.9; 0.2**

The information for textural fractions and SOC content can be used for estimation the volume of water hold at field capacity and wilting point by pedotransfer functions (e.g. Toth et al.2014)

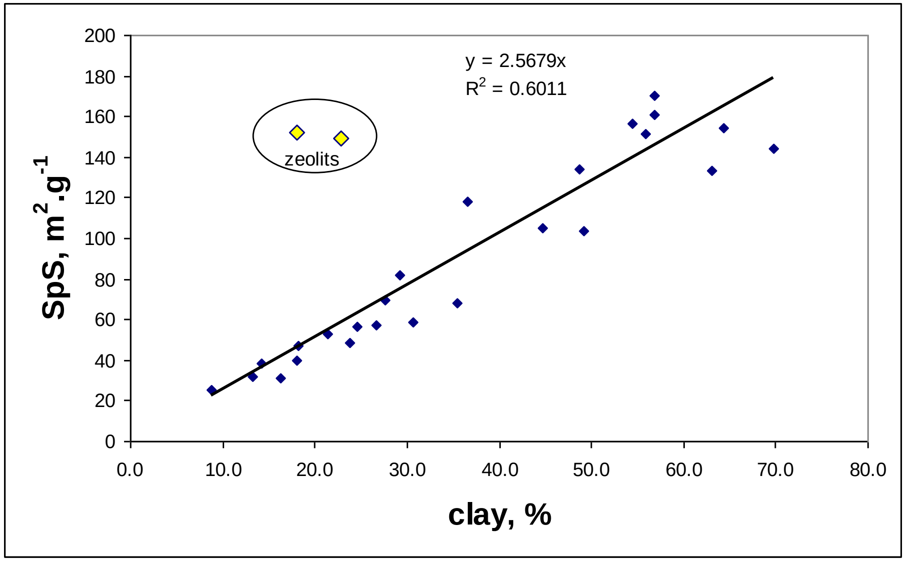


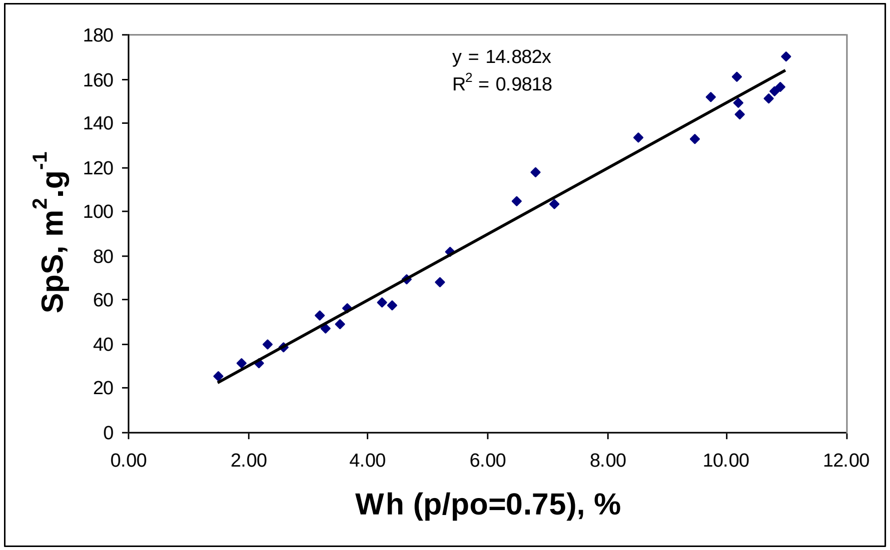
Tóth, B., Weynants, M., Nemes, A., Makó, A., Bilas, G., Tóth, G. 2014. New generation of hydraulic pedotransfer functions for Europe. European Journal of Soil Science, doi: 10.1111/ejss.12192.

Methods for estimation of pore size distribution (PSD) and adsorption properties of soils

Methods	**Equipment**	**Effective pore radii,** μm
WRC - soil water retention curve (ISSAPP)	Ceramic pressure plate extractor; Pressure membrane (cellulose) extractor (Soil Moisture Equipment) Vapour pressure method with controlled relative humidity of air (p/p_o=0.75) over saturated solution NaCl	<0.3, 0.3-4.4 <0.1 <0.004
MIP -mercury intrusion porosimetry (IA)	Autopore IV 9500 (Micrometrics) INC, USA	0.0015 to 47
Nitrogen adsorption isotherms (IA)	Sorptomatic (model SO 1990, Fisons Instruments) (p/p_o=0.004-0.997)	0.001 to 0.1
Water vapor desorption isotherms (IA)	vacuum chamber method using sulphuric acid of stepwise increasing concentrations (p/p_o=0.35-0.99)	0.001-0.04

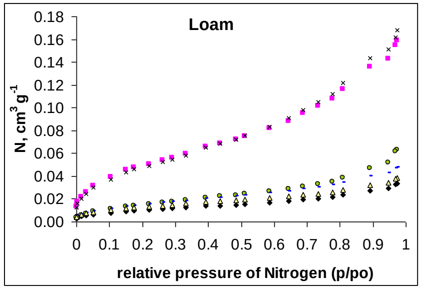
SpS determined by N adsorption data and B.E.T. equation

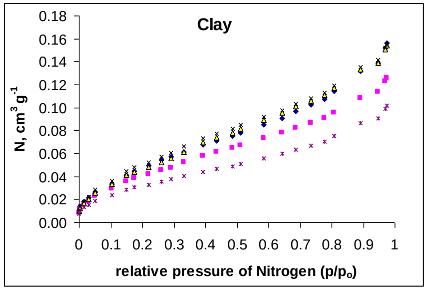




Texture class	SL	L	SiL	SiCL	CL	SiC	C	HC
SpS, $m^2.g^{-1}$	29±4	41±7 **151±2**	56±2	70	82±26	128±33	145±27	144±11

***parent material zeolite**





Volume ($cm^3.g^{-1}$) of micropores

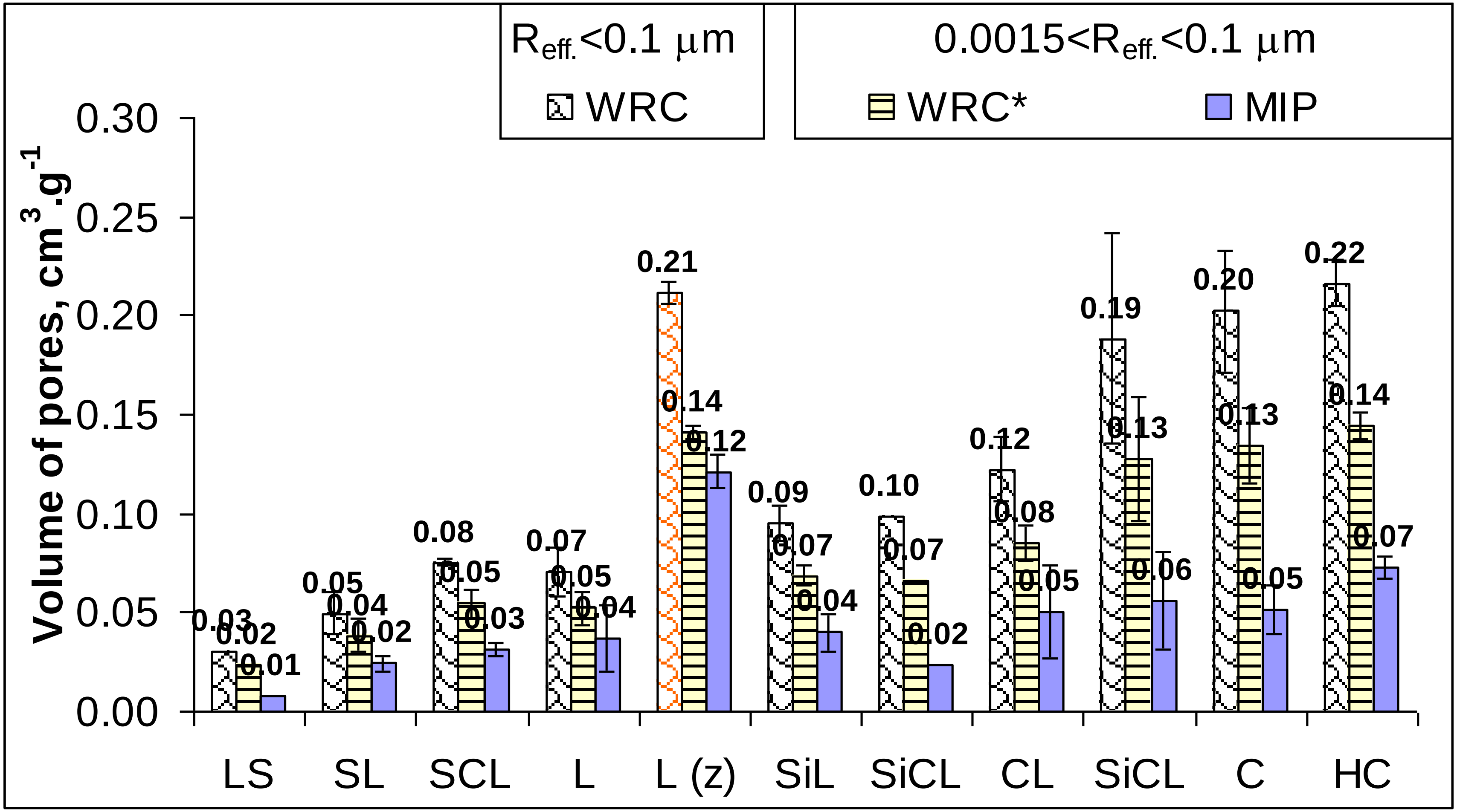
Texture class	SL	L	SiL	SiCL	CL	SiC	C	HC
Water vapor desorption (IA, Lublin) **(0.001-0.04 μm)**								
mean	0.017	0.028 **0.102***	0.039	0.038	0.052	0.073	0.080	0.103
stdev	0.004	0.009	0.004		0.012	0.014	0.018	0.009
Water vapor desorption (ISSAPP "N.Pushkarov", Sofia) **(0.001-0.004 μm)**								
mean	0.017	0.028 **0.098***	0.037	0.046	0.053	0.085	0.095	0.101
stdev	0.003	0.006	0.006		0.010	0.030	0.017	0.007

***parent material zeolite**

The volume of micropores, as determined by water vapor desorption methods increase 5 times from SL to Heavy Clay texture classes.

The water content adsorbed at RH=75% over saturated solution of NaCl especially by fine textured soils was higher than that the obtained over sulphuric acid.

Volume ($cm^3.g^{-1}$) of pores containing unavailable for plant water

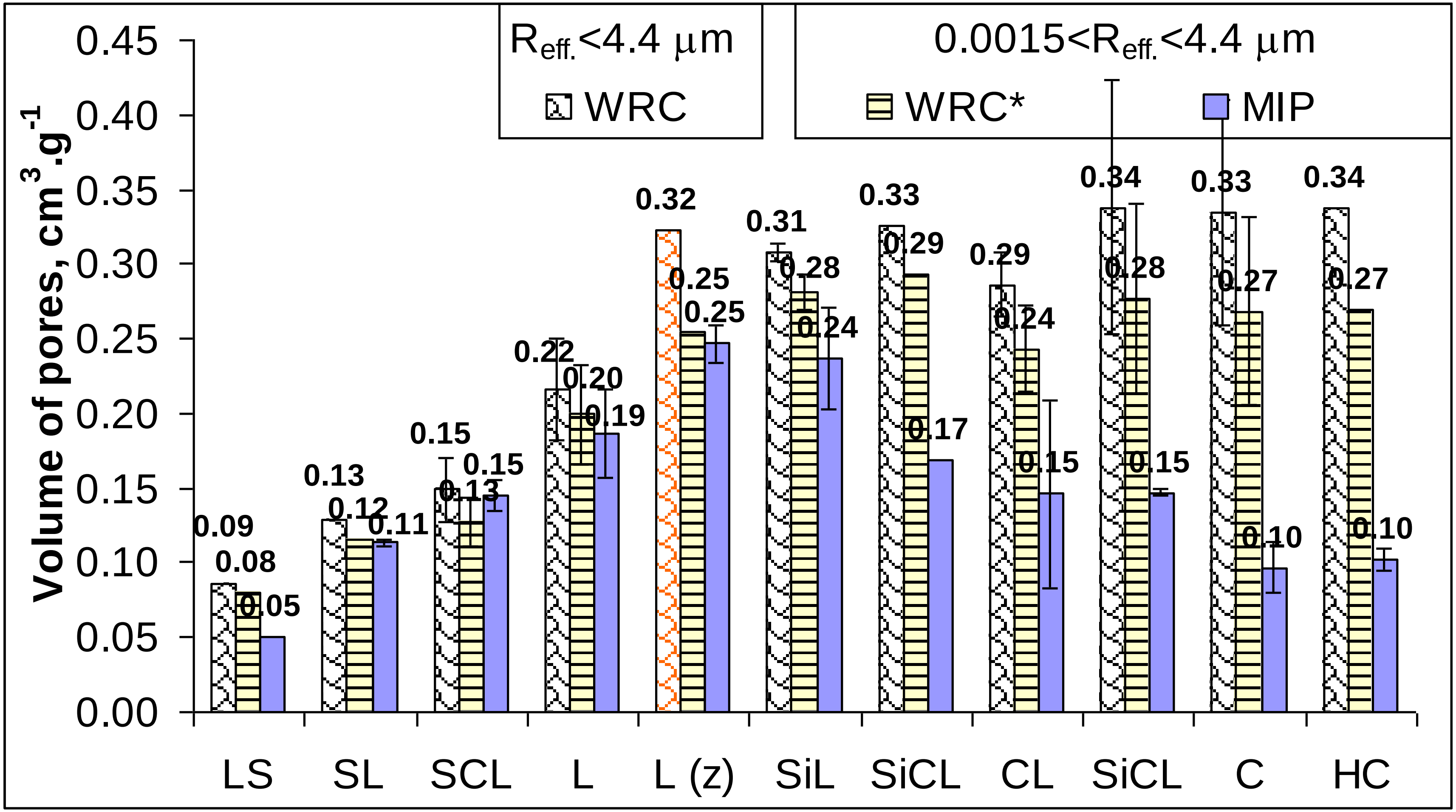


z - parent material zeolite

The volume of pores with r_{eff}<0.1mm (WP) increase 7 times from SL to Heavy Clay texture classes.

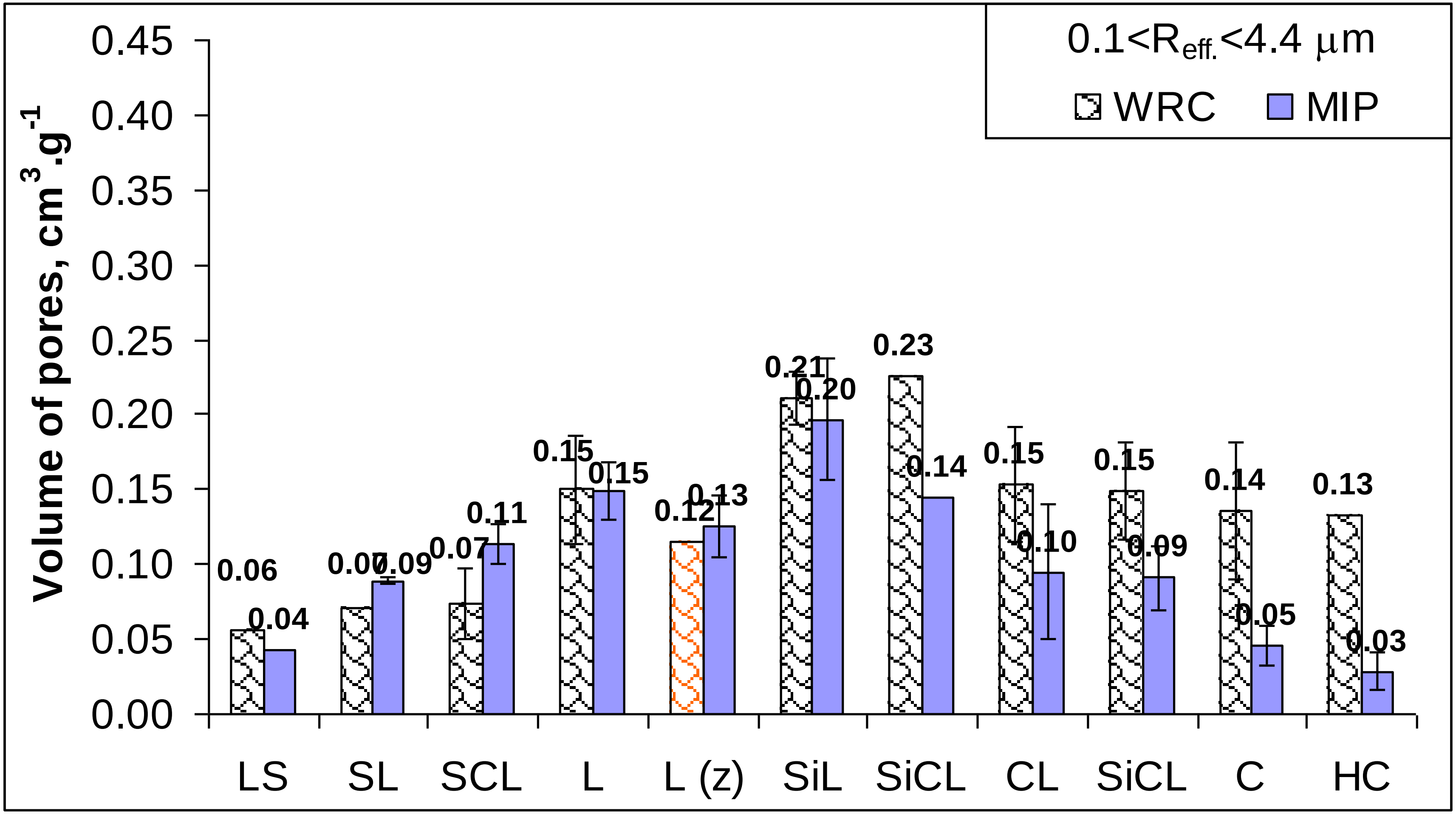
Values obtained by WRC method are higher than the data obtained by MIP

Volume ($cm^3.g^{-1}$) of pores with r_{eff}< 4.4 μm (FC)



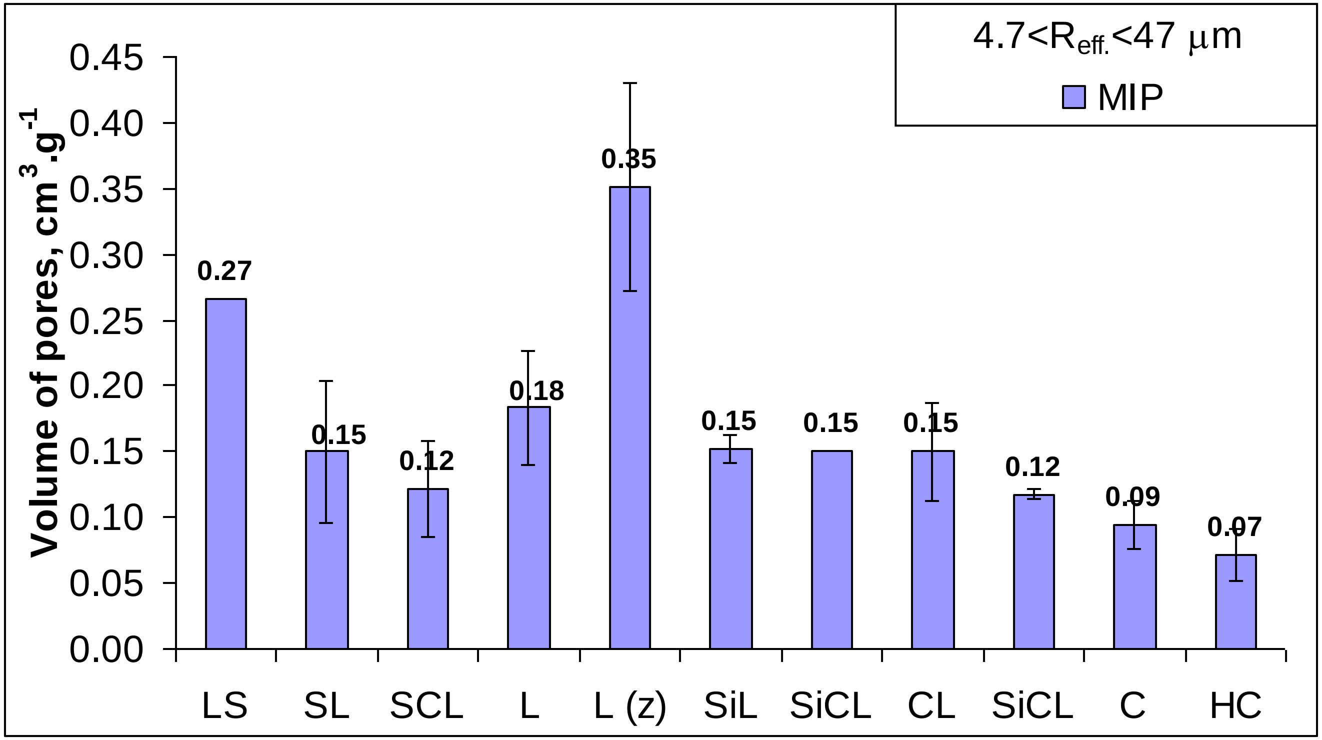
Data for volume of pores <4.4 μm measured by MIP are lower than measured by membrane pressure extractors for soil texture classes with clay >27%.

Volume ($cm^3.g^{-1}$) of pores containing plant available water

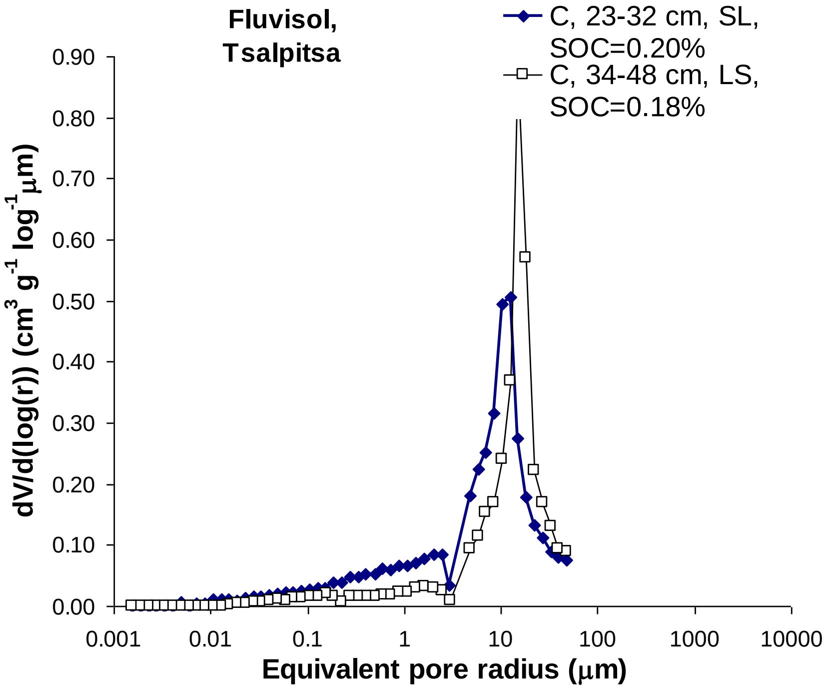


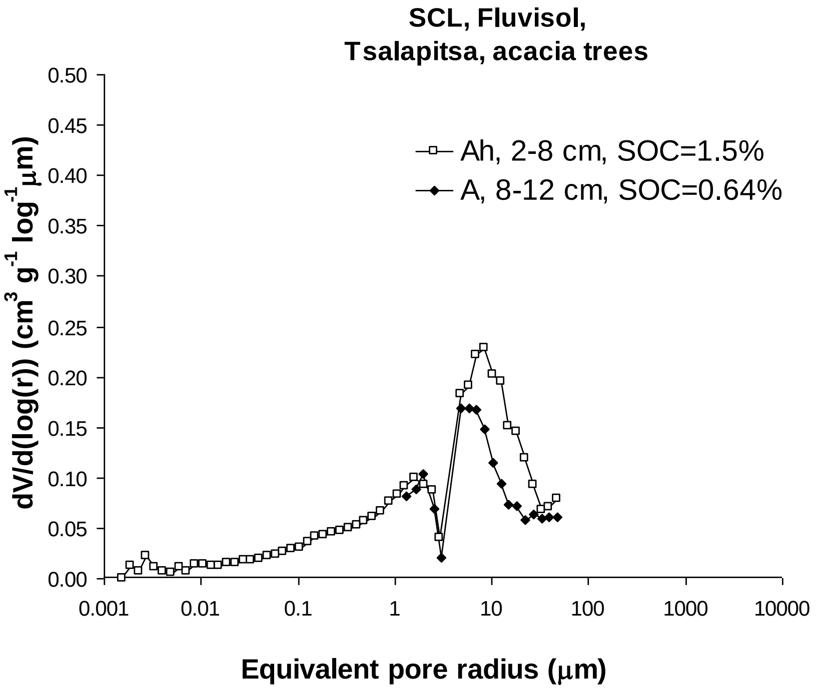
Data for volume of pores containing PAW measured by MIP are lower than measured by membrane pressure extractors for soil texture classes with clay >27%.

Volume ($cm^3.g^{-1}$) of drainage aeration pores with r_{eff}=4.7-47 μm



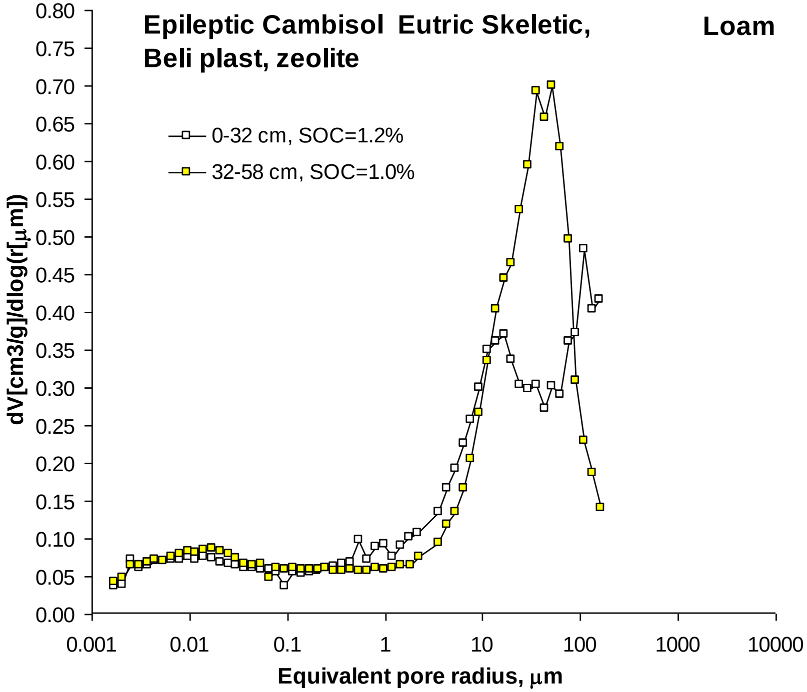
Examples of differential curves of PSD obtained by MIP

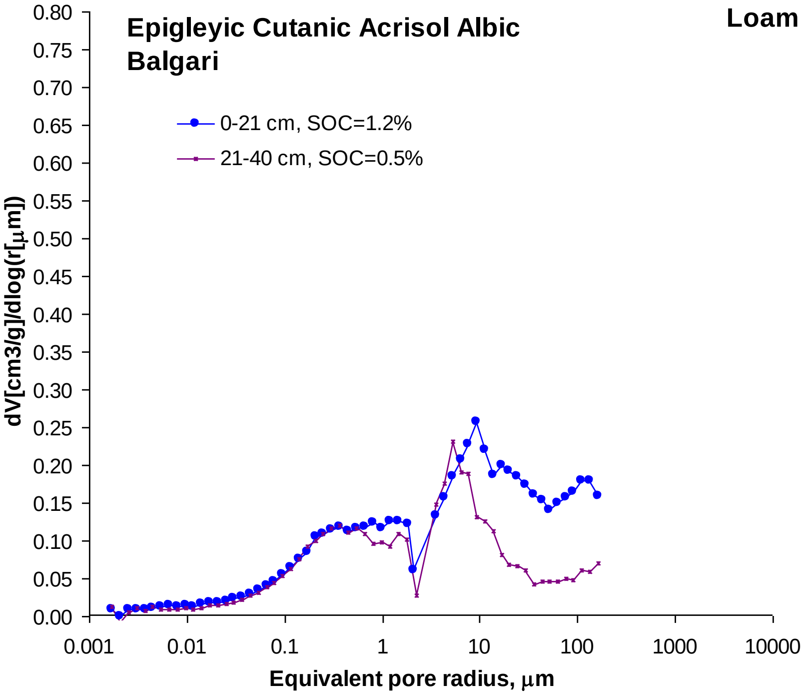




TC	Hor.	SOC, %	Total intrusion volume, $cm^3.g^{-1}$	Total pore area, $m^2.g^{-1}$	Average Pore Radius (2V/A), μm	Porosity %
SCL	Ah	1.6	0.339	6.99	0.097	42.8
SCL	A	0.64	0.267	7.65	0.070	38.6
SL	C1	0.20	0.398	2.16	0.368	49.7
LS	C2	0.18	0.356	0.56	1.281	47.7

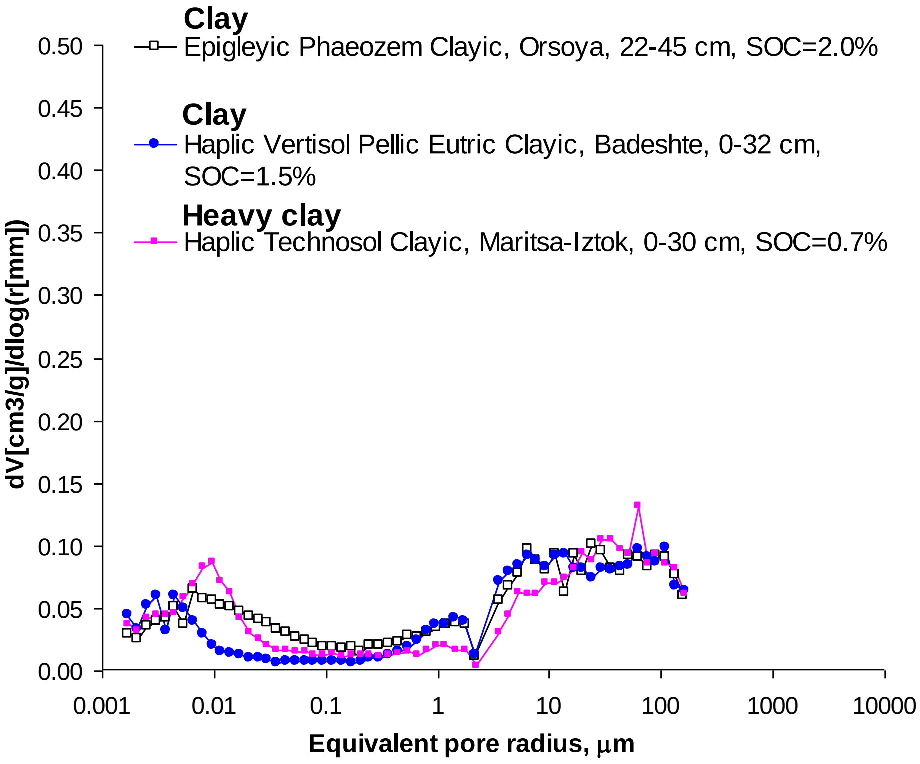
Examples of differential curves of PSD obtained by MIP

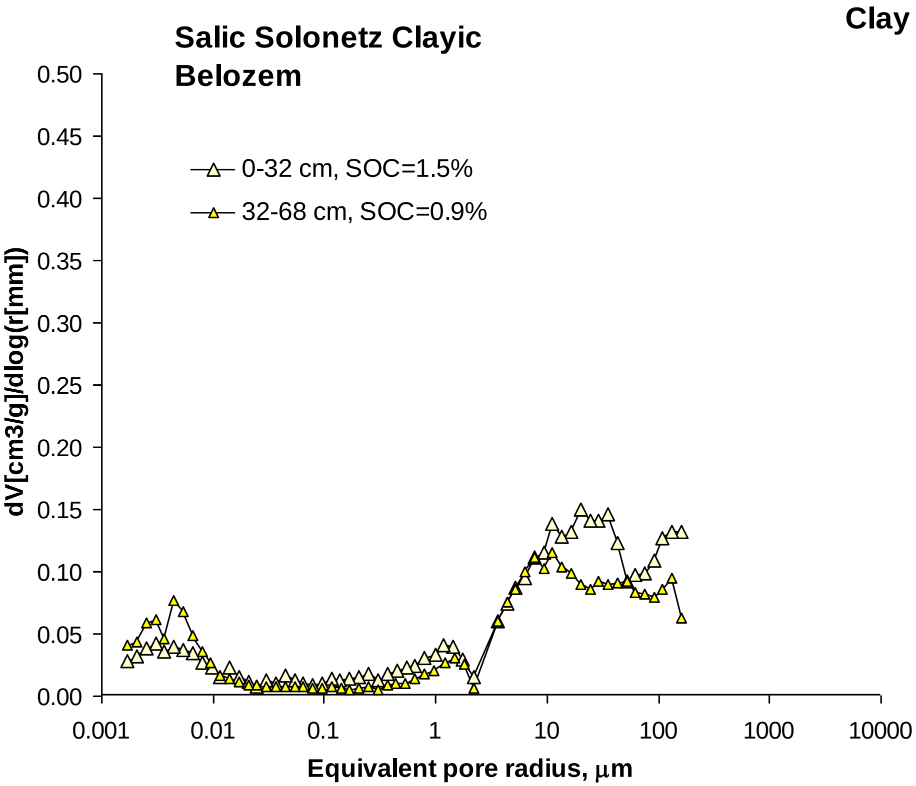




Place	TC	Hor.	Total intrusion volume, $cm^3.g^{-1}$	Total pore area, $m^2.g^{-1}$	Average Pore Radius (2V/A), μm	Porosity %
Beli plast	L	AC	0.765	32.6	0.047	61.7
	L	CR	0.863	35.0	0.049	64.8
Bulg.	L	AE	0.497	6.6	0.150	55.3
	L	BE	0.337	5.6	0.120	46.5

Examples of differential curves of PSD obtained by MIP





The data show two well distinguished ranges of maximum volume of pores (3.5 to 100 μm) and (0.003 to 0.03 mm). The second range is different for genetically diiferent soils.

- **Conclusion**:
  - New quantitative information on pore size distribution and adsorption characteristics of genetically and texturally different Bulgarian soils were obtained;
  - The information can be used for assessment the rate of impact of environmental and anthropogenic factors on physical status of soil porous system.

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Thank you for your attention!