SPATIAL CORRELATION BETWEEN SUFFOSION PROCESSES AND LAND USE IN SĂLCUȚA PLAIN (SOUTHWESTERN ROMANIA)

GEORGE TĂNASE*[1], OANA MITITELU-IONUȘ**, CRISTIANA VÎLCEA**, MIHAELA LICURICI**, SANDU BOENGIU***

Key-words: Loess, micro-depressions, morphometry, compaction, agricultural land, soil, GIS.

Abstract. The present study aims to establish how the agricultural lands in Sălcuța Plain, a piedmont subunit of the Romanian Plain, are affected by the presence of micro-depressions on loess deposits. The formation of these micro-depressions is closely related to the chemical and mechanical compaction process, which is conditioned by several factors, including the thickness of the loess deposit, the quantity of carbonates in the deposit, local morphometry, paleogeographic evolution, and climatic conditions. Based on satellite imagery from the 2010–2019 period, 303 micro-depressions were identified. Out of the total number of depressions, 293 are located on agricultural lands, covering approximately 9.31 km^2. On the surface of some of these depressions, soils with stagnant horizons (0.7 km^2) have formed due to prolonged excess moisture. These types of soils gradually lead to the long-term degradation of agricultural lands. It is recommended to constantly monitor the evolution of soils with stagnant horizons and implement ameliorative agricultural measures in case an expansion of their area is observed in the long term.

1. INTRODUCTION

The process of suffosion is a global issue (Dinar *et al.*, 2021; Herrera-Garcia *et al.*, 2021). It has both natural and anthropogenic origins (Erkens *et al.*, 2015), with hydrogeological processes being some of the main triggering factors (Galloway *et al.*, 2016).

In the studied area, a network of micro-depressions has formed as a result of the subsidence process (Posea *et al.*, 2005). To decipher the formation mechanisms of these micro-depressions in the study area, it is necessary to have a good understanding of the characteristics of loess, loess-like deposits, and local morphometry.

Loess is an unstratified sediment, primarily dusty, friable, and yellowish-brown in colour (Ielecniz *et al.*, 1999; Újvári, 2016). It formed through the accumulation of wind-blown dust during glacial periods (Smalley *et al.*, 2011; Buggle *et al.*, 2011; Újvári, 2016; Peric *et al.*, 2022; Mörtsjö, 2023). The source of the dust is complex, originating from the vicinity of glacial caps, the alluvial plains of hydrographic networks during glacial periods, or even from desert areas (Buggle *et al.*, 2011; Zhuang *et al., 2021*). Loess can be found either as true deposits with a metastable structure (Smalley and Marković, 2019), or as loess-like deposits that contain other sediments, sometimes interspersed with fossil soils (Meszner *et al.*, 2013; Banak *et al.*, 2013; Constantin *et al.*, 2021). This sediment is composed of a series of minerals, the most important of which are quartz (Perić *et al.*, 2022), clay (Roberts, 2019), and carbonates, especially calcium carbonate (Smalley and Marković, 2019). Loess deposits and loess-like deposits are found on all continents (Marković *et al.*, 2013) and cover about 10% of the continents'

* PhD Student, Geography Department, Faculty of Sciences, University of Craiova, 13 A.I. Cuza Street, 200585, Craiova, Dolj, Romania, tanasegeorge818@gmail.com

** Lecturer, Geography Department, Faculty of Sciences, University of Craiova, 13 A.I. Cuza Street, 200585, Craiova, Dolj, Romania, oana_ionus@yahoo.com, cristiana_oana@yahoo.com, mihaela.licurici@edu.ucv.ro

*** Professor, Geography Department, Faculty of Sciences, University of Craiova, 13 A.I. Cuza Street, 200585, Craiova, Dolj, Romania, sboengiu@central.ucv.ro

[1] Corresponding Author

surface area, being concentrated primarily in the middle latitudes of Eurasia (Újvári *et al.*, 2008; Marković *et al.*, 2013).

The loess in Romania has the following characteristics: macro-porosity and a columnar structure, and is composed of dust (the highest percentage), clay, fine sands, and carbonates (Posea *et al.*, 1974).

In Romania, loess deposits and loessoid deposits cover approximately 40,000 km^2 (Protopopescu-Pake *et al.*, 1966), with thicknesses of up to 30 meters (Geography of Romania, *1983*). The most extensive deposits are located in the Southern and Southeastern parts of Romania, with approximately 28,370 km^2 found in the Romanian Plain (Geography of Romania, *1983*).

On the surface of loess and loessoid deposits, depending on certain circumstances, a series of negative landforms can appear in the form of depressions with various shapes (Kołodyńska-Gawrysiak *et al.*, 2015; Kołodyńska-Gawrysiak and Poesen, 2017; Fagg and Smalley, 2018). In international literature, they are known as micro-depressions, closed depressions, or loess depressions (Grecu *et al.*, 2015). Depending on the stage of evolution, these depressions have the following names in Romanian specialized literature: *"crovuri"* – with diameters of up to 1 km (which were formed by the mechanical and chemical compaction of loess deposits), *"găvane"* – representing the next stage of evolution resulting from the expansion or merging of *"crovuri"*, and *"padine"* – which have surfaces of several square kilometres and consist of multiple *"crovuri"* (Posea, 2006; Boengiu, 2008; Grecu *et al.*, 2015; Achim, 2016; Grecu, 2019).

According to the existing literature, there are several mechanisms for the formation of micro-depressions on the surface of loess deposits, which can occur separately or together:

- The chemical and mechanical compaction of the deposit, a mechanism conditioned by factors such as the thickness of the deposit, the amounts of salts, especially calcium carbonate (CaCO3), slope and relief fragmentation, paleogeographic evolution, and climate regime (Tufescu, 1966). This process occurs due to vertical water circulation, facilitated by the high permeability and porosity of this sediment (Florea, 1970). The salts within the deposit, especially calcium carbonate (CaCO3), dissolve in water and are transported to the base of the sediment, resulting in voids that are mechanically compacted under the weight of the deposit. This leads to the formation of unevenness at the topographic surface, which can later evolve into depressions (Florea, 1970; Costea, 2018).
- Deflation (Kołodyńska-Gawrysiak and Poesen, 2017), which involves the wind-driven removal of fine particles from the surface of the loess deposit. The shape of the resulting depressions is influenced by the predominant wind direction in the area.
- Depressions influenced by the paleo relief beneath the deposit, in which case loess takes on the shape of certain depressions or valleys that were part of the original relief (Kołodyńska-Gawrysiak, 2019).
- Anthropogenic depressions formed as a result of human activities, including the excavation of deposits, the collapse of underground galleries in limestone mines, and the creation of mining craters (Kołodyńska-Gawrysiak and Poesen, 2017).

The purpose of this study is to highlight how the agricultural lands in Sălcuța Plain, a small lowland unit in Southwestern Romania, can be directly affected by the excess moisture associated with loess depression, and indirectly impacted through the degradation of the soils on the surface of these depressions.

2. STUDY AREA

Sălcuța Plain is a subunit of the Oltenia Plain with an approximate area of 220 square kilometres, located in the Southwest of Romania, between the following geographical coordinates: 23°36'48" – 23°52'40" eastern longitude and 44°01'07" – 44°14'30" northern latitude (Fig. 1).

According to the *2018 Corine Land Cover data*, 10 land use categories were identified (Table 1, Fig. 2): non-irrigated arable land (156.98 km²), broad-leaved forests (23.13 km²), pastures (14.06 km²), vineyards (9.61 km²), discontinuous urban fabric (6.06 km²), complex cultivation patterns (5.92 km²), land principally occupied by agriculture with significant areas of natural vegetation (3.17 km²), fruit trees and berry plantations (0.83 km²), industrial or commercial units (0.62 km²), transitional woodland-shrub (0.21 km²).

The geographic position on the continent places this region in the temperate-continental climate zone. This area is periodically invaded by masses of dry and hot, and sometimes humid air from Northern Africa or the Mediterranean Sea Basin (Vlăduț, 2011).

From the perspective of the genetic type of relief it falls into, Sălcuța Plain is an old piedmont plain, an extension into the plain of the Getic Piedmont to the North (Posea, 2006; Grecu, 2019).

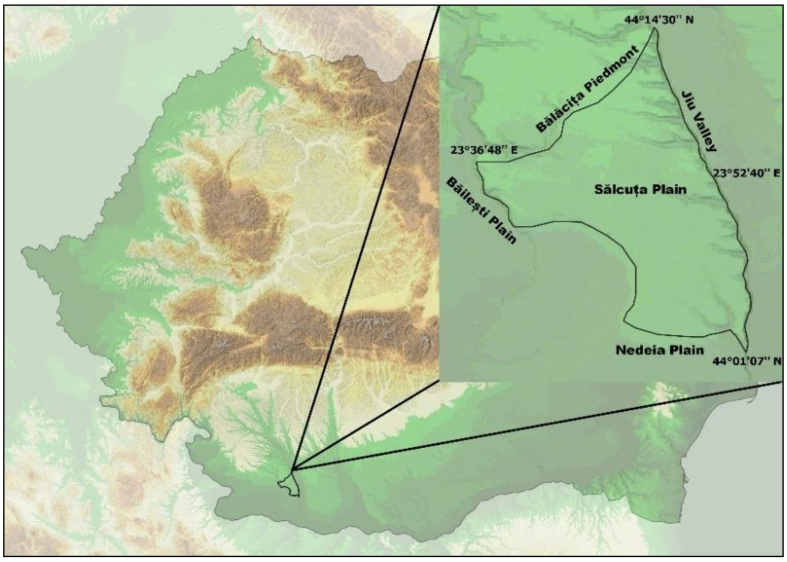

Fig. 1 – The location of Sălcuța Plain at the national level.

Table 1

Land use in Sălcuța Plain (2018)

Land use categories	**Area (km²)**
Vineyards	9.61 – 961
Non-irrigated arable land	156.98 – 15,698
Industrial or commercial units	0.62 – 62
Broad-leaved forest	23.13
Transitional woodland-shrub	0.21
Discontinuous urban fabric	6.06
Complex cultivation patterns	5.92
Pastures	14.06
Land principally occupied by agriculture with significant areas of natural vegetation	3.17
Fruit trees and berry plantations	0.83

Source: Corine Land Cover 2018.

Considering the genetic type of relief (piedmont plain), the altitude of the entire area ranges between 52 and 175 meters (Fig. 3). Overall, altitudes between 145 and 160 meters predominate (Fig. 3). A significant level difference of approximately 80 meters has been identified between the upper part of the slopes and the parallel valley low points that intersect the Eastern half of the study area. This level difference is due to strong erosion in friable formations, caused by native hydrographic organisms and the gradual deepening of the Jiu River, the main collector.

The studied area is clearly outlined to the West by the Desnățui River Valley, and to the East by the Jiu River Valley, looking like an interfluve with a low slope ranging between 0 and 2 degrees (Fig. 3). An exception to this rule is found on the slopes of the previously mentioned parallel valleys, where steep slopes of over 15 degrees are recorded (Fig. 3).

The degree of relief fragmentation is generally low, with the indicator of relief fragmentation depth having low values ranging between 0 and 85 meters (Fig. 4). In this case, the relief energy is low, characteristic of a plain relief. Similarly, the indicator of relief fragmentation density has low values (0 - 3.27 km/km²), indicating a poorly developed drainage network (Fig. 4).

The main types of soils that are found in the study area are Chernozems, Phaeozems and Preluvosols. The solification rocks, on which these soils were formed, consist of loamy deposits (Simulescu & Grigoraș, 2016). Due to these loamy deposit in "crovuri" and "padine" cambic and argic chernozems, stagnic phaeozems, albic and preluvic stagnosols were formed. The structure of these soil types, the high content of loess, and the land use favour the intensification of hydric erosion processes.

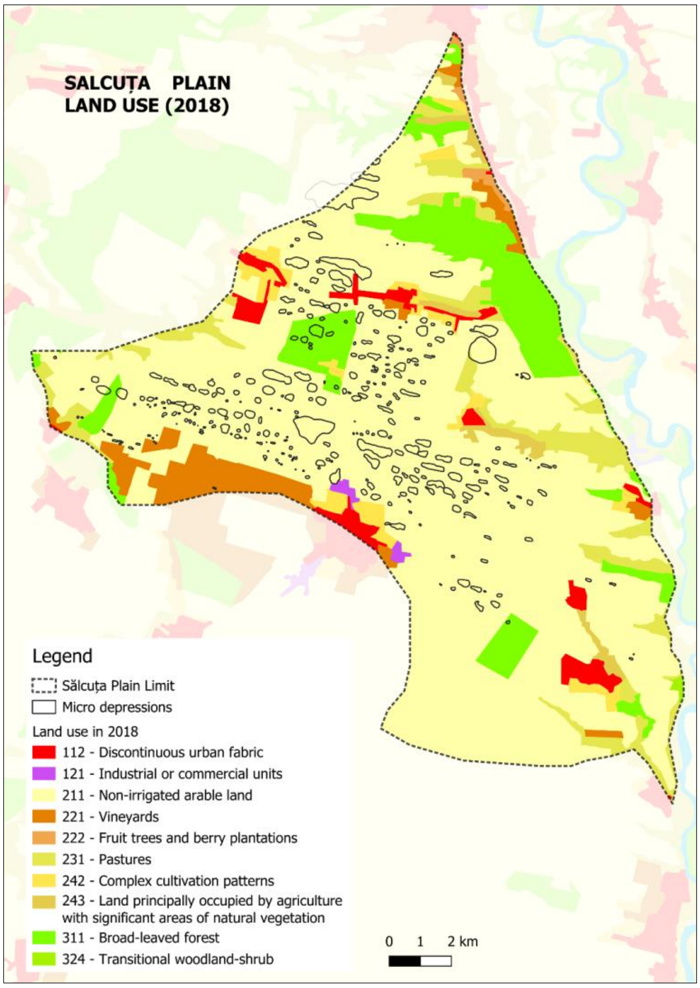

Fig. 2 – Land use and land cover in Sălcuța Plain (2018).
Source: Corine Land Cover 2018, https://land.copernicus.eu/.

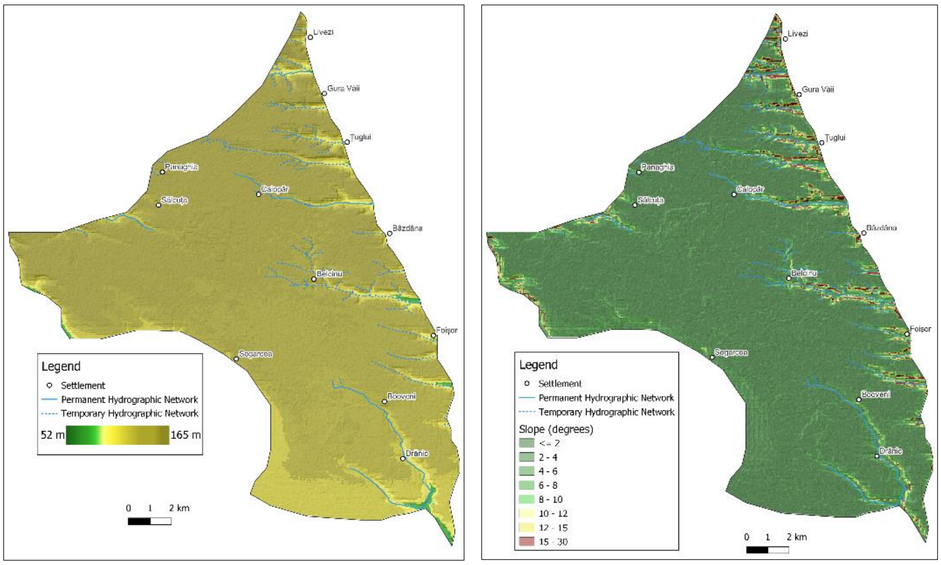

Fig. 3 – The value of altitude and slope steepness in Sălcuța Plain
Source: Tănase *et al*., 2023.

The entire surface of Sălcuța Plain is covered in loess deposits measuring approximately 10 to 15 meters in various areas (Coteț, 1957). In the vicinity of Podari settlement in the Northern part of the study area, the loess deposits measure 15 meters, while further South, in the vicinity of Bâzdana settlement, the thickness of the deposits decreases to 10 meters (Coteț, 1957). Geological profiles were created in the areas mentioned above (Coteț, 1957), revealing that the loess deposits are interspersed with fossil soils appearing as dark-coloured bands.

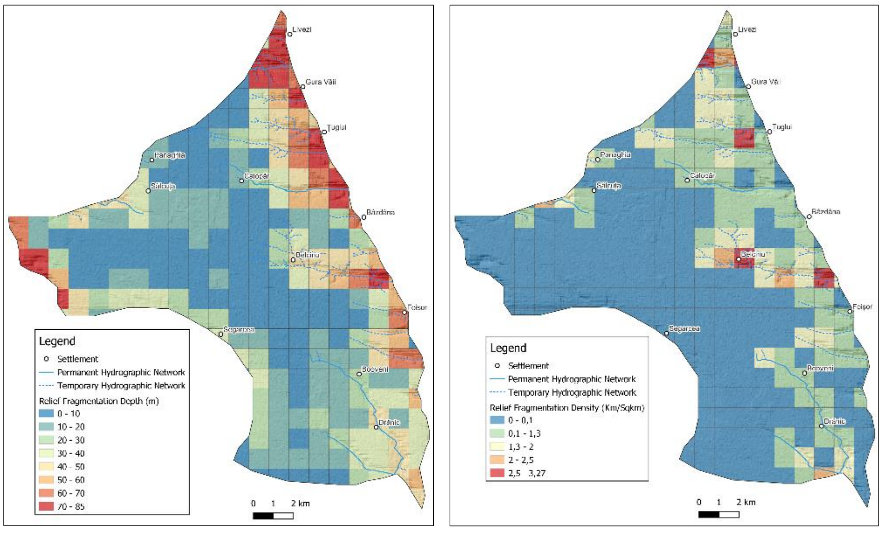

Fig. 4 – The value of relief fragmentation depth and relief fragmentation density in Sălcuța Plain.

According to dating conducted through the magnetostratigraphic and paleomagnetic methods in three subsections near Drănic locality in the Southern part of Sălcuța Plain by Rădan & Rădan in 1998, it was concluded that the age of the loess deposits reaches as far back as the Middle to Upper Pleistocene (Rădan, 2012).

2.1. Data and methods

The basis of this study consists in the analysing and interpretation of a complex geospatial database that includes both vector data and grid or raster data. All morphometric and statistical data were automatically calculated using the QGIS 3.22 software.

The vector delineation of the study area was obtained from the geo-spatial.org site and was carried out by Bogdan Candrea, Petronela Candrea, and Mihai Daniel Niță based on the "Geomorphological Regionalization of Romania - 1984" map compiled by Grigore Posea and Lucian Badea.

The vector data corresponding to the hydrographic network and localities were obtained from OpenStreetMap.

The entire geospatial dataset was georeferenced and reprojected in the Pulkovo 1942(58) / Stereo70 projection – EPSG 3844.

The working methods used in the identification and characterization of micro-depressions consist in the use of GIS tools (surfaces, spatial and nonspatial statistics, selection and extraction, overlay and proximity) in the analysis of different cartographic materials that reproduce the relief conditions, lithology, land use and land cover of the study area. Morphometric characteristics (elevation, slope, terrain fragmentation) of the study area were generated using SAGA GIS 7.8 based on the digital elevation model (DEM) with a spatial resolution of 20 meters, made available by the National Agency for Cadastre and Land Registration. Raster data takes a different approach. We used raster data as a backdrop to be used behind vector layers in order to provide more meaning to the future vector information.

For this study, the authors use QGIS 3.22 software tools for automatically calculated depression morphometry (area, perimeter, minimum and maximum extent). Land use determination was carried out through the analysis of the vector "Corine Land Cover" dataset from 2018 for to Sălcuța Plain. The soils affected by frost and stagnant processes were identified using the "Soil Map of Romania" on a scale of 1:200,000 published by the Institute of Pedology and Agrochemistry in Bucharest, from which all soil types in the study area were manually vectorized. The identified soil types were reclassified according to the Romanian Soil Taxonomy System of 2012.

Finally, depressions were identified and mapped using a series of satellite images from Google Earth Pro and Microsoft Bing platforms from the 2012–2019 period. Subsequently, the results were validated through field observation campaigns.

3. RESULTS AND DISCUSSIONS

3.1. Relief conditions

Following the inventory and mapping process using satellite imagery and field campaigns, 303 depressions have been identified (Fig. 2). These are concentrated in the Central and Western part of the study area where terrain fragmentation is low, and the drainage network is poorly developed. In addition to the reduced terrain fragmentation, the low inclination of the slopes (< 2 degrees) has enabled the formation and evolution of these depressions (Tănase *et al*., 2023).

The number of depressions has decreased over the past hundred years due to applied agricultural techniques, unclogging ploughing works (Stroe, 2003), and drainage channels, which have drained a significant portion of the depressions, causing many to disappear (*Răducă et al., 2021*). The removal of excess moisture and, consequently, compaction has allowed for land cultivation, but it has not eliminated the stagnant soil imprint and has contributed to bringing the carbonate illuvial horizon to the surface.

3.2. Main features of soil suffosion forms

From the total surface area of 220.59 km² of Sălcuța Plain, depressions take up 11.45 km² (5.2%), with an average density of 1.6 depressions/km², the highest density of depressions, ranging from 10 to 12 depressions/km², is recorded in the Central-Eastern part of the study area (Tănase *et al*., 2023).

The surface area of depressions varies from 0.00015 km² (minimum) to 1.26 km² (maximum), with an average of 0.04 km² (Table 2). The average perimeter is 0.58 km, with a maximum value of 5.81 km and a minimum value of 0.0455 km (Table 2).

Table 2

Values of the morphometric indicators for micro-depressions

Indicator	Average value	Maximum value	Minimum value
Area (m²)	0.04 km²	1.26 km²	0.00015km²
Perimeter (m)	0.58 km	5.81 km	0.0455km
Maximum extension (m)	0.22 km	2.32 km	0.0171km
Minimum extension (m)	0.13 km	0.86 km	0.0115 km

The shape of depressions varies from circular, oval, elliptical, elongated to irregular in some special cases. The dominant direction of elongation of micro-depressions is influenced by the direction of underground drainage (Fig. 2).

3.3. Soil degradation and LULC categories

Of all the land use categories (Table 1), 7 are affected by the presence of depressions (Table 3): non-irrigated arable land (9 km²), Broad-leaved forests (0.31 km²), pastures (0.03 km²), complex cultivation patterns (0.02 km²), vineyards (0.01 m²), industrial or commercial units (0.01 km²), discontinuous urban fabric (0.0058 km²).

Table 3

Land use categories affected by micro-depressions

Land use categories	**Spatial extension of micro-depressions (km²)**
Vineyards	0.01
Non-irrigated arable land	9.3
Broad-leaved forests	0.31
Industrial or commercial units	0.01
Discontinuous urban fabric	0.0058
Complex cultivation patterns	0.02
Pastures	0.03

The classes raising the most significant problems are non-irrigated arable land (Fig. 5), secondary pastures, complex crop areas, and vineyards because the presence of depressions in these areas leads to the accumulation of a significant amount of water at the surface topography level. In this case, two problems arise for agricultural crops, one in the short term and one in the long term.

The short-term problem is the excess of moisture that forms due to water accumulation. The direct and short-term effect is the alteration of the soil gas exchange process, affecting photosynthesis and respiration by reducing the oxygen supply to the plant roots (Cannarozzi *et al.*, 2018). The risk in this case is a decrease in agricultural production or even complete crop failure if the water stagnates for a prolonged period of time, a subject which will be tackled in a future research endeavour.

Fig. 5 – Non-irrigated arable land cultivated with wheat, affected by excess moisture – North of Calopăr, Sălcuța Plain. Photo by Tănase G, 2023.

On the long term, excess water leads to soil degradation through the formation of stagnogleic horizons, which are the product of surface water stagnation (Grigoraș *et al.*, 2004). The genesis of stagnogleic horizons is closely related to excessive moisture and reduced aeration over a certain timeframe, leading to reduction processes and the appearance of reduced iron (Fe) and manganese (Mn) compounds with a greenish-grey colour (Grigoraș *et al.*, 2004; Grigoraș *et al.*, 2009). In depressions, two types of soils with stagnogleic horizons have been identified: stagnant argic phaeozems and luvic stagnosols. Stagnant argic phaeozems take up about 0.4 km², have a clay-loamy texture, and pose a moderate risk of excess water in rainy years (*Soil Map of Romania* 1:200,000, 1964–1994). Luvic stagnosols cover a smaller area of about 0.3 km², have a similar structure but experience prolonged water excess each year (*Soil Map of Romania* 1:200,000, 1964–1994). Soil degradation through the formation of stagnogleic horizons in the agricultural area of these depressions is a medium- and long-term issue that can lead to a gradual decline in agricultural production.

A part of the micro-depressions, especially those with large surfaces, has been drained through drainage channels. Currently, the efficiency of drainage through this network of channels is low due to sedimentation and the vegetation cover.

In this case, the continuous monitoring of stagnogleization process in the depression area and the implementation of ameliorative measures are necessary. The most important ameliorative measure is draining the excess water from the depressions by extending the existing surface channel network. In this regard, a slight slope of the relief from West to East facilitates drainage. Through this measure, besides slowing down the stagnogleization process, the short-term problem of excess moisture can be controlled.

4. CONCLUSIONS

The chemical and mechanical compaction of loess deposits is the fundamental process that has led to the formation of 303 micro-depressions. The occurrence of the compaction process was favoured by the morphometric characteristics of the area, especially the low inclination (less than 2 degrees) and the limited fragmentation of the relief. The generally elongated shape of the micro-depressions is a result of the overall West-to-East inclination of the terrain, which allowed for easy surface water drainage along the aforementioned direction.

The most vulnerable categories are non-irrigated arable lands and areas with complex crops, as in these areas, micro-depressions have the largest spatial extent (9.31 km²) and the highest density (around 10 micro-depressions/km²).

Within the aforementioned categories, argic stagnic facies and luvic stagnosols have been identified, which exhibit stagnant gley horizons.

The depressions in the loess deposits at the level of Sălcuța Plain pose a serious problem for agricultural lands. In this regard, in the future, the issue may be extended to analyse how the accumulation of water at the topographic surface level has led to a reduction in cereal production in years with excessive precipitation.

REFERENCES

Banak, A., Pavelić, D., Kovačić, M., Mandic, O. (2013), S*edimentary characteristics and source of loess in Baranja (Eastern Croatia)*. Aeolian Research. **11**: pp. 129–139, https://doi.org/10.1016/j.aeolia.2013.08.002.

Boengiu, S. (2008), *Piemontul Bălăciței. Studiu de geografie*, Edit. Universitaria Craiova.

Buggle, B., Glaser, B., Hambach, U., Gerasimenko, N., Marković, S. (2011), *An evaluation of geochemical weathering indices in loess–paleosol studies*. Quaternary International, **240**(*1-2*), pp. 12–21, https://doi.org/10.1016/j.quaint.2010.07.019.

Cannarozzi, G., Weichert, A., Schnell, M., Ruiz, C., Bossard, S., Blösch, R. & Tadele, Z. (2018), *Waterlogging affects plant morphology and the expression of key genes in tef (Eragrostis tef)*. Plant direct, **2**(*4*), e00056. https://doi.org/10.1002/pld3.56.

Constantin, D., Mason, J.A., Veres, D., Hambach, U., Panaiotu, C., Zeeden, C., Zhou, L., Marković, S.B., Gerasimenko, N., Avram, A., Tecsa, V., Groza-Sacaciu, S.M., del Valle Villalonga, L., Begy, R., Timar-Gabor, A. (2021), *OSL-dating of the Pleistocene-Holocene climatic transition in loess from China, Europe and North America, and evidence for accretionary pedogenesis*. Earth-Science Reviews, **221**, 103769, https://doi.org/10.1016/j.earscirev.2021.103769.

Costea, Marioara (2018), *Investigations on some soil physical properties of lands affected by hydric erosion. Case study from Secaşe Plateau, Romania*. International Multidisciplinary Scientific GeoConference: SGEM, **18**(*3.2*), pp. 289–296.

Coteț, P. (1957), *Câmpia Olteniei*, Edit. Științifică, București.

Dinar, A., Esteban, Encarna, Calvo, Elena, Herrera, G., Teatini, P., Tomás, R., Li, Y., Ezquerro, P., Albiac, J. (2021), *We lose ground: Global assessment of land subsidence impact extent*, 786, 147415, https://doi.org/10.1016/j.scitotenv.2021.147415.

Erkens, G., Sutanudjaja, E. H. (2015), *Towards a global land subsidence map*. Proceedings of the International Association of Hydrological Sciences, **372**(*372*), pp. 83–87. https://doi.org/10.5194/piahs-372-83-2015.

Fagg, R., Smalley, I. (2018), *Hardcastle Hollows' in loess landforms: Closed depressions in aeolian landscapes – in a geoheritage context*, Open Geosciences, **10**(*1*), pp. 58–63. https://doi.org/10.1515/geo-2018-0005.

Florea, N. (1970), *Câmpia cu crovuri, un stadiu de evoluţie al câmpiilor loessice. Studii tehnice şi economice*, București.

Galloway, D. L., Erkens, G., Kuniansky, E. L., Rowland, J. C. (2016), *Preface: Land subsidence processes*. Hydrogeology Journal, **24**(*3*), pp. 547–550. https://doi.org/10.1007/s10040-016-1386-y.

Grecu, Florina (2019), *Geografia câmpiilor României*. Edit. Universității din București.

Grecu, Florina, Gherghina, Carmen-Alina, Ghiţă, Cristina, Chaouki, Benabbas (2015), *The loess micro-depressions within the Romanian Plain. Morphometric and morphodynamic analysis*, Revista de Geomorfologie, **17**, pp. 5–18.

Grigoraș, C., Boengiu, S., Grigoraș, E. N. (2003), *Noțiuni de bază în știința solului*. Edit. Universitaria Craiova. Craiova.

Grigoraș, C., Boengiu, S., Vlăduț, A., Grigoraș, E. N. (2009), *Solurile României,* Vol I. Edit. Universitaria Craiova.

Herrera-García, G., Ezquerro, P., Tomás, R., Béjar-Pizarro, M., López-Vinielles, J., Rossi, M., & Ye, S. (2021), *Mapping the global threat of land subsidence*. Science, **371**(*6524*), pp. 34–36. https://doi.org/10.1126/science.abb8549.

Ielenicz, M., Comănescu, Laura, Nedelea, Al., Bogdan, M., Oprea, R., Pătru, I. (1999), *Dicționar de geografie fizică*, Edit. Corint, București.

Kołodyńska-Gawrysiak, Renata, Jean, Poesen (2017), *Closed depressions in the European loess belt – Natural or anthropogenic origin?* Geomorphology. **288**, pp. 111–128. https://doi.org/10.1016/j.geomorph.2017.02.004.

Kołońdyska-Gawrysiak, Renata, Mroczek, P. Chodorowski J., Plak, A., Kiebała, A., Zgłobicki, W. (2015), *Human-induced landscape evolution in the loess areas of Lublin Upland, E Poland: evidence from pedosedimentary archives in closed depressions*. Zeitschrift für Geomorphologie. **59**, pp. 155–175. https://doi.org/10.1127/zfg_suppl/2015/S-59209.

Kołodyńska-Gawrysiak, Renata (2019), *The impact of palaeorelief on the origin of some closed depressions in loess areas in the Lublin Upland*. Polish Journal of Soil Science, **52**(*1*), 1. https://doi.org/0.17951/pjss/2019.52.2.295.

Marković, S., U., Hambach, T., Stevens, M., Jovanović, K., O'Hara-Dhand, B,. Basarin, H., Lu, I., Smalley, B., Buggle, M., Zech, Z., Svirčev, P., Sümegi, N., Milojković, L., Zöller, L. (2013), *Loess in the Vojvodina region (Northern Serbia): An essential link between European and Asian Pleistocene environments*. Netherlands Journal of Geosciences – Geologie En Mijnbouw, **91**(*1-2*), pp. 173–188. https://doi.org/10.1017/S0016774600001578.

Meszner, S., Kreutzer, S., Fuchs, M., Faust, D. (2013), *Late Pleistocene landscape dynamics in Saxony, Germany: Paleoenvironmental reconstruction using loess-paleosol sequences*. Quaternary International, **296**, pp. 94–107. https://doi.org/ 10.1016/j.quaint.2012.12.040.

Mörtsjö Zung, W. (2023), *Reconstructing Mid-Late Holocene Arctic Climate Using Loess Deposits From Kangerlussuaq, Greenland*. Uppsala Universitet Uppsala (www.geo.uu.se).

Peric, Z., Stevens, T., Obreht, I., Hambach,U.F. Lehmkuhl, F., Markovic, S. (2022), *Detailed luminescence dating of dust mass accumulation rates over the last two glacial-interglacial cycles from the Irig loess-palaeosol sequence, Carpathian Basin*. Global and Planetary Change. **215**. 103895. https://doi.org/10.1016/j.gloplacha.2022.103895.

Posea, G. (2006), *Geomorfologia României. Relief – Tipuri, Geneză, Evoluție, Reginoare.* Ediția a II a revăzută și adăugită. Edit. Fundației România de Mâine, București.

Posea, G., Popescu, N., Ielenicz, M. (1974), *Relieful României*, Edit. Științifică, București.

Posea, G., Badea, L. (1984), *Republica Socialistă România. Unităţile de relief. Regionarea geomorfologică,* Edit. Ştiinţifică şi Enciclopedică, Bucureşti.

Posea, G., Bogdan, Octavia, Zăvoianu, I., Buza, M., Bălteanu, D., Niculescu, Gh. (editori) (2005), *Geografia României, vol. V, Câmpia Română, Dunărea, Podişul Dobrogei, Litoralul Românesc al Mării Negre şi Platforma Continentală*, Edit. Academiei Române, Bucureşti.

Protopopescu-Pache, E., Crăciun, F., Popescu, D. (1966), *Loessuri şi pământuri loessoide ca roci macroporice în RSR*, Hidrotehnica, **II**, *6*.

Rădoane, Maria, Dumitriu, D., Ichim, I. (2020), *Geomorfologie – volumul II*. Edit. Universității Suceava, Suceava.

Rădan, S. C. (2012), *Towards a synopsis of dating the loess from the Romanian Plain and Dobrogea: Authors and methods through time,* Geo-Eco-Marina, București -Constanța, Romania, **18**, pp. 153–172.

Răducă, C., Crişu, Lavinia, Boengiu, S. (2019), *Aridity risk in the west of the Oltenia Plain: natural factors and human impacts on land degradation*. Forum geographic, **18** (*2*), pp. 143–152. https://doi.org/10.5775/fg.2019.052.d.

Răndan, S. C., Rădan, Maria (1998), *Study of the geomagnetic field struc-ture in Tertiary in the context of the magnetostratigraphic scaleelaboration. I – The Pliocene*, Anuarul Institutului Geologic al României, Bucharest, **70**, pp. 215–231.

Roberts, H. M. (2019), *Aeolian Geomorphology: A New Introduction*. Wiley-Blackwell, New Jersey.

Simulescu, D., Grigoraş, C. (2016), *Classification, typology and distribution of solification rocks in Romania*, Forum Geografic, no. **XV**, Issue *2*, Edit. Universitaria, Craiova, pp. 162–170, doi:10.5775/fg.2067-4635.2016.166.d

Smalley, I., Marković, S. B., Svirčev, Z. (2011), *Loess is [almost totally formed by] the accumulation of dust. Quaternary International*, **240** (*1-2*), pp. 4–11. https://doi.org/10.1016/j.quaint.2010.07.011.

Smalley, I., Marković, S. B. (2019), *Controls on the nature of loess particles and the formation of loess deposits*. Quaternary International, **502**, pp. 160–164. https://doi.org/10.1016/j.quaint.2017.08.021.

Stroe, R. (2003), *Piemontul Bălăciței. Studiu geomorfologic*, Edit. MondoRo, București.

Tănase G., Boengiu S., Mititelu-Ionuș O., Simulescu D. (2023), The influence of topograpyhy on the subsidence processes of loess-like deposits from Sălcuța Plain (South-Western Romania). Annals of the University of Craiova Series Geography. 24. 18–28. 10.52846/AUCSG.24.02.

Tufescu, V. (1966), *Modelarea naturală a reliefului și eroziunea accelerată*, Edit. Academiei, București.

Újvári, G., Varga, A., Balogh-Brunstad, Z. (2008), *Origin, weathering, and geochemical composition of loess in southwestern Hungary*. Quaternary Research, **69**(*3*), pp. 421–437. doi:10.1016/j.yqres.2008.02.001.

Újvári, G., Kok, J.F., Varga, G., Kovács, J. (2016), *The physics of wind-blown loess: Implications for grain size proxy interpretations in Quaternary paleoclimate studies*. Earth-Sci. Rev. **154**, pp. 247–278. https://doi.org/ 10.1016/j.earscirev.2016.01.006.

Vlăduț, Alina (2011), *Temperature – Humidity Index (THI) within the Oltenia Plain between 2000 and 2009*. Forum Geografic – Studii și cercetări de geografie și protecţia mediului, **10**(*1*), pp. 149–156, https://doi.org/10.5775/fg.2067-4635.2011.033.i.

Zhuang, J., Peng, J., Zhu, Y., Leng, Y., Zhu, X., Huang, W. (2021), *The internal erosion process and effects of undisturbed loess due to water infiltration*. Landslides, **18**(*2*), pp. 629–638 https://doi.org/10.1007/s10346-020-01518-z.

*** (1983), *Geografia României*, Vol. I, Geografia Fizică, Institutul de Geografie, Edit. Academiei, Bucureşti.

*** Harta solurilor României 1:200.000 (1964–1994), *Institutul de Pedologie și Agrochimie București*.

*** (2012), *Sistemul Român de Taxonomie a solurilor (SRTS)* [Romanian Soil Taxonomy System], Edit. Sitech, Craiova

https://www.bing.com/maps/

https://earth.google.com/

http://www.geo-spatial.org/

https://geoportal.ancpi.ro/portal/home/

http://land.copernicus.eu/pan-european/satellite-derived-products/eu-dem/eu-dem-v1.1/view -

https://land.copernicus.eu/pan-european/corine-land-cover/clc2018

https://www.openstreetmap.org/

Received September 19, 2023