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METHODS FOR EXPANSIVE SOILS IDENTIFICATION

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Abstract: In accordance with SRTS-2012, Vertisols class comprises soil with shrinkage - swelling properties (z), which are manifested from the first 25 cm pending above to 100 cm, and contain ≥ 45% clay. There are two soil types in this class: Vertosol and Pelosol, both of them with z horizon – shrinking and swelling and a vertic horizon, Bzy, namely Vertosol but also Pelosol. For a better identification of the two soil types from the Vertisols Class, respectively Vertosol and Pelosol, the present thesis proposes some rheological indexes. we have selected only these indexes which don't need special equipment: Free swelling (UL), (vertic horizon >140%, pelic horizon 100 - 140%); Plastic index, (Ip), (Ip=25-45 pellic horizon, Ip≥45 vertic horizon); lower plastic limit (wp); indexes: volume contraction, Cv, (Cv = 75 - 100 – pellic horizon, Cv > 100 – vertic horizon); activity index, IA, (IA 1,00 – 1,25 – pellic horizon, IA > 1,25 – vertic horizon).

Keywords: smectites, slickenside, Vertisols, index

1. INTRODUCTION

The subsidence process continued in Quaternary age have been provoked the Pannonic Lake disappearance, instead of it remains a large area with swamps.

The sedimentation of the weathering product transported of the rivers from the mountain zone are slow, calm and forms clayey layers of 1-2 m thickness. As the soils dry, crystallization of smectitic clay minerals occurs within the soil. The wetting and drying cycles cause these clays to expand and contract. (figure 1)

The clay has a high content of humin, which confers a black color to the A horizon. In the dry season the contraction causes large cracks (> 1 cm width) which allows surface material to fall down the cracks, producing an undulating “gilgai” microrelief.

In accordance with SRTS-2012, Vertisols class comprises soil with shrinkage - swelling properties (z), which are manifested from the first 25 cm pending above to 100 cm, and contain ≥ 45% clay. There are two soil types in this class: Vertosol and Pelosol, both of them with z horizon – shrinking and swelling and a vertic horizon, Bzy, namely Vertosol but also Pelosol.

The difference between Vertosol and Pelosol is gave by the first horizon and the intensity of the vertic processes.

So, the Vertosol has a humiferous horizon with < 3.5 values and ≤ 2 croma (brown – black), deeply, whereas the Pelosol has a humiferous horizon with > 3.5 values and > 2 croma.

The problem is caused by the Vertic Pelosols, which has and Bzy and by the Pelosols which are formed on the fluvic materials rich in humus, with a croma ≤ 2.

Romanian System (2012) proposes a quantitative define for the shrinkage - swelling horizon (page 32) with the rheological indexes, like free swelling (Rogobete) and coefficient of volume expandable COVE (Mocanu și Florea).

WRB (2014) proposes two types of vertic horizons: protovertic and vertic:

- protovertic horizon with ≥ 30% clay, and one or more of wedge shaped soil aggregates, or slickensides, or shrink-swell cracks, or a COLE of ≥ 0,06, and a thickness of ≥ 15 cm
- vertic horizon, with ≥ 30% clay, and one or both of wedge shaped and aggregates with longitudinal axis tilted between ≥100 and ≤ 600 from the horizontal, or slickensides, and shrink-swell cracks, and a thickness of ≥25 cm.

WRB specifies that the wetting and drying cycles cause the smectitic clays to expand and contract. In the subsoil, expansion and contraction causes slickensides on the parallelepiped structure faces.

2. MATERIAL AND METHOD

Soil mechanics is a branch of science studying in civil engineering and agricultural engineering, the mechanical properties and processes of soils. Soil mechanics can be divided in two branches: mechanical properties – like grain size descriptions, density, bulk density, pore space, void ratio, packing, permeability and rheological properties – like consistency, plasticity, deformation, resistance to shearing, stress-stain, compression, compaction, consolidation, swelling and shrinking, elastic modulus, pressure.

The scientific considerations relied on a lot of studies effectuated during 40th years in Banat region, published in many science publications.

3. RESULTS AND DISSCURSION

Vertisols occupied large areas in Romania (figure 2), such, as:

- in the hilly regions of Banat, Oltenia, Muntenia (piedmonts);
- in the north part of Transylvania (on the tableland);
- in the subsidence plain, like Aranca Plain, from the west part of Banat;
- near the water course, in the water meadow from tableland - Plateau Bârladului and Plateau Sucevei (in the perimeter of town Iasi, Vaslui, Barlad, Roman).

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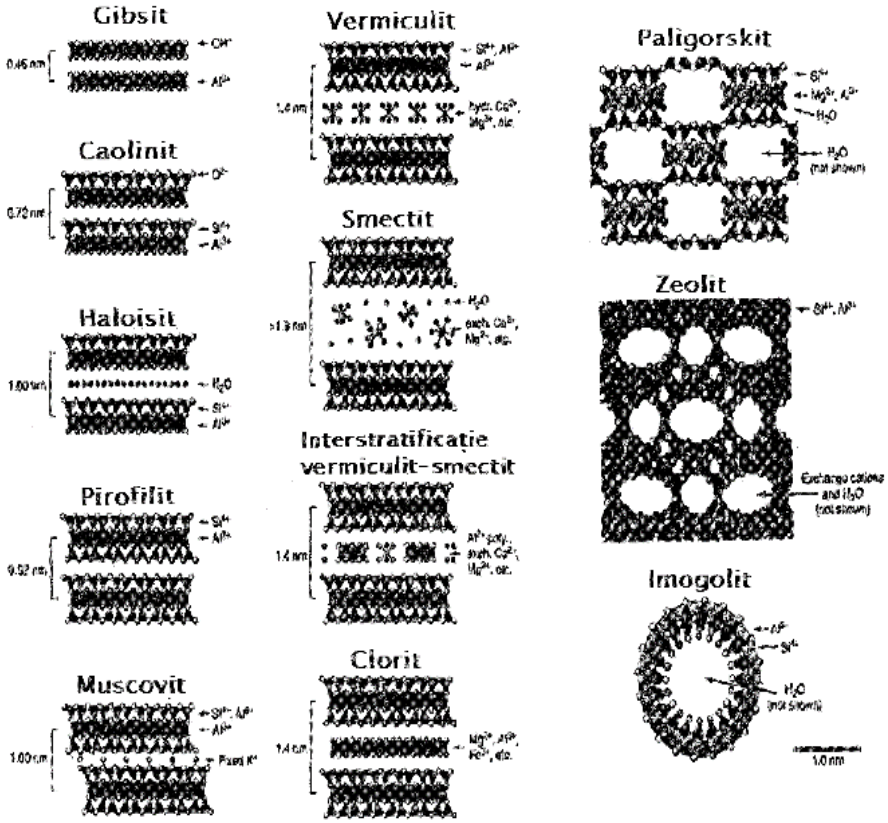


Figure 1 Stratified and three – dimensional silicates

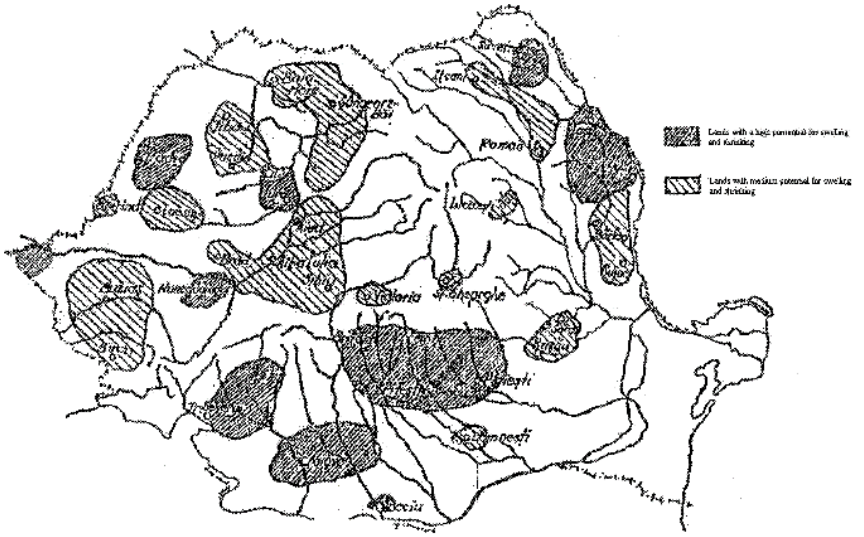


Figure 2 Swelling and shrinking soils in Romania

Important contributions for geotechnical studies with soil rich in smectites, made in Romania: Andrei S. (1967), Boti N. (1992, 1996, 2002), Siminica I. (1996) and Raileanu P. (1986, 1992).

The determination of the elastic deformation, in the case of soils with swelling and shrinking phenomena, can be realized with the method of double edometer, either with the theorem of moisture equilibrium.

Table 1 Rheological properties, Sacalaz drilling 1

Depth, m	-0.50	- 1.10	-1.90	-2.80
Coarse sand, %	0.50	0.45	0.40	0.65
Fine sand, %	25.30	52.35	26.80	28.20
Silt, %	21.90	20.70	23.43	28.70
Clay, %	52.30	53.50	49.40	42.45
Density, g/cm^3	1.46	1.60	1.62	1.52
Total porosity, %	44	40	41	43.5
Pores index, %	0.78	0.66	0.71	0.77
Penetration resistance, Rp, no knock	21	19	17	9
Plasticity index, Ip, %	59.10	66.10	30.00	28.10
Consistence index, Ic, %	0.91	1.10	0.92	0.91

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Volume contraction, Cv, %	51.20	57.96	49.55	44.68
Natural humidity, w, %	24.4	20.65	20.07	19.65
Contraction limit, ws, %	8.6	8.9	9.9	15.4
Optimum humidity for compaction, Proct. 27, %	18.4	19.7	18.3	16.4
Deformation module, M, daN/cmp	60	105	90	44
Cohesion, c, daN/cmp	0.50	0.65	0.65	0.40
Activity index, IA	1.13	1.23	0.61	0.66
Internal angle of response, ϕ°	9.5	10.0	10.5	15.3
Critical pressure, Pcr, t/m^2	13.65	18.18	18.49	23.13
Admissible pressure, Padm, t/m^2	6.82	9.09	9.24	11.56

In order to evaluate the intensity of the swelling and shrinking phenomena and the presence of the "active layer", we present the limits for the main rheological properties.

Table 2 Classification of the soil with swelling and shrinking

Activity	Clay %	I_p %	I_A %	U_L %	ws %	Cv, %		w15 %	Pu MPa
						matur struct.	modified struct.		
verry active	>30	>35	>1.25	>140	<10	>100	>35	>18	>0.4
active	18-35	25-35	1.0-1.25	100-140	14-10	75-100	25-35	13-18	0.1-0.4
less active	15-25	20-30	0.75-1.00	70-100	16-14	55-75	15-25	10-13	0.05-0.1

The rheological indexes which have presented in the scientific paper [6] can be analyzed throughout of all laboratory experiment from the Agrochemical and Pedological Studies Offices from Romania, because we have selected only these indexes which don't need special equipment.

1. Free swelling (U_L)

The trial relies on the properties of colloidal system to sedimentation, namely the setting the colloidal particles in the gravitational field.

In the liquid dispersium medium, like distillated water, the colloidal particles named "lyosols" are complied with gravitational forces and viscosity resistance.

From a soil sample of 100 - 150 g, oven dry at 105°C, grinded and sieving by 0.5 mm sieve, we will take 13 g soil with medium compaction, corresponding with 10 cm^3 volume.

In a graduated cylinder of 100 cm^3 will be introduced 80 cm^3 distillated water and the 13 g soil sample after a short stirring. After 4 - 5 hours it must restirring the cylinder and add with water until 100 cm^3, but must be involved entire quantity of soil sample. On the next day it will be reading the final volume (V_f)

For every determination must be effectuated 5 repetitions, the value of free swelling is he average of the 5 repetitions.

$$U_L = 100 \cdot (V_f - 10)$$

where the: U_L — free swelling
V_f — final volume (cm^3)

The significance of results:
- vertic horizon > 140%
- pelic horizon 100 - 140%

2. Plastic index. Ip

Between certain conditions of moisture content, the soil behaves as a plastic body, namely suffer an irreversible deformation beneath action some external loadings, without to change the volume.

The moisture contents which delimit lower and upper the plastic behavior are named plastic limits.

Lower plastic limit (w_p) or kneading limit, represents the minimum moisture content at which the behavior of soil passes from the semisolid state to the plastic state.

Upper plastic limit (w_L), or flow limit, represents the maximum moisture content, up to which the clayey soil has a plastic behavior and demarcate passes to the flow state.

Plastic index, (I_p) results from the difference between upper plastic limits and lower plastic limit.

$$I_p = w_L - w_P$$

a) Determination of upper plastic limit (w_L)

The determination needs a piece of laboratory apparatus named Cassagrande (figure 3) which is composed of a bowl from copper and a lever which raise or descend the bowl on 10 mm height and fall down on an ebonite support with a frequency of 120 fallings/minute.

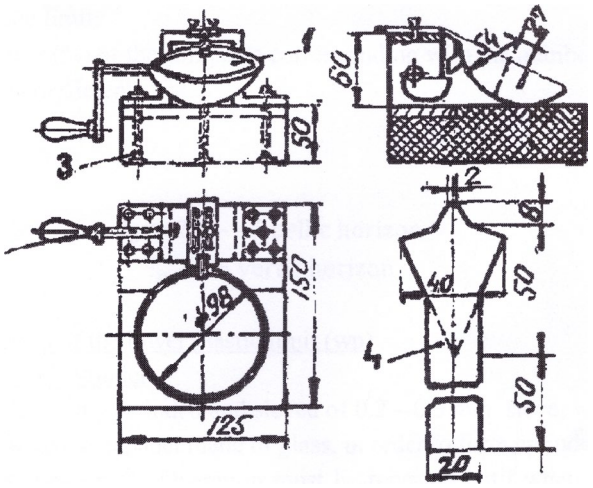


Figure 3 Cassagrande apparatus

The soil sample, air dry, grinded and sieved of 0.2 - 0.5 mm sieve, will be pestled and kneaded with so much water how the sample needs to become a soft paste.

The paste will be introduced into the bowl (2/3 from the bowl volume) and leveled. With the spatula we make a cut deep until the base of bowl. Wind the

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lever until when the deep cut of 12 mm is closed, counting the fallings.

Leveling the surface of the paste, and the method must be repeated until when the cut is closed after an equal number (± 1) of falling and determine the water content of the paste. The result express the value of upper plastic limit (w_L) after correction with the date of from table 3.

Table 3 Values of K - correction coefficient

n	K	n	K	n	K
20	-1,4	30	+1,2	40	+3,1
21	-1,1	31	+1,4	41	+3,2
22	-0,8	32	+1,6	42	+3,4
23	-0,5	33	+1,8	43	+3,5
24	-0,3	34	+2,0	44	+3,7
25	0,0	35	+2,2	45	+3,8
26	+0,2	36	+2,4	46	+4,0
27	+0,5	37	+2,5	47	+4,1
28	+0,8	38	+2,7	48	+4,2
29	+1,0	39	+2,9	49	+4,4
				50	+4,5

where: n – number of falling
and:

$$w_L = w_n + K$$

where:

w_L – upper plastic limit;

w_n – water content (%) of the soil paste corresponding with the number of fallings;

K – correction coefficient

Interpretation

$I_p = 25 - 45$ pellic horizon

$I_p \geq 45$ vertic horizon

b) Determination of the lower plastic limit (w_p)

Method of soil cylinder

The soil sample, air dry, grinded and sieved of 0.2 — 0.5 mm, sieve, will be pestled and kneaded, and shaped rolled on a panel made of glass, in order to form cylinders with 3-4 mm diameter and 40 — 50 mm length. Operation must be repeated until when the cylinders are fissured.

The moisture content will be determined exactly in this moment. For each soil sample must be made three trials. The obtained result represents the lower plastic limit (wp)

3. Calculated rheological indexes

a) Volume contraction, Cv

$$C_v\,\% = 100 \cdot \frac{V_i - V_f}{V_f}$$

where:

V_i - initial volume of saturated soil sample, cm^3;

V_f - final volume after dry of soil sample, cm^3;

C_v = 75 - 100 - pellic horizon

C_v > 100 - vertic horizon

b) Activity index, I_A

$$I_A = \frac{I_p}{A}$$

where:

I_p - plastic index;

A - content of clay < 2μ,

I_A - 1,00 - 1,25 - pellic horizon

I_A > 1,25 - vertic horizon.

4. CONCLUSIONS

In SRTS - 2012, there is the Class Vertisols, with two soil types, respectively Vertosol and Pelosol.

Nearby, WRB - 2014 has two types of horizons with shrink - swell properties, namely protovertic and vertic.

The difference between Vertosol and Pelosol sometimes is difficult to establish Vertic horizon, Bzy can be present of both of soil types, and also there are Pelosols with A horizon with black color.

For this reason, we have considered that is necessary to introduce in the SRTS - 2012 some rheological indices, which are possible to measure in the Soil Physics Laboratory from OSPA. These rheological indices can make the difference, respectively: UL - free swelling, Ip - plastic index, Cv - volume contraction, I_A - activity index.

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