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The conceptual sedimentary model of the Lower Danube loess basin: Sedimentogenetic implications

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ABSTRACT

New information on the entire Lower Danube Basin was obtained through the selection, reworking and integration of previously published data concerning the loess accumulations from the Romanian Danube Plain, Bulgarian Danube Plain, and Dobrogea Highland. A conceptual sedimentary model was outlined, based on the integrated textural and isopach maps of the Lower Danube loess and loess-like deposits. The loess in the Lower Danube Basin appears as an accumulation with the coarsest-grained and thickest loess deposits situated along the Lower Danube River channel. Both grain-size and thickness gradually decrease to the basin margin. During the initial genetic stage, the Lower Danube loess basin functioned as a large flood plain. The alluvial and eolian loess generation stages repeatedly alternated. Several sources supplied the Lower Danube loess clastics, determining the Danubian, Carpathian/Balkan and Black Sea littoral provenance of the detrital material.

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1. Introduction

Mapping and texture have been priority tasks of the Lower Danube Plain loess investigation. An important part of the knowledge regarding these topics was reached during the second half of the preceding century (Minkov, 1968; Conea, 1970a,b; and others). According to the conditions of that time, the results of the loess studies were presented mostly in scientific publications with national or regional distribution. Many of the papers were written in Romanian or Bulgarian. Moreover, due to the lack of collaboration between the research groups, the data were limited, restricted only to the Romanian Danube Plain, or the Bulgarian Danube Plain, or the Dobrogea region. Texture and sediment thickness characteristics, essential information for the understanding of the Lower Danube loess genesis, were not available for the entire Lower Danube Basin.

The objectives of this study are the following:

(1) to study the sedimentogenetic significance of the loess texture and thickness areal distribution, at the scale of the entire Lower Danube Plain; and
(2) to investigate the part played by the Lower Danube River and its tributaries to the supply, transport and accumulation of the loess clastic material.

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2. Regional setting

The Lower Danube River is the term given to the Danube after it crosses the Carpathian Mountains at the Iron Gates gorges (Figs. 1 and 2). From here to its discharge in the Black Sea, the Lower Danube flows some 1000 km, over one third of the total length of the river.

2.1. Study area

The Southern Carpathians and the Balkans outline the western and central parts of the Lower Danube loess basin (Fig. 2). The eastern boundary of the basin is marked by the western Black Sea littoral zone.

The Lower Danube Plain is geographically divided into three main areas. The Romanian Plain (Fig. 2) is the low-lying region bounded by the Carpathian foothills to the north and west and by the Danube River to the south and east. “Wallachian Plain” is another name sometimes used for the Romanian Plain. The southern part of the Lower Danube Plain, extending between the Balkans and the Danube River, is the Bulgarian Danube Plain (Fig. 2). Another important unit of the Lower Danube is the Dobrogea Plateau, located between the south-north running section of the River (from Călărasi to Galaţi) and the eastward-flowing sector from Galaţi to the Black Sea shores (Fig. 2).

Among the loess zones crossed by the Danube River (Fig. 1), the Lower Danube loess area deserves to be considered a distinct

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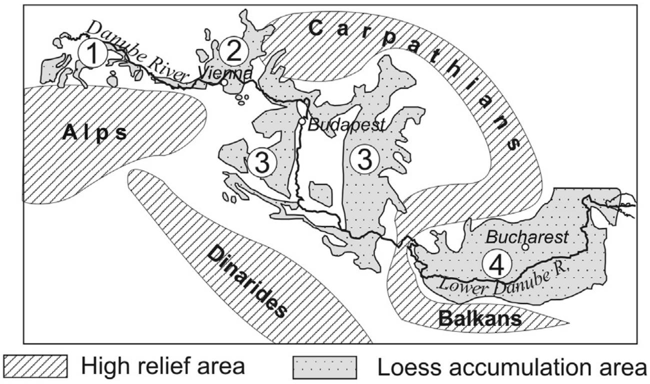

Fig. 1. Loess accumulation zones in the Danube River basin. 1. North Alpine zone. 2. Vienna zone. 3. Pannonian zone. 4. Lower Danube zone. Loess areal distribution after Haase et al. (2007).

sedimentary basin. Downstream of the Iron Gates (Figs. 1 and 2), the Lower Danube River enters a new physiographic setting, which provides new sediment source-areas and a well outlined sediment accumulation area.

The area corresponding to the Lower Danube Plain served as a sediment accumulation unit long before it became a loess basin. During the existence of the brackish-marine Dacian Basin (11–4 Ma), the sediment accumulation area was limited to the territory north of the Danube. At the end of Dacian time (4 Ma) the sedimentary environment of the previous Dacian Basin became predominantly fluvial, and encroached the Danube extending to the Balkans, with the Danube Paleo-river as its central element.

2.2. Loess dating

In the area of the Lower Danube Basin, loess dating has a history of more than five decades. Rădan (2012) published a comprehensive synopsis of the dating studies carried out for the Romanian Plain and Dobrogea loess.

The loess dating in the Lower Danube Basin was initiated with the classical stratigraphic methods. Minkov (1968) in the Bulgarian Plain, Liteanu (1961) and Conea (1970a) in the Romanian Plain, and Conea (1970b) in Dobrogea have been the promoters of these investigations. After the fossil remains of *Elephas primigenius* Blum. and *Rhinoceros tichorninus* were found in Northern Bulgaria, the upper three loess-paleosol sequences were attributed to the Riss–Wurm, Mindel–Riss and Günz–Mindel Interglacials (Evlogiev, 2007; cited in Jordanova and Petersen, 1999). For the Dobrogea loess, Conea (1970b) assigned the paleosol succession to the time between Würmian (Soil Groups 1 and 2) and Günz–Mindelian or older stages (Soil Group 7).

The use of the magnetic polarity dating method led to important progress in Lower Danube loess chronology. In Southern Dobrogea loess sections (Costineşti, Nazarcea, Cuza Vodă and Cernavodă and others; Rădan et al., 1984; Rădan and Rădan, 1984a,b) and in the south-eastern Romanian Plain (Mostiştea Lake; Panaiotu et al., 2001), paleomagnetic investigations revealed the presence of the normal magnetization associated with the Brunhes chron. In northern Bulgaria, at the Viatovo and Koriten loess sections, the position of the Brunhes/Matuyama boundary was revealed in the basal loess unit (L7). The Matuyama/Brunhes boundary (0.781 Ma) was identified in the 30 m thick Zimnicea borehole profile (southern Romanian Plain), within the L8 loess horizon (Rădan, 2012). Consequently the initiation of the Lower Danube loess accumulation process is older than 700 ka (not older than 781 ka in L6 level-southern Dobrogea after Rădan et al., 1984; Rădan, 2012; 900 ka in L7 level, according to Jordanova and Petersen, 1999; at least 800 ka in L8-Southern Romanian Plain, after Rădan, 2012).

Lower Danube loess chronostratigraphy became more accurate through the correlation of the loess magnetic susceptibility variation with the deep sea paleoclimatic oscillations. Jordanova and Petersen (1999) pointed out the close correspondence between the Koriten magnetic susceptibility curve and the marine oxygen-isotope stages timescale. This investigation approach was applied to the Romanian Plain loess (Panaiotu et al., 2001; Rădan, 2012) and Dobrogea loess (Buggle et al., 2009), contributing to the development of a Danube stratigraphic model. Presently, the time span of the Lower Danube loess is considered to extend between MIS 5 (corresponding to S1; about 100 ka) and MIS 20 (corresponding to L8; at least 800 ka) (Marković et al., 2008; Buggle et al., 2009; Fitzsimmons et al., 2012; Rădan, 2012). Luminescence dating, both by the ISRL (Balescu et al., 2003, 2010) and OSL methods (Timar et al., 2010; Vasiliniuc et al., 2011) confirmed the magnetic polarity/oxygen-isotope Lower Danube loess chronology.

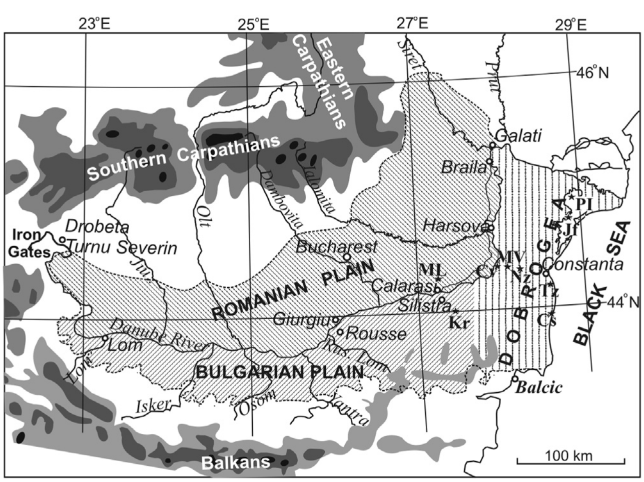

Fig. 2. The Lower Danube Plain and its main areal subdivisions. Northern limit of the Romanian Plain after Conea (1970a). Southern Bulgarian Plain boundary from Fotakieva and Minkov (1966). Loess sections: Cs- Costineşti; Cv – Cernavoda; Jf – Jurilofca; Kr – Koriten; ML – Mostiştea Lake; MV – Mircea Voda; Nz – Nazarcea; PI – Popina Island; Tz – Tuzla.

2.3. Loess enviromagnetism

The enviromagnetism methodology (Hambach et al., 2008) was used for the magnetic susceptibility time-variation analysis of the Lower Danube loess. Warm and wet climate occurred during the accumulation of the older paleosol units (S4 – S6) of the North Bulgarian Koriten section (Jordanova et al., 2007) and of the S3 paleosol from Mostiştea Lake (Panaiotu et al., 2001). Magnetic investigation pointed out the higher sedimentation rate of the younger loess units in the Koriten section (Jordanova and Petersen, 1999) as well as in the Mircea Vodă section (Buggle et al., 2009).

2.4. Main facies

The Lower Danube loess deposits share the typical characteristics of the loess in general. The alternation of loess and paleosol units is one of these features (Haase and Richter, 1957; Conea, 1970b). The number of the loess-paleosol couples from the Lower Danube Basin is variable. Important loess sections located close to the Danube River show no paleosol intercalations. The 20 m thick loess sequence investigated by Rădan et al. (1984) at Cernavoda (South Dobrogea) is an example of this kind. The best developed loess successions show six or seven loess-paleosol couples, as

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