LOESS WAS FORMED, BUT NOT SEDIMENTED

NICOLAE FLOREA[*]

Key-words: loess genesis, concomitant sedimentation, soil-forming, accretion, diagenesis, profound soil layer, loess formation areas.

Le lœss s'est formé, mais il ne s'est pas déposé. L'article expose un nouveau scénario pour la genèse du lœss comme roche sédimentaire. Le lœss s'est formé par une action concomitante des suivants processus: une sédimentation faible et régulière des matériaux aleuritiques, notamment transportés par vent, un processus du formation du sol avec l'intégration de la poussière déposée (pédogénèse sédintégrante) et une accrétion graduelle déterminée par la sédimentation continuelle de la poussière et son intégration dans le sol, de sorte que l'horizon supérieur du sol, antérieurement formé, devient couche profonde qui n'est plus influencée par les facteurs et processus pédogénétiques. En continuation cette couche est transformée par diagenèse en lœss avec ses propriétés spécifiques. La genèse du lœss est donc le résultat du processus complexe de sédimentation, solification, accrétion et puis diagenèse, et non un simple processus de sédimentation. En espace et en temps on peut distinguer trois aires de formation du lœss: *une aire toujours aride*, sans oscillations climatiques significatives, avec formation continuelle du lœss sans intercalation de sols; *une aire intermédiaire*, aux oscillations climatiques entre arides et humides, avec formation d'une alternance des lœss et des sols (sol tchernozemiques, sol luvisoliques); *une aire toujours humide*, sans oscillations climatiques significatives, avec évanouissement de la formation du lœss, qui conduit à la formation de sols très profonds sans couche de lœss (étant intégré dans les sols). On ne peut pas dire "sédimentation du lœss" ou "le lœss à été déposé"; c'est la poussière qui a été déposée, mais le lœss a été formé.

The Quaternary period began with climate cooling and glaciation, well expressed in the northern part of the boreal hemisphere. This period developed with many climatic cyclic variations, very cool periods (glacial) alternating with relatively warm periods (interglacial). A glacial cycle (glacial and interglacial) covered some 120,000 years, out of which the interglacial lasted about 10,000–20,000 years. These contrasting climatic events reverberated at low latitudes (subtropical zone) by pluvial and inter-pluvial periods.

One of the main phenomena produced in zones located around the ice-cap – shifting in time – and in the desert and around desert areas was loess formation, often with intercalated brown bands considered generally to be fossil soils.

The term loess, introduced (1834) by Charles Lyell (1797–1875), originates from the German word "lose" (*loose*).

Loess is defined as a sedimentary unconsolidated aleurite rock, unstratified, formed in the Quaternary, loose, with high porosity and detachment along the vertical faces, generally having 12–25% calcium carbonates, yellowish in colour.

There are many loess studies synthesized in some works by several different authors: Charlesworth (1957), Ložek (1964), Conea (1970), Ruhe (1971), Yaalon (1971), Tsatskin (1997), Smalley *et al.* (1997) and others.

* PhD. eng., *"Gheorghe Ionescu-Şişeşti"* Academy of Agricultural and Forestry Sciences, B-dul. Mărăşti, no. 61, Sector 1, 011464, Bucharest, Romania.

OPINIONS ON LOESS FORMATION

Loess genesis is one of the most discussed and controversial problems in the geological, geographical and pedological literature. In their study of loess and loess-like deposits, Marossi (1970) and then Gherghina, Grecu and Coteț (2006) brought together many theories and hypotheses on the origin of these formations, grouping them by 5 categories:

– *aquatic origin theories*: marine, lacustrine and lacustrine-glacial (currently considered obsolete), or fluvial and fluvio-glacial (regarded at present as ways of transport and accumulation of loess component materials);

– *sub-aerial origin theories*, very important being the *aeolian theory* Richthofen 1878, 1882; Tutkovskii 1899, Obruchev, 1911, 1945, 1950, 1957, and numerous other researchers), which is also the most widely embraced one; according to it, the dust transported and deposited by the wind has originated from neighbouring deserts, from periglacial zones or from local sources;

– *theories of loess accumulation through slope processes* (deluvial, colluvial or proluvial), generally associated to other processes;

– *the polygenetic theory,* which considers loess to be the result of many continental sedimentation agents, one of them playing a dominant role in certain conditions;

– *loessification theories* (Berg 1916, 1940; Gerasimov 1964) assume that loess with its specific features is the product of weathering and the soil formation process in the loessification zone specific to the siallite – carbonate weathering earth crust zone. According to *the pedological theory of loess formation* (L.S. Berg) "loess should be considered as a soil eluvial formation arising in a normal manner from its parent material, in an environment of desert climate which was prevailing in a postglacial time". This theory gave rise to a fierce discussion in the former Soviet Union, exposed by Smalley and Rogers (1997). Berg's pedological theory received partial support in Russia from Gerasimov[1] (1964) and no support outside Russia. "If loess represents a normal soil formation, the presence of its deep homogeneous thickness at a depth of 5 to 10 m, and even 20 m … refutes Berg's hypothesis, since with the process of soil-formation forming soil, in the usual sense of the word, the transformation of any layer of a mechanical consistency corresponding to that of loess can be explained only at a depth of 2 to 3 m" (quoted from Smalley and Rogers, 1997, p. 388).

In Romania, loess layers and loess-like strata are widespread in the Danube Plain, the Dobrodgea Tableland, the Moldavian Tableland, the Transylvania Plain and in intra-mountainous and intrahilly depressions, especially on different terraces. From the published works of Macarovici (1968) and Conea (1970) it seems that the aeolian theory of loess formations was in general the most backed-up one (by L. Mrazec, Sava Athanasiu, Gh. Murgoci, P. Enculescu, N. Florov, C. Brătescu, M. Popovăț, M. Spirescu, Ana Conea, C.V. Oprea, N. Florea, N. Băcăințan and others). Dust was considered by Mrazec originate from the southern regions of the Ukrainian steppe, while Murgoci and then Ana Conea showed it the Lower Danube Plain dust to come from the alluvial deposits of the large river valleys running across the plain, fact that entitled N. Macarovici to attribute an alluvio-aeolian origin to the loess of this plain. In Dobrogea and in some lower mountainous areas, the alteration products of rocks from proeminent massifs can also be added (alteration products transported by wind or by surface running waters).

Loess genesis from alluvial sediments was described by I. Simionescu, I. Atanasiu and N. Bucur and N. Barbu, the last ones attributing it (1956) a fluvial origin combined with the loessification process for the loesses of Moldavian terraces. Loessification is defined as a diagenetic process whereby the sediments with a certain granulometrical composition (alluvial deposits, marls) acquire loess features under the influence of geochemical alteration processes. The granulometrical composition, a certain $CaCO_3$ content, aridity and alteration play an important role in this process. The authors proposed the term loess-like rocks for the rocks formed by diagenesis and the term loess only

[1] In 1971, Gerasimov considered loess as pedolith. This term was also used by H. Erhart (1965 and Pecsi).

for the aeolian formations. Also, Oprea and Contrea (1956) consider that the loess of the Mureş Plain was formed by the loessification of certain fluviatile deposits. Also Florea *et al.* (1966, 1989) underlined the role of aeolian accretion and of "sedintegration by soil forming process of the deposited dust, as well as of diagenesis in the process of loess formation".

The hypothesis of the deluvial-prolluvial origin of loess-like materials was sustained by E. Liteanu and his disciples.

N. Bucur and N. Barbu in their turn (1959) support loess formation by the alteration of old clayey deposits (Sarmatian) through a process of loessification.

A new modality (model) of loess genesis as geological formation (non deposit) by concomitant sedimentation – soil forming and subsequent accretion and diagenesis (Florea 2002, 2009) has recently been presented, and developed in this paper with some modifications.

CONDITIONS NECESSARY FOR LOESS FORMATION

Loess formation depends on certain conditions occurring simultaneously:

– a certain stability of geomorphic conditions;

– some bioclimatic conditions of aridity and a desert or steppe vegetation;

– the existence of rich deposits of aleurite materials – as source of dust – or certain circumstances favourable to generating continuously large quantities of such material, as for example: aleurite material resulted from the alteration in situ of some rocks, especially in areas with rocky massifs, as is the case of certain mountaineous and hilly regions, which are a common supplier of this material; material of physical alteration by gelifraction of surface deposits, obviously under propitious climatic conditions (periglacial area with moraines and other glacial deposits, desert or semi-desert areas with scarce vegetation); material resulted from the transport and sedimentation of running waters in fluvio-glacial plains, floodplains, etc.;

– the existence of transport agents, such as wind blowing from a dominant direction (that of the source of aleurite material), and being high enough to transport by air particles of dust and very fine sand over long distances (coarser particles are left in the "source" area, generally sand remains modelled as a rule into dunes), or running waters on slopes;

– conditions of relatively slow and regular sedimentation of the aleurite material carried by the wind and fixed on land surface as the force of wind diminishes, the vegetation cover is able to retain the dust, shelter and stabilize it, etc.

All these conditions occur especially around deserts and former glacial areas and along river valleys, fact that explains why loess is wide spread in these areas.

If in time climatic conditions are changing and pass from arid or sub-arid to sub-humid or humid, loess formation ends up in soil formation (Luvic Chernozem-like or Luvisol-like), which interrupts the vertical continuity of the loess layer by the soil layer formed, which in the course of time can become fossil soil.

Loess formation can also begin on aleurite deposits of different origins by the soil-formation process associated closely with continuous aeolian sedimentation.

A NEW SCENARIO OF LOESS GENESIS BY CONCOMITANT SEDIMENTATION – SOIL FORMING – ACCRETION AND THEN DIAGENESIS OF THE LOWER PART OF THE SOIL WHICH TURNED INTO DEEP SOIL

Synthesizing opinions on the origin of loess in a relatively simple, but comprehensive manner, shows that loess formation is a complex natural process characteristic of the arid – sub-humid zone, whereby different dominant aleurite sediments from the surface of the earth are transformed into loess or loess-like deposits. The largest loess areas are widespread in the vicinity of deserts and in periglacial zones.

The complex process of loess genesis consists in the simultaneity of phenomena described in the following (a-d):

a) The relatively slow and continuous sedimentation of the aleurite material transported especially by wind (but locally also by running surface waters particularly during the first phase), from the neighbouring area, sometimes from long distances, and deposited in arid zones on land surface; according to studies carried out in the USA (Ruhe *et al.* 1971) and in Romania (Conea 1970), loess layer thickness decreases with the distance from the source, but its texture becomes finer and finer. Very frequently the material close to the source is coarse and modelled in the form of dunes.

b) *The continuous soil-forming of the deposited material* (of the type of seraziom or loess like soil according to Murgoci, 1910, or even Chernozem) by processes of weathering and pedogenesis specific to the relatively arid zone, processes which take place simultaneously with continuous sedimentation in the layer situated at the surface, elevating the earth's crust and thickening the soil horizons (sedintegrating soil-forming);

c) *The soil accretion*, *i.e.* the gradual rising of the land surface and also of the soil by continuous deposition and concomitant soil formation (sedintegrating) of the deposited aleurite material so that, in time, the surface soil (previously formed) becomes a layer situated at ever greater depth that will no longer be influenced by alteration and soil forming processes specific to the respective zone (arid). In the soils of the Romanian Danube Plain developed in loess, the age at different depth (Munteanu *et al.* 1977) determined by ^{14}C method in The Netherlands laboratories, is of 1,000–2,000 years for A horizon, 6,600–9,100 years for Bv and Bt horizons and 13,000–26,000 years for loess at 200 cm depth, average rate of soil growth (accretion) is of 0.2–1.0 cm per century for soil and 0.5–2.5 cm per century for loess. Similar data were presented by Scharpenseel (1971) for Chernozems, namely 5,000 years at 100 cm depth and about 15,000 years at 245 cm depth (for a Chernozem from Orel, Russia).

These data prove without doubt that soil is rising (growing) in time (aeolian accretion); one can also deduce that the sedimented material on the soil surface was subjected to a soil-forming process (in A horizon) for about 2,000 years, a process whereby the deposited material accumulated humus, acquired a dark colour, became structured, homogeneous and porous without stratification traces; also a $CaCO_3$ migration with carbonate-illuvial horizon formation took place, etc.

d) *Diagenesis of the deep layer* – previously subjected to soil forming processes – after the loss of a direct connection with land surface processes; by this diagenesis some soil features are lost, for example the humus content (due to the mineralization of the organic matter and to the lack of annual addition of organic remnants) and macrostructure, etc, but others are preserved, for example the microstructure (Postolache 1966; Florea *et al.* 1987), high loosening and porosity, vertical direction of the tubular pores, lack of stratification, etc. Thus, the layer situated below the soil cover (from the surface) is transformed into loess, a process sometimes named proper loessification, (broadly speaking according to this concept loess formation, loessification or loessifying includes, all the above-mentioned processes).

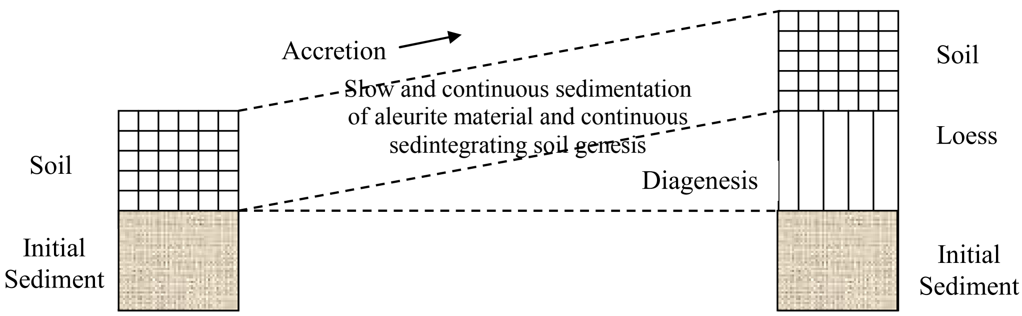
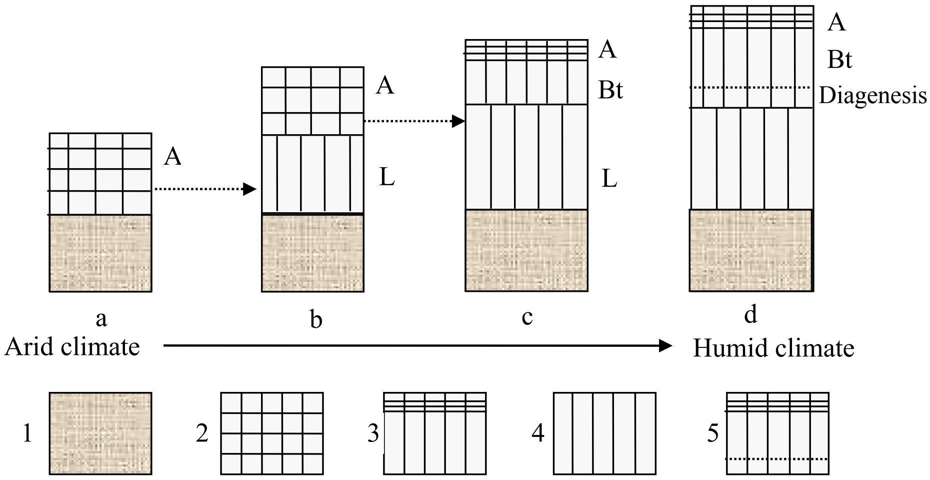


Fig. 1 – Scheme of the interaction of sedimentation, accretion, sedintegrating soil genesis and diagenesis in the process of loess formation.



1 – Initial sediment. 2 – Soil with humus accumulation (Calcisol, Cernisol) in arid or steppe climate. 3 – Soil with clay and/or oxides illuviation. 4 – Loess. 5 – Soil with clay and/or oxides illuviation, deep soil; the lower part of the soil is transformed by diagenesis into old soil.

Fig. 2 – Loess forming as a dynamic complex process closely correlated with sedintegrating soil-forming process in the arid-subarid climate. Stages of loess forming by concomitant processes of: *a* – slow and continuous sedimentation and sedintegrating soil-forming in arid conditions; *b* – sedimentation and sedintegrating chernozemic soil forming, soil accretion and diagenesis of the lower soil part (which turned into deep soil) with its transformation into loess in an arid-semiarid climate; *c* – sedimentation, sedintegrating eluvio-illuvial soil forming, soil accretion and diagenesis of the lower soil part with its transformation into loess in a semiarid-semihumid climate; *d* – sedimentation, sedintegrating eluvio-illuvial soil forming, soil accretion and diagenesis of the lower soil part with its transformation into old soil in a humid climate (without loess forming), unseparated ("welded") from the actual soil.

This complex loess-forming process involves concomitant and successive occurrence of the various phenomena mentioned above, whose interaction is schematically rendered in Figure 1 in the conditions of arid-to-sub-arid regions.

If the climatic conditions change becoming humid, the complex process of loess genesis ends with (is interrupted by) a soil (Bt horizon) that cannot be transformed into loess, but into brown clay layer (argilith).

Figure 2 presents schematically the evolution phases of the complex loess genesis process with the climate changing from arid to humid; the whole process of loess forming is presented in the legend and needs few explanations. One finds that loess is formed only in the conditions of a relatively arid climate, because the transformation into loess of the soil illuvial B horizon (formed under humid climatic conditions) is not feasible; this horizon (layer) can become buried Paleosol in time.

This loess formation model can be designated in short as the hypothesis (theory) of loess genesis by concomitant sedimentation, soil-forming, accretion and subsequent diagenesis or, more explicitly, the hypothesis of loess genesis by the sedimentation process of aleurite material and its concomitant soil-formation in an arid zone, followed by subsequent accretion and then by diagenesis of the *lower part* of the previously formed soil (the consequence of its surface rising due to continuous deposits of aleurite material piling up, accretion).

This model integrates especially data on arid regions and represents a combination between Berg's soil genesis theory of loess formation and the other theories, particularly the aeolian theory. It also explains the possibility of thick loess strata formation in the conditions of steady accretion in continuously arid conditions.

Nevertheless, the origin of the aleurite material (the dust) which generated the loess is predominantly aeolian; in the hilly regions and in the piedmont plains other similar granulometrical materials (deluvial, prolluvial) can also interfere with the aeolian ones or can interrupt vertical loess continuity.

According to this loess genesis concept, loess is considered to be a complex sedimentary rock and not simply a deposit. Although during the formation process loess passes through a soil phase, so that it can be considered fossil Paleosol (G. Murgoci 1910), yet by its attributes loess constitutes a sedimentary rock formed though the diagenesis of an aleurite sediment previously subjected to a soil forming process in a relatively arid climate, so that it can be considered a pedolith as well (in the sense of Gerasimov 1971).

Therefore, expressions such as “loess was deposited” or “loess sedimentation produced…” seem to be inadequate because “dust” was deposited, then transformed into a true geological rock.

The new view on loess genesis brings clarifications on the material origin, climatic conditions of formation and relationships with fossil and actual soils. It also has implications concerning the stratigraphic significances of loess layers, buried fossil soils and the interpretation of climatic variations in the Quaternary; the local-regional value of all interpretations of loess sequences and fossil soils (sequences of pedoliths) is also noteworthy.

FORMS AND AREAS OF LOESSIFICATION IN THE PERIGLACIAL REGION

The loess-forming (loessification) process correlated with the soil-forming process develops non-uniformly in space and time in the region that has conditions propitious to loessification. Based on this new scenario of loess genesis and on the model of the loess – fossil soil sequences formation (Florea 1966), some forms of this loessification process can be distinguished, having various and variable extent in the territory.

The diagenesis (loessification) of the layer situated under the soil develops normally – according to the process described above – if the soil which is forming on the land surface is a Calcisol (Aridisol) and desert or steppe bioclimatic conditions also exist. But these bioclimatic conditions could change (cyclically) in the course of time, becoming more and more humid and, after a certain period, the climatic cycle will start again.

Of course, in parallel with the change of bioclimatic conditions over time, corresponding changes also occur in the other environmental conditions, gradually altering the processes of sedimentation, soil-forming and diagenesis as well. The following situations can be distinguished:

– If the Quaternary climate remained continuously relatively arid in a certain place of the periglacial area (Figs 3 on the left and 4a), then the soil stratum (with humus) reached at depth (by accretion) would be transformed by diagenesis at a rate similar to that of soil-forming on land surface, so that the vertical column of the formed loess is relatively uniform (without coloured bands). Continuous loess forming takes place steadily (in areas with relatively arid conditions without notable oscillations).

– The global climate change modifies the environmental conditions of the respective place and the steppe-to-sylvosteppe transition conditions with Chernozem formation on land surface. In this case, the evanescence of the dark horizon (with humus), previously formed and reached at depth (by accretion) after a period of sedimentation reactivating, needs more time so that this layer remains for some time in the loess-soil column as a blackish layer between two loess layers; as a rule, such situations occur in recent loess layers, but not in the older ones, as a consequence of evanescence by diagenesis. The climatic oscillations from arid to sub-arid (sub-humid) are, therefore, characterized by loess formation with intercalations (bands) of fossil chernozemic soils.

If the climate of the respective place changes from arid to humid (in parallel with Quaternary climatic fluctuations) dust sedimentation becomes more reduced (and with finer dust) and the concomitant development of sedimentation and soil-forming processes takes another course. Soil accretion (or growth) is very slight, so that the alteration and soil-forming processes lead to the formation of a soil with Bt horizon enriched in clay, of reddisher colour, of variable thickness depending on the duration of the humid period.

The transition to a new arid climatic period leads to the intensification of dust transport and sedimentation and in this way to processes described for loess genesis will resume.

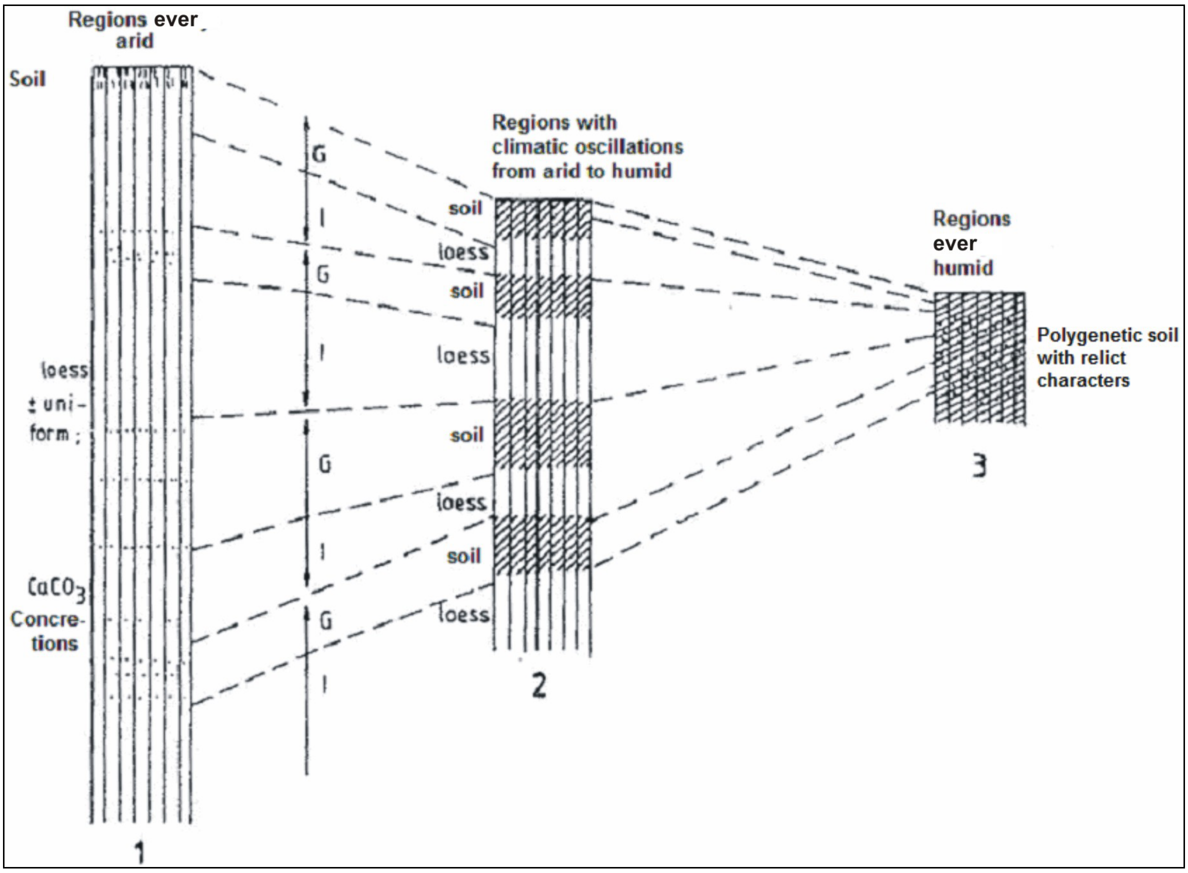


Fig. 3 – Scheme of correlation between loess forming and soil forming during the Quaternary in tabular periglacial areas with different climatic oscillations.
1 – all-time arid climate; *2* – climatic oscillations from arid to humid; *3* – all-time humid climate.

This new loess will cover the soil of the previous humid period, of which Bt horizon largely keeps its features because it cannot be "loessified" by diagenesis, so that it remains as a brown coloured band, clayey, perceived as fossil soil between two loess layers. The band (layer) of fossil soil finishes, then, one cycle of climatic evolution of sedimentation – soil-forming from arid climate (loess) to humid climate (fossil soil). The new loess marks the beginning of a new climatic arid-humid cycle. The climatic oscillations from arid to humid are thus characterized by loess formation with intercalations of fossil (luvisol-like) soils, clayey (Fig. 3 in the center and 4).

– If the climate in the respective place was and remained humid throughout the period of climatic oscillations and if sedimentation remained insignificant, the soil-forming process exceeded the dust sedimentation intensity, so that in the course of time well-developed soils with Bt horizon, clayey and deep, get formed; the deposited dust is integrated into the soil, so that a loess layer will not be differentiated. The soil that is forming on the land surface is in fact a profound present-day paleosol which self-"condenses" over a long period of time; the upper part is of course active as actual soil, but the lower part (below 2 m) is more or less changed by diagenesis, acquiring rock features (pedolith).

In this case, the relative humid climate was characterized by insignificant oscillations, favouring soil-forming to the detriment of sedimentation and loessification, and resulting the continuous formation of a paleosol, the lower part of which is a pedolith, lacking loess layers (Fig. 3 on the right and 4u).

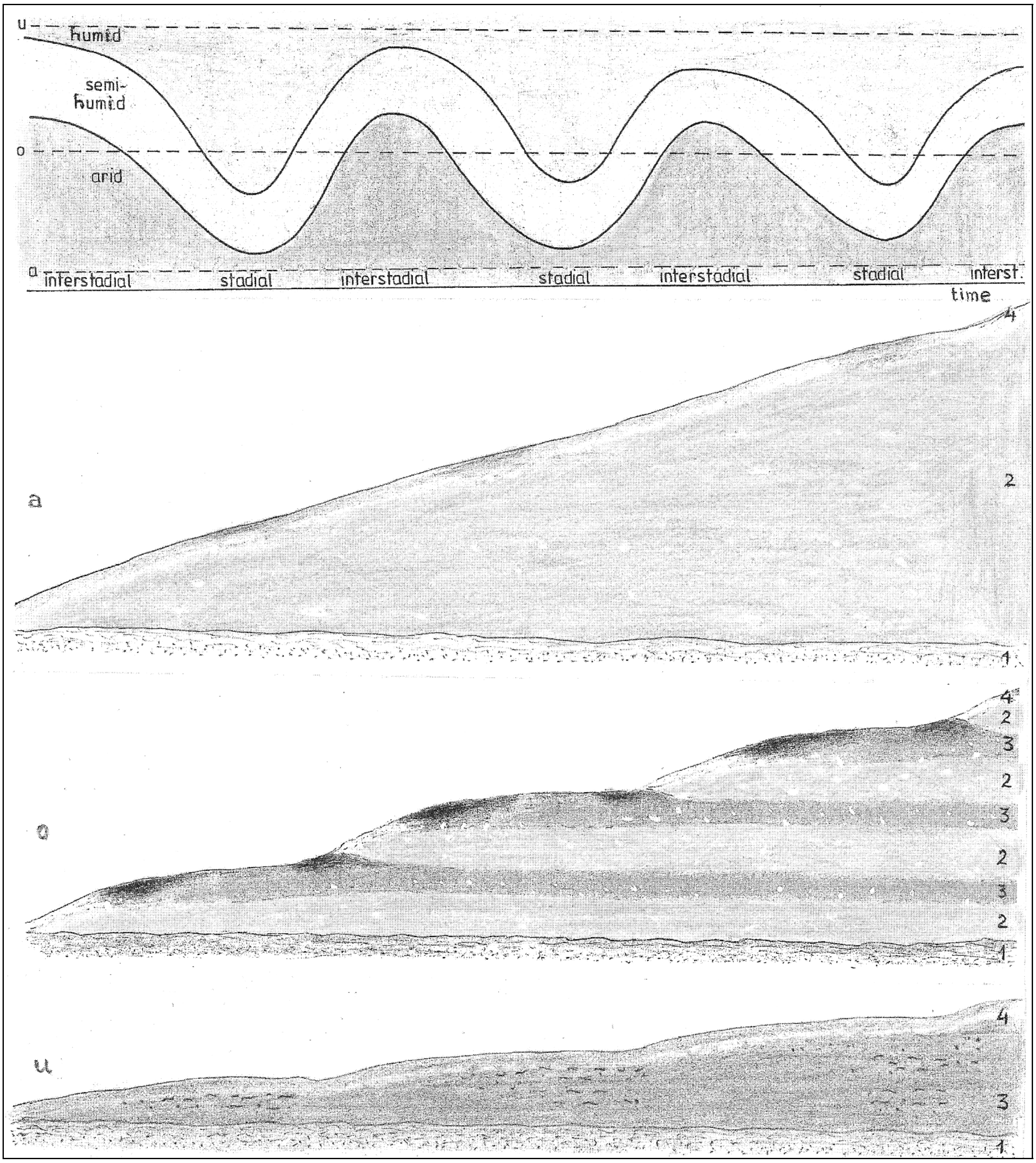


Fig. 4 – Scheme of some loess – fossil soil sequence fluctuations in time (in correlation with advances and withdrawals of the ice-cap) and in space (in areas or locations with different climatic oscillations): a – area with insignificant climatic oscillations in arid climate; o – area with climatic oscillation from arid to humid; u – area with insignificant climatic oscillations in humid climate. (*1* – fluvial deposit; *2* – loess; *3* – fossil soil; *4* – present-day soil; *o* – concretions of $CaCO_3$ *iron* oxides neoformations; ~ – cryogenic features).

A similar opinion is advanced by Dan and Yaalon (1971) for the paleopedological formations in the coastal desert fringe areas near the Mediterranean Sea. Also, Yaalon (1990) finds that uninterrupted "aeolian deposition and pedogenesis could produce the continuous bands of soil horizons (complex or welded profiles)". In this case, "more than one soil forming period and/or sedimentation of new material, when it is less than the depth of pedogenesis, are the cause of the superposition. Such sections are frequently difficult to recognize and interpret".

Taking into account the ratio between sedimentation intensity and soil-forming intensity and its modification in the course of the Quaternary, some main areas of loess genesis and pedogenesis can be distinguished in the periglacial zone, namely (Fig 4, upper part):

– ever-arid area of continuous loessification with formation of the loess layer without apparent intercalations of fossil soils, in which sedimentation and loessification are active and pedogenesis is slight (loessifying pedogenesis); it corresponds to the territories relatively far from the glacial region or near the desert region, in which the climatic conditions were permanently more or less arid and dust-sedimentation intense;

– arid-to-humid oscillation area of intermittent loessification, with formation of sequences of loess layers and fossil soils (Fig. 4.o), in which arid and humid conditions are succeeding each other in the course of time, as are the corresponding sedimentation-soil-forming conditions; two sub-areas may be distinguished, a first one in which buried Chernozem-like soils appear, corresponding to climatic variations from arid to sub-humid, and the second one in which buried soils with Bt clayey brown or reddish appear, corresponding to climatic oscillations from arid to humid; often the two sub-areas are succeeding each other in time, so that the two categories of fossil soil in the loess layer appear superposed;

– ever-humid area of evanescent loessification, with formation of deep soils (Fig. 4u), pedogenesis being very intense, sedintegrating and superimpressing, with slight sedimentation and integration of the deposited dust in the soil, without forming loess layers, take place.

Considering the loess layers and fossil soils as pedoliths (Gerasimov 1971; Florea 2009), the mentioned areas can be designated as: *area of continuous loessification, area of successive loessification and pedargithification and area of continuous pedargithification (sedintegration)*.

There are, of course, very different situations of transition among these types of areas. It must be pointed out that the periods of different climatic conditions do not always correlate with the evolution periods of glacial phenomena.

WERE LOESS AND FOSSIL SOILS FORMED IN THE GLACIAL (STADIAL) OR INTERGLACIAL (INTERSTADIAL) PERIOD?

A question raised in discussion and very much debated was the chronological relationship between loess layers and soils, on the one hand, and the glacial and interglacial (stadial and interstadial) phases, on the other. Some researchers think that the loess layers formed in the glacial (stadial) phase and that the soil was created in the interglacial (interstadial) period, an opinion defended in Romania by Popovăț, Conea and others; yet, other researchers consider that the soil formed in the more humid glacial (stadial) periods, and the loess layers in the more arid interglacial (interstadial) periods, opinion argued in Romania by Protopopescu-Pache and Spirescu (1961).

In order to find an answer to this question it is necessary to scrutinize the location of the loess–fossil soil sequence in time and space as opposed to the ice-cap region. Acting in this way, one comes to the conclusion that in the area occupied by the ice-cap and in its adjoining zones from the soils that turned fossil were really formed in the interglacial (interstadial), while in the area beyond the ice-cap, subjected to arid-to-humid climatic variations, the soils developed continuously, the phase of maximum development being the humid glacial (stadial) period, with the loess layer having been developed in the previous period (Florea, 1966, 2002, 2009). In the area that remains arid in the glacial period as well, little differentiated soils have developed in time, soils continuously growing and being transformed into loess by diagenesis in the lower part of their horizons (area of continuous loessification). On the contrary, the area which keeps humid all the time, with minute variations, sequences of loess fossil soils do not appear, their place being taken by deep clay polygenetic soils (area of continuous pedargithification). A full recording ("memory") of all climatic variations in the soil cover is found only in those areas of periglacial region in which the climatic conditions changed from arid to humid (sub-humid) in parallel with the transition from interglacial (interstadial) to glacial (stadial) periods in the Quaternary (area of successive loessification and pedargithification) (Fig. 3).

The problem of the glacial or interglacial phase of fossil soil or loess forming ceases – according to the model of loess and fossil soil formation presented above – the respective phases of pedoliths formation becoming a *problem of variation of the ratio between sedimentation and soil-forming processes over time*, depending on climatic conditions, the loess layer corresponding to the phase of sedimentation–soil forming in the arid-subhumid climate, but fossil soil well expressed, corresponding to one of the humid climate phases which finish the geological cycle of climatic evolution. The extent of congruence of climatic variations with oscillations of glacial phenomena depends on the location in time and space of each investigated loess–fossil soil sequence.

CONCLUSIONS

The new scenario of loess genesis as sedimentary rock consists of a complex process built by the conjugated action of several processes. The following processes take place concomitantly: slow and regular *sedimentation* of the aleurite material, especially that transported by wind; *soil-forming* with the integration within the soil of the deposited dust (sedintegrating pedogenesis) and gradual soil *accretion* due to continuous sedimentation and soil forming, so that the upper soil horizon, previously formed, becomes deep layer no longer subjected to soil-forming processes and factors. This layer is transformed then by *diagenesis* into loess with its specific properties.

Loess genesis, closely correlated with soil genesis, takes place in space and time around glacial areas and in deserts and steppe areas, depending on the climatic conditions and oscillations. Three areas can be distinguished: arid area all along, without significant climatic oscillations with continuous formation of loess without intercalations of soil; intermediary area (with climatic oscillations from arid to humid), with formation of loess having soil intercalation either of the Chernozem or the Luvisol type; humid area all along, without significant climatic oscillations, with evanescent loess formation, leading to the formation of deep soils without loess layers (being integrated into the soil).

Therefore, one cannot speak of "loess sedimentation" or say that "loess was deposited", etc; only the aleurite materials were deposited (sedimented), but loess was formed.

This concept of loess genesis obviously entails modifications in the geological interpretation of the loess – fossil soil sequences.

REFERENCES

Arnold, R.W., Szabolcz, I., Targulian, V.O. (1990), *Global soil change*, II ASA Laxenberg, Austria, 110 p.

Băcăinţan, N., Madeleine, Al., Cişmaşiu N. (1983), *Solurile fosile cuaternare de la Araci-Cărămidărie (Depresiunea Braşov)*, Lucr. Conf. Naţ. Şt. Sol., Brăila, 30.VIII–2.IX.1982, pp. 60–68.

Brătescu, C. (1933), *Profile cuaternare în falezele Mării Negre în Cuaternar*, Bul. Soc. Reg. Rom. Geogr., t. **LII**.

Bucur, N., Barbu, N. (1956), *Contribuţii la studiul lutului loessoid de terasă din bazinul Siretului la nord de Mărăşeşti*, St. Cerc. St. Biol. şi Şt. Agr., Acad. Rom., Fil. Iaşi, an **VII**, fasc. 2, Iaşi.

Bucur, N., Barbu, N. (1959), *Contribution à l'étude des roches lœssoïdes de la Dépsession de Jijia et Bahlui*, Anal. Univ. „Al. I. Cuza", secţ. II, **V**, Iaşi, pp. 149–164.

Charlesworth, J.K. (1957), *The Quaternary era*, Ed. Arnold Publishers, LTD, London, vol. **I** and **II**.
Conea, Ana, Ghiţulescu, Nadia, Vasilescu, P. (1963), *Consideraţii asupra depozitelor de suprafaţă din Câmpia Română de Est*, St. tehn. econ., C, **11**, Bucureşti, pp. 61–85.
Conea, A. (1970), *Formaţiuni cuaternare in Dobrogea*, Edit. Academiei Republicii Socialiste România, 234 p.
Dan, J., Yaalon, D.H. (1971), *On the origin and nature of the paleopedological Formations in the Coastal Desert Fringe Areas of Israel*. In *Paleopedology*, pp. 245–260, Israel Univ. Press., Jerusalem.
Enculescu, P. (1929), *Loessul din România şi solurile zonale formate pe socoteala sa*, Bul. Agr., t. **6**, Bucureşti.
Florea, N., Asvadurov, A., Cioflică, Gianina (1966), *Consideraţii paleogeografice pe baza profilului cuaternar de la Semlac, Câmpia Tisei*. Inst. Geol. D. d. S. ale Şed. Inst. Geolog. Rom., LII, 1 (1964–1965), Bucureşti, pp. 443–460.
Florea, N., Vlad, Lucia, Postolache, Tatiana, Ghinea, P., Grigorescu, Adriana, Crăciun, C. (1989), *Evoluţia continuă policiclică sedintegratoare şi supraimprimatoare a solurilor din Câmpia Piteştiului*, Publ. Soc. Naţ. Rom. de Şt. Solului, 26B, Bucureşti, pp. 97–112.
Florea, N. (2002), *Un model general de evoluţie continuă ciclică a alternanţelor de loessuri şi soluri fosile din regiunile periglaciare în cuaternar*, Ştiinţa Solului, vol. **XXXVI**, nr. 2, pp. 40–54.
Florea, N. (2009), *Pedodiversitate si pedociclicitate*, Bucureşti, 280 p.
Florea, N., Gherghina, Alina, Ignat, P. (2010), *Ipoteza genezei loessului prin procese concomitente de sedimentare – solificare – acreţie şi diageneză*, Rev. Geografică, t. **XVII**, (in print).
Florov, N. (1927), *Über Lössprofilen in den Steppen am Schwarzen Meer,* Zeitschrift für Gletscherkunde, Bd. **XV**, pp. 191–231.
Florov N. 1930. *Cuaternarul în stepele Mării Negre şi repartizarea humusului şi solurilor în stepele din sudul Basarabiei*, D. D. Şed. Inst. Geol. Rom., XV (1926–1927), Bucureşti, pp. 99–105.
Gerasimov, I.P. (1971), *Nature and originality of paleosols*. In *Paleopedology*, edited by D.H.Yaalon, pp. 15–27.
Gherghina, Alina, Grecu, Florina, Coteţ, Valentina (2006), *The loess from Romania in the Romanian specialists' vision*, „Factori şi procese în zona temperată", Symposium Proceedings Ed. Universităţii "Al. I. Cuza" Iaşi, vol. **5**, pp. 103–116.
Lieberoth, Immo (1963), *Loess sedimentation und Boden in Sachsen*, Geologie, Jahrgang, **12**, Heft 2, pp. 149–187, Berlin.
Lieberoth, Immo (1964), *Die Stratigraphie der Sächsischen Lősse ein Beitrag zur Wűrmchronologie*, Rep. VIth Int. Congr. on Quaternary, Warsaw (1961), vol. **IV**, Symposium on Loess, Lódz.
Liteanu, E. (1953), *Geologia ţinutului de câmpie din bazinul inferior al Argeşului şi a teraselor Dunării*, St. tehn. econ., E, 2, Bucureşti.
Liteanu, E. (1961), *Aspecte generale ale stratigrafiei Pleistocenului şi geneticii reliefului din Câmpia Română*, St. tehn. econ., seria F, Hidrogeologie, Inst. Geol. Rom., nr. 5, pp. 41–64.
Macarovici, N. (1968), *Geologia Cuaternarului*. Edit. Didactică şi Pedagogică, 234 p., Bucureşti.
Marossi, P. (1970), *Scurtă privire asupra evoluţiei teoriilor loessogenezei*, Studia Universitatis Babeş-Bolyai, series Geologia-Mineralogia, fasc. 1.
Mrazec, L. (1889), *Comunicare asupra originii loessului în România*, Bul. Soc. Şt., an VIII, 4–5, Bucureşti.
Munteanu, I., Florea, N., Parichi, M. (1997), *Consideraţii privind evoluţia învelişului de sol din Câmpia Română în cuaternar*, Publ. Soc. Nat. Rom. Şt. Solului, 29D, Bucureşti, pp. 13–25.
Murgoci, G.M. (1957), *Opere alese*. Edit. Academiei Române, Bucureşti.
Obrucev, V.A. (1953), *Bazele geologiei*, Edit. de Stat, Bucureşti.
Oprea, C.V., Contrea, A. (1956), *Contribuţii la cunoaşterea formării şi răspândirii loessului în partea de vest a ţării*, St. cerc. şt., seria Ştiinţe Agricole, **III**, 1–2, Filiala Acad. Rom., Timişoara, pp. 9–22.
Penck, Al., Bruckner, Ed. (1901/1909), *Die Alpen in Eiszeitalter* (3 vol.), Leipzig.
Popovăţ, M., Conea, Ana, Munteanu, I., Vasilescu, P. (1964), *Loessuri şi soluri fosile în Podişul Dobrogei Sudice*, St. tehn. Econ., C, Pedologie, 12, Bucureşti, pp. 11–44.
Postolache, Tatiana (1966), *Folosirea metodei secţiunilor subţiri pentru studiul structurilor pământurilor loessoide*, St. şi cercet. hidrot, St. hidroameliorative, III, Bucureşti.
Protopopescu-Pache, Em., Spirescu, M. (1961), *Relaţii între pedogeneză şi litogeneză eoliană*, St. Tehn.-econ., seria C, 11, Inst. Geol., Bucureşti, pp. 41–59.
Ruhe, R.V., Miller, G.A., Vreeken, W.J. (1971), *Paleosoils, Loess Sedimentation and Soil Stratigraphy*. in *Paleopedology*, pp. 41–60.
Scharpenseel, H.W. (1971), *Radiocarbon dating of soils – problems, troubles, hopes*. in: *Paleopedology: Origin, Nature and Dating of Paleosoils*. ISSS and Israel Universities Press, Jerusalem, pp. 77–88.
Smalley, I.J., Rogers, C.D.F. (1997), *L.S. Berg and the soil theory of loess formation*. In *History of Soil Science*, Advances in Geoecology, **29**, Catena Verlag, Reiskirchen, Germany, pp. 377–391.
Spirescu, M. (1970), *Loessuri şi soluri fosile*, St. tehn.-econ., seria C Pedologie, Inst. Geol. Rom., **16**, Bucureşti.
Tsatskin, A. (1997), *A history of Soviet paleopedological studies and their relation to soil science and Quaternary Geology*, in *History of Soil Science*, Advances, in Geoecology, **29**, Catena Verlag, Reiskirchen, Germany, pp. 277–291.
Yaalon, D.H. (Editor) (1971), *Paleopedology*, ISSS and Israel Univ. Press, Jerusalem, 350 p.
Yaalon, D.H. (1983), *Climate, time and soil development*, in *Pedogenesis and Taxonomy, Development in Soil Science* 11 A, p. 233–251, Elsevier, Amsterdam.
*** (1990), *Global Soil Change*, IIASA, Laxenburg, Austria, 110 p.

Received June 3, 2010