UPDATE OF SOIL MAPS WHERE DRAINING AND UNDERGROUND PIPE DRAINAGE SYSTEMS WERE INTRODUCED BASED ON THE ROMANIAN SOIL TAXONOMY SYSTEM (SRTS-2012, 2012$^+$)

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Abstract

In the territorial administrative units where open draining systems have been introduced, and which locally are associated to underground pipe drainage systems, the modernization/rehabilitation of the existent hydro technical structures and the update of soil maps for the sustainable exploitation of agricultural fields results necessary. The present case study was conducted on the premises of Baia-Sasca hidroameliorative system in Suceava County, on a total surface of 5,527 ha, between 1978 – 1980; in 1977, it was drawn up a pedological study based on the old Romanian Soil Classification System (SRCS – 1976, 1980). The update of the soil cartographic units was performed using the framing criteria for the soil taxonomic units regulated by the new Romanian Soil Taxonomy System (SRTS – 2012, 2012$^+$). At the same time, additional field studies were conducted to highlight the various soil modifications after almost 35 years of agricultural exploitation. The geospatial database for the soil cartographic units was represented on the geodetic trapeziums corresponding to the soil maps, scale 1:5000. It included the surfaces from the following administrative territorial units from Suceava County: Horodniceni, Cornu Luncii, Radaseni, and Vadu Moldovei.

Key words: soil taxonomic and cartographic units, draining system, underground pipe drainage system

In the past few years, soil resources have started being perceived differently because of the increased request of food worldwide. In this context, the soil, as a limited resource of food, represents one of the most important goods of humanity.

Due to its limited distribution, nowadays it is necessary to fully capitalize soil fertility potential, and sustainable and profitable usage of the resources belonging to terrestrial ecosystems.

The pedological studies conducted in time in various territorial administrative areas of Suceava County have pointed out the great diversity of soils. The altitude of this territory varies between a minimum of 233 m in the North-East area of the country in the water meadow of Siret river – at Dolhasca and maximum of 2,100 m (Pietrosu peak in Călimani Mountains).

The altitude difference of this territory which, with an extension includes the volcanic frame of Oriental Carpathians, has determined the spatial distribution of soils.

Thus, first of all, there is a horizontal zonation in the plain regions and a vertical one in the hilly and mountain regions, as the altitude increases; simultaneously, climate and vegetation change.

At the same time, a latitudinal zonation stands out because of the latitude differences of the area considered are relatively insignificant and not evident anymore in vertical zonation.

The territory of Suceava County included a total surface of 855,350 ha, of which: 349,502 ha agricultural field (41%) and 505,848 ha non-agricultural field (59%). The agricultural field included 177,801 ha of arable land (Moca, V., Bucur D., 2014).

Considering the natural conditions of Suceava County, the agricultural land spatial distribution included three different areas.

The plain area, including almost 1/3 of the agricultural surface, is situated in the water meadows and the terraces from the hydrographic basins of Siret and Suceava Rivers.

The hilly and plateau area includes the sub Carpathian areas from the central and northeastern part of the county, being mentioned, *Fălticeni Plateau, Suceva Plateau, Dragomirna Plateau.*

The mountain area generally characterized by cold and wet climate, with natural lawns and

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not very fertile soils, is represented by the geographic area of the *Oriental Carpathians.*

The summary of the pedological studies conducted in time on a surface of 398,771 ha, in Suceava County has permitted the classification of soil units into 10 classes and 19 soil types, according to SRTS – 2003 criteria.

Using this database and the pedological studies, it was possible to identify the fertility potential and to support the measures and improvement works.

MATERIAL AND METHOD

The water excess in Suceava County manifested itself in different ways in the pedogenci conditions on the agricultural field of Suceava County. In this context, it stands out both the long-time effect of humidity excess due to the groundwater and the temporary humidity excess due to the rainfall that caused soil gleization and/or stagnogleization in various areas.

Among the most important geographic subunits of Suceava County where excessive humidity was present, the plains and the terraces of the following areas are mentioned: *Siret Valley, Suceva Valley* and *Moldova Valley.*

The first works to eliminate the water excess consisted in a systematic network of draining canals that was then completed by underground pipe drainage systems. They were performed towards the end of the 19th century and the beginning of the 20th century in Radauti Depression by the Agricultural Society of Vienna (Moca, V.,et al., 2010).

The hydrographic basin and the Moldova river water meadow from the extra Carpathian region Păltinoasa-Roman, which also includes the territory of the area known as "*Baia Depression"* represents a distinct territorial unit. It is characterized by the complex morphology of the major streambed, being represented by the size of the low and high meadow levels and by the apparition of alluvial cones.

In 1959-1960, in the Baia-Sasca Depression there have been performed the first regulations of the local hydrographic network and the first open canal draining works on almost 1700 ha of agricultural field from the joint water meadow of Moldova river and Şomuzul Băii stream.

In the second phase, the works performed in the first phase were expanded based on the studies conducted between 1976-1977 and the project for the hydroameliorative system drawn up between 1978 – 1980.

The Baia-Sasca hydroameliorative system included draining a surface of 5,527 ha using a systematic network of open canals and on 1,806 ha of this surface there was implemented a systematic network of underground pipe drainage system made of ceramic or other plastic materials. (Moca, V., Bucur, D., 2014).

The case study consisted of updating the soil maps drawn up in 1977 - 1980 for 6,500 ha, based on the Romanian Soil Classification System, SRCS – 1976, 1980 (Conea, Ana, Florea, N., Puiu, S., 1980).

For the correspondence of the names of soil units from the old system the criteria from the Romanian System of Soil Taxonomy (SRTS - 2012, 2012+) were used. At the same time, the soil names were correlated with World Reference Base for Soil Resources 2014 (IUSS Working Group WRB, 2014).

RESULTS AND DISCUSSIONS

a. Pedogenetic conditions

The hydrographic basin and the Moldova river meadow from the left waterside of the Băişeşti-Baia-Vadu Moldovei sector, with a surface of almost 9,500 ha represents a different territorial unit. This depression-like geographic area is delimited in the West by the sub Carpathian hills with 632 m *(Runcu)* and 915 m *(Pleşului Peak)*, altitude and in the east, by the *Suceava Plateau* represented by the hills situated at the limit of the hydrographic basin from Lămăşeni and Rădăşeni areas, that go beyond 400-500 m altitude.

The sub Carpathian hills and those from the plateau region contrast with the almost plane landform of the alluvial plain of the joint meadow of Moldova river and Şomuzul Băii stream that continues with storied terraces with altitudes of up to 300- 400 m.

The depression that includes the area from the Baia – Moldova – Siret region, is the result of the latest tectonic movements of Moldova Plateau at the end of the *Pliocene* and in *Quaternary*, which lead to the apparition of hilly piedmonts and low plains with erosion and quaternary accumulation features.

The parent material consists of sandy-stoney and sandy-bouldery allochtonous sediments with a thickness of 2-9 m in the water meadow. On the terraces, there are loessoid deposits of medium and smooth texture and 3-20 m thickness. These parent materials have influenced solidification with their mineralogical-chemical composition and their granulometric structure.

Landform and micro landform were differentiated longitudinally and transversally using numerous positive and negative specific forms: *levees, glacis, terraces, alluvial plain, accumulative cones, local microdepressions and others*. These landforms have influenced the non-uniform distribution of rainfall and surface water discharge, which has caused a different evolution of the solidification process.

The climate has generally been determined by the interference of continental, arctic and polar air masses with maritime air of oceanic origin.

The climatic regime of the region was framed in the Dfbx provence, with the following parameters: average annual temperature: 7.9^{0}C (Fălticeni); average annual precipitations: 631.2

mm (Fălticeni); 793.0 mm (Baia); potential evapotranspiration: 599.0 mm (Fălticeni).

The climate and its components have influenced the intensity of alteration processes and soil eluviation – illuviation.

The hydrographic network is dominated by the Moldova river and its local affluents Şomuzul Băii and Şomuzel springs and others that generate a relatively thick density of 0.4-0.7 Km/ Km^2.

The phreatic water found in the permanent storeys from the water meadow of Moldova river and Şomuzul Băii spring oscillated between the surface of the land and the average depth of 1.00 m before the first hydroameliorative works were performed. After these works were conducted between 1959-1960 and 1978-1980 it became stable, at an average depth of 1-2 m. An average depth of more than 3-5 m frequently characterized the aquifer layer in the lower and upper terraces. The seasonal pedophreatic water is present in the meadows or terraces with depression microrelief.

The spontaneous vegetation is represented in the meadows by *hydrophytes* and on the terraces, by *mesophytes*.

The humans intervened by draining hydromorphic soils and cultivating crops.

b. Soil units framing in the Romanian System of Soil Classification (SRCS – 1976, 1980)

The ensemble of the pedogenetic factors from Baia Depression that was characterized by great longitudinal and transversal diversity generated a great diversity of soils with different features and fertility levels.

To identify the soil units more than 600 main, secondary and control profiles were conceived.

The name and the presence of the soil units in the region was established using the criteria of the Romanian System of Soil Classification (SRCS – 1976, 1980).

Considering the pedogenetic conditions of Baia depression four soil classes have been identified: mollisols, argiluvisols, hydrogenic soils and immature soils, that are included in 11 soil types, 21 subtypes and 47 soil varieties (*figure 1* and *table 1*).

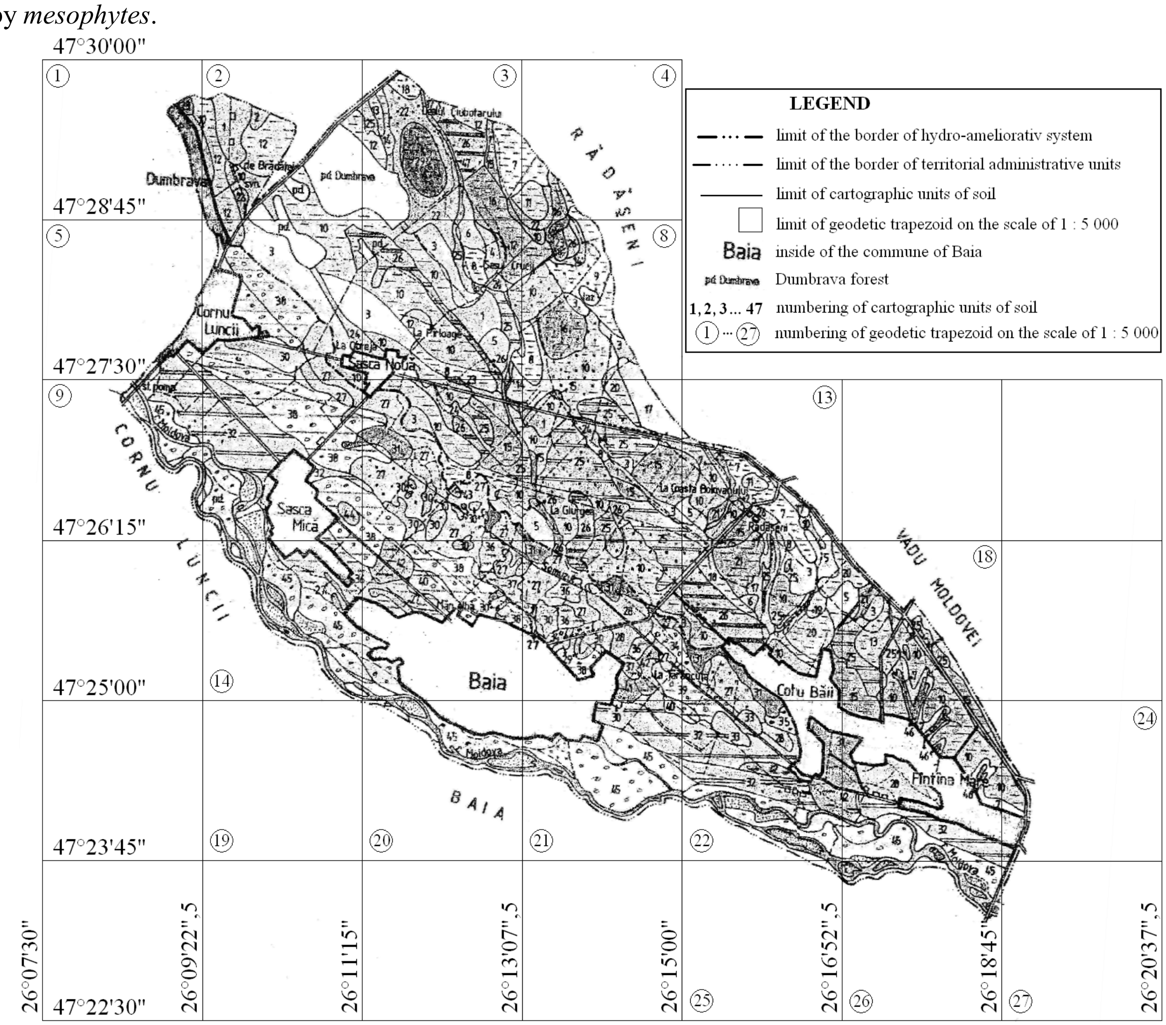

Figure 1 **Soil map from Baia depression with cartographic units represented on geodetic trapeziums**

Table 1

Classification of soil types and subtypes from Baia Depression, according to the Romanian System of Soil Classification (SRCS – 1976, 1980)

Crt. no.	Soil class, type and subtypes	Soil class, type and subtype	Area	
			ha	%
	MOLISOLURI	**MOLLISOLS**	**2,729**	**42.0**
1	Sol cernoziomoid cambic (CM ca)	Argilic cambic pratoziom	134	2.1
2	Sol cenuşiu cambic (CN ca)	Grey cambic soil	431	6.6
3	Sol cenuşiu pseudogleizat (CN pz)	Grey pseudogleyied soils	2,164	33.3
	ARGILUVISOLURI	**ARGILUVISOLS**	**522**	**8.0**
4	Sol brun argiloiluvial (BD ti)	Argilic brown soil	87	1.3
5	Sol brun luvic pseudogleizat (BP pz)	Pseudogleyied podzolied brown soil	213	3.3
6	Luvisol albic pseudogleizat (SP pz)	Podzolic pseudogleyied soil	146	2.2
7	Luvisol albic pseudogleic (SP pg)	Podzolic pseudogleyied soil	76	1.2
	SOLURI HIDROMORFE	**HYDROGENIC SOIL**	**1,482**	**22.8**
8	Sol pseudogleic tipic (PG ti)	Tipic pseudogley	65	1.0
9	Sol pseudogleic molic (PG mo)	Mollic pseudogley	405	6.2
10	Sol pseudogleic luvic (PG lv)	Podzolic pseudogey	210	3.3
11	Sol amfigleic molic (GC mo)	Mollic amphigley	500	7.7
12	Sol amfigleic molic – cambic (GC mo-ca)	Cambic amphigley	152	2.3
13	Sol gleic turbos (GC tb)	Histic gley	150	2.3
	SOLURI NEEVOLUATE	**IMMATURE SOIL**	**1,767**	**27.2**
14	Sol aluvial molic (SA mo)	Mollic alluvial soil	465	7.2
15	Sol aluvial litic (SA ls)	Lithic alluvial soil	41	0.6
16	Sol aluvial gleizat (SA gz)	Gleyic alluvial soil	177	2.7
17	Sol aluvial molic - litic (SA mo-ls)	Mollic lithic alluvial soil	653	10.0
18	Sol aluvial molic – gleizat (SA mo-gz)	Mollic gleyied alluvial soil	138	2.1
19	Protosol aluvial litic (AA ls)	Lithic alluvial soil	267	4.1
20	Coluvisol gleizat (CO gz)	Gleyied colluvial soil	16	0.3
21	Erodisol pseudogleizat (ER pz)	Pseudogleyied eroded soil	10	0.2
	TOTAL SURFACE MAPPED		**6,500**	**100.0**

The pedological studies conducted in Baia depression on 6,500 ha are represented on the soil map (Figure 1) and grouped into classes, soil types and subtypes according to (SRCS – 1976, 1980) (Table 1).

The mollisols class, representing 42.0% of the mapped surface includes the soils characterized by mollic A horizon and subjacent horizon with colours of mollic horizon. These soil types and subtypes were identified on the high and medium terraces of the hydrographic basin of Moldova river from the contact with Falticeni Plateau; it occupies a surface of 2,729 ha. The three soil types/subtypes are represented on the soil map by numbers (1 - 2); (3 – 6); (7 - 16).

The argiluvisols class representing 8.0%, of the mapped surface includes the soil units with the following pedogenetic horizons: (El or Ea), formed over an argiloiluvial Bt horizon. These soils cover a surface of 522 ha and were formed on the plain terraces with small slopes and depression-like relief. On these areas where pluvial and superficial water used to accumulate intense processed of illuviation and eluviation appeared, which lead to the formation of luvic or albic horizon.

The four main soil types/subtypes are represented on the graphic support of the soil map by numbers (17); (18 - 21); (22) and (23).

The hydrogenic soil class representing 22.8%, of the mapped surface was classified according to the long-term influence of the pedogenetic factors into three types/subtypes of pseudogleic soils and three types/subtypes of gleic soils. After the intense pseudogleization processes, the pseudogleic horizon (W) of the pseudogleic soils was formed; it was present on all terraces with relatively plane or depression-like landforms. Gleic soils are present in the joint plain of Moldova river and Şomuzul Băii spring, and were identified based on the apparition of the gleic horizon (G). The six soil types/subtypes with a surface of 1,482 ha are represented on the soil maps as follows: (24); (25); (26); (27, 28, 29); (30) and (31).

The immature soil class, representing 27.2%, of the mapped surface includes the alluvial soils and the alluvions of different evolution stages from the floodable and non-floodable water meadow of Moldova river. At the same time, there have been identified a series of local areas represented by colluvisols and erodisols. These two soil types with limited areas have been identified at the base of the terraces and on the bank of the terraces with high slopes.

The surface of 1,767 ha is represented on the soil map by the numbers (32 - 33); (34 - 35); (36 - 37); (38 - 40); (41 - 44); (45); (46) and (47).

c. Equivalating class, type and subtype soil names from SRTS – 2012, 2012+ with the ones from SRCS – 1976, 1980 and correlating them with the World Reference base (WRB-2014)

By replacing the ”*Classification system”* with the ”*Taxonomic system”* was intended to update soil taxonomy in Romania based on the new data collected in the last 20 years (1980 - 2000), and correlate it with the existent systems worldwide.

The first edition of the Romanian System of Soil Taxonomy was published in 2000 under the coordination of the Institute of Research for Pedology and Agrochemistry, Bucharest (Florea, N., Munteanu, I., 2000). This first edition was amended and republished in 2003 with the same coordinator (Florea, N., Munteanu, I., 2003).

Based on the experience of eight years of using them (2003 - 2012), to which are added the scientific debates from the SNRSS national conferences and the on-field applications from Banat, Dobrogea, Moldova and Oltenia there have been added a series of modifications useful in practice. With these completions and amendments the third and the forth editions were published (Florea, N., Munteanu, I., 2012) and (Vlad, V., Florea, N., et. al., 2014), respectively.

Compared to the Romanian Soil Classification System (SRCS - 1976, 1980) the new Romanian System of Soil Taxonomy (SRTS – 2003, 2012 and 2012+) presents a better classification of soils in the nomenclature, higher practical usage and uniformization of soil terminology. At the same time, the Romanian System of Soil Taxonomy is also correlated with the classification criteria of international systems.

Among the modifications from SRTS in comparison to SRCS it is first mentioned the SRTS 2003 structure that included 12 soil classes and 32 soil types. The SRTS – 2012, 2012+ structure kept the 12 soil classes, and reduced the number of soil types to 29.

The present taxonomy system (SRTS – 2012, 2012+) defined 12 soil classes compared to the 10 soil classes from SRCS – 1976, 1980. Each soil class is characterized by the presence of a certain horizon or key feature.

The update of soil classes from Table 1 consisted in replacing the old names with the new ones: Mollisols with *Cernisols*; Argiluvisols with *Luvisols*; H*ydromorphic soils* with *Hidrisols* and the class of immature and trunked soils was transferred to the next two, *Protisols* and *Anthrisols* (*table 2*).

Table 2

Classification of soil types and subtypes from Baia Depression, according to the Romanian System of Soil Taxonomy and its correlation to the World Reference Base

Crt. no.	Soil class, type and subtype (SRTS-2012, 2012+)	Soil class, type and subtype (WRB-2014)	Area	
			ha	%
	CERNISOLURI	**CERNISOLS**	**3,229**	**49.7**
1	Faeoziom cernoziomid cambic (FZ cm.cb)	Haplic Phaeozems (PH hp)	134	2.1
2	Faeoziom cambic greic cernic (FZ cb.gr.ce)	Greyic Phaeozems (PH gz)	431	6.6
3	Faeoziom argic greic stagnic cernic FZ ar.gr.st.ce	Luvi-stagni-greyic Phaeozems (PH gz-lv-st)	2,164	33.3
4	Faeoziom gleic cernic (FZ gl.ce)	Gleyic Phaeozems (LV ab)	500	7.7
	CAMBISOLURI	**CAMBISOLS**	**152**	**2.3**
5	Eutricambosol molic amfigleic (EC mo.dg.st)	Mollic stagnic gleyic Combisols CM mo-gl-st	152	2.3
	LUVISOLURI	**LUVISOLS**	**446**	**6.8**
6	Preluvosol tipic (EL ti)	Haplic Luvisols (LV ha)	87	1.3
7	Luvosol stagnic (LV st)	Stagnic Luvisols (LV st)	213	3.3
8	Luvosol albeglosic stagnic (LV gl.st)	Stagnic Albeluvisols (AB st)	146	2.2
	HIDRISOLURI	**HYDRISOLS**	**906**	**14.0**
9	Stagnosol tipic (SG ti)	Haplic Stagnosols (ST ha)	65	1.0
10	Stagnosol molic (SG mo)	Haplic Stagnosols (ST ha)	405	6.2
11	Stagnosol luvic (SG lv)	Luvic Stagnosols (ST lv)	210	3.3
12	Albeglosic Stagnosols (SG ab.gl.dg)	Stagnic Albeluvisols (AB st)	76	1.2
13	Gleiosol histic (GS tb)	Histic Gleysols (GL hi)	150	2.3
	PROTISOLURI	**PROTISOLS**	**1,757**	**27.0**
14	Aluviosol molic (AS mo)	Mollic Fluvisols (FL mo)	465	7.2
15	Aluviosol prundic (AS pr)	Skeletic Fluvisols (FL sk)	41	0.6
16	Aluviosol gleic (As gk)	Gleyic Fluvisols (FL gl)	177	2.7
17	Aluviosol molic prundic (AS mo.pr)	Skeletic mollic Fluvisols (FL mo-sk)	653	10
18	Aluviosol molic batigleic (AS mo.dg)	Mollicgleic Fluvisols (FL mo-gl)	138	2.1
19	Aluviosol entic eutric (AS en.eu)	Eutric haplic Fluvisols (FL ha-eu)	267	4.1
20	Aluviosol coluvic batigleic (AS co.eu)	Haplic Fluvisols (FL ha)	16	0.3
	ANTRISOLURI	**ANTHRISOLS**	**10**	**0.2**
21	Antrosol erodic (AS er)	Eutric Regosols (RG eu)	10	0.2
	TOTAL SURFACE MAPPED		**6,500**	**100.0**

The cernisols class, representing 49.7% of the mapped surface maintained the three soil types from mollisols class: *Faeoziom cernoziomid cambic (FZ cm.cb)*; *Faeoziom cambic greic cernic (FZ cb.gr.ce); Faeoziom argic greic stagnic cernic (FZ ar.gr.st.ce)*.

Mollic amphigley (GC - mo) was included in the Cernisoils class, with the new name *Faeoziom gleic cernic (FZ gl.ce)*, according to SRTS – 2012, 2012^+. The definition of this soil type was determined by the modification of the depth interval of the diagnosis pedogenetic horizon, which decreased its depth from 0-125 cm to 0 - 50 cm. The four soil types/subtypes are represented on soil map by numbers (1-2); (3-6); (7-16); (27-29).

The Cambisols class representing 2.3% of the mapped surface included the Cambic amphigley *(GC mo-ca)* from the old classification with the new name *Eutricambosol molic amfigleic (EC mo.dg.st)*. Due to the succession of pedogenetic horizons of *Cambic amphigley* soil it was included in the Cambisols class, being supported by the B cambic horizon, preceded by a Aocric horizon. The presence of the reduction gleic horizon at depths higher than 50 cm justifies the inclusion of this Hydrogenic soil into the cambisol class. The reductomorphic features of weaker intensity define only the amphigley soil subtype. The soil unit previously mentioned is represented on the soil map by number (30).

The Luvisols class representing 6.8%, of the mapped surface maintained the following three soil types: *Preluvosol tipic (EL ti); Luvosol stagnic (LV st); Luvosol albeglosic stagnic (LV gl.st).* The three soil types/subtypes cover 446 ha and are represented on the soil map by numbers: (17); (18 - 21) and (22).

The Hydrisols class representing 14.0% of the mapped surface maintained the following four soil types: *Stagnosol tipic (SG ti); Stagnosol molic (SG mo); Stagnosol luvic (SG lv), and Gleiosol histic (GS tb).*

The Podzolic pseudogleyied soil (SP pg) from the Argiluvisols class was reintroduced into Hydrisols class under the name *Albeglosic Stagnosols (SG ab.gl.dg)*, which points out the mixture of albic alluvial soil with horizon B as gloze (E+B). The five soil types/subtypes are noted: (23); (24); (25); (26); and (31).

In the Protisols class (27.0%) there were maintained: *Aluviosol molic (AS mo); Aluviosol prundic (AS pr); Aluviosol gleic (As gk); Aluviosol molic prundic (AS mo.pr); Aluviosol molic batigleic (AS mo.dg); Aluviosol entic eutric (AS en.eu); Aluviosol coluvic batigleic (AS co.eu)*. The five soil types/subtypes are noted: (32-33); (34-35); (36-37); (38-40); (41-44); (45) and (46).

In the Antrisols class that includes the soils that evolved under anthropic influence it was included the highly eroded soil that became an erodic subtype of the anthrosol type, *Antrosol erodic (AS er).* The types are noted: (47).

The geospatial database for the soil cartographic units was represented on the geodetic trapeziums corresponding to the soil maps, scale 1:5000. It included the surfaces from the following administrative territorial units in Suceava County: Horodniceni, Cornu Luncii, Radaseni, and Vadu Moldovei.

CONCLUSIONS

The graphic and alphanumeric database used for updating the soil map included a mapped surface of 6,500 ha. The soil units were identified using the structure of the Romanian System of Soil Classification (SRCS – 1976, 1980), that synthesized the following classification: 4 soil classes, and 21 main soil types/subtypes.

Updating the soil unit names according to the present criteria of the Romanian System of Soil Taxonomy (SRTS – 2012, 2012^+) underlined, based on the study conducted, the following classification: six soil classes with the same 21 soil types/subtypes and inclusion into other soil classes, depending on the presence of certain key features or horizon diagnosis.

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