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Geochemical archive in the three loess/paleosol sections in the Eastern Croatia: Zmajevac I, Zmajevac and Erdut

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ABSTRACT

The loess record in the Eastern Croatia provides an excellent high-resolution archive of climate and environmental change, providing evidence for the interaction between accumulation and erosion of aeolian and fluvial sediments during the Middle and Late Pleistocene. Impressive loess–paleosol successions up to 30 m thick are exposed by neotectonic movements along SE slope of the Bansko Brdo (=Bansko Hill) (Zmajevac I and Zmajevac) and the steep cliffs of the Danube River (Erdut). The published lithostratigraphical results are complemented by geochemical studies (content of major, trace and REE and pH). In Zmajevac I section three paleosols are intercalated in the loess, in Zmajevac four and in Erdut four paleosols are intercalated in the loess. IRSL age estimates of 17.8 ± 1.9 and 217 ± 22 ka indicate that most of the middle and upper pleniglacial loess record is missing. In all investigated sections, alluvial sediments are intercalated in the loess deposits, indicating periods of fluvial activity. Geochemical characteristics of investigated paleosols explain both the main characteristics and degree of pedogenesis. Paleosol horizons could be clearly distinguished from loess based content of major, trace and REE and on weathering coefficients, such as Ba/Sr and $(CaO+Na_2O+MgO+K_2O)/Al_2O_3$.

1. Introduction

Quaternary alluvial, marshy and lake sediments are widespread in Eastern Croatia (Figs. 1 and 2). They are mostly overlain by aeolian-derived sediments, e.g., loess, that were formed during the cold periods of the Pleistocene. Some paleosols, which were formed during more humid and warmer periods of the Pleistocene, are intercalated in the loess. In the study area, two main processes cause exposures of loess sections: neotectonic elevation of Bansko Brdo and the Danube River erosion of loess sediments forming steep cliffs along the Danube River. These loess successions are excellent archives of climate change, entailing environmental change, during the Middle and Late Pleistocene time periods (Galović et al., 2009, 2011; Újvári et al., 2014; Marković et al., 2009, 2011).

Loess research in Croatia extends back to the beginning of the 20th century. The famous "Gorjanović Profile" situated on the west of the Danube River has been extensively investigated for about 100 years by means of mineralogical, paleontological, chronological, geomorphological, pedological and climatological studies (Gorjanović-Kramberger, 1912, 1914; Bronger, 1976, 2003; Rukavina, 1983; Galović and Mutić, 1984; Poje, 1985, 1986; Singhvi et al., 1989; Mutić, 1990; Wacha and Frechen, 2011). After the first luminescence dating approach to the sections investigated in this study (Galović et al., 2009), specific investigations were carried out for the Zmajevac loess–paleosol sequences (Molnár et al., 2010; Banak et al., 2012, 2013) and the Šarengrad sequence (Hupuczi et al., 2010; Galović et al., 2011; Wacha et al., 2013). According to Bronger (1976, 2003), at least six paleosols are intercalated in the loess sections from Eastern Croatia, spanning the time period of the Middle and Late Pleistocene (Galović et al., 2009). The later geochemical and/or geochronological investigations of Quaternary aeolian sediments in Croatia were directed to the islands and coastal area of the Adriatic Sea (Wacha et al., 2011; Mikulčić Pavlaković et al., 2011; Pavelić et al., 2011; Romić et al., 2014) and to the Northwestern Croatia (Galović and Peh, 2014; Rubinić et al., 2014, XXXX).

The scope of this work is to investigate the geochemical composition and to correlate those parameters with the sedimentological data of analyzed loess/paleosol sediment successions. Sedimentological data (grain-size coefficients), geochemical content of major, trace and rare earth elements (REE) and acidity (pH), accompanied with previously published data on IRSL dating, grain-size distribution,

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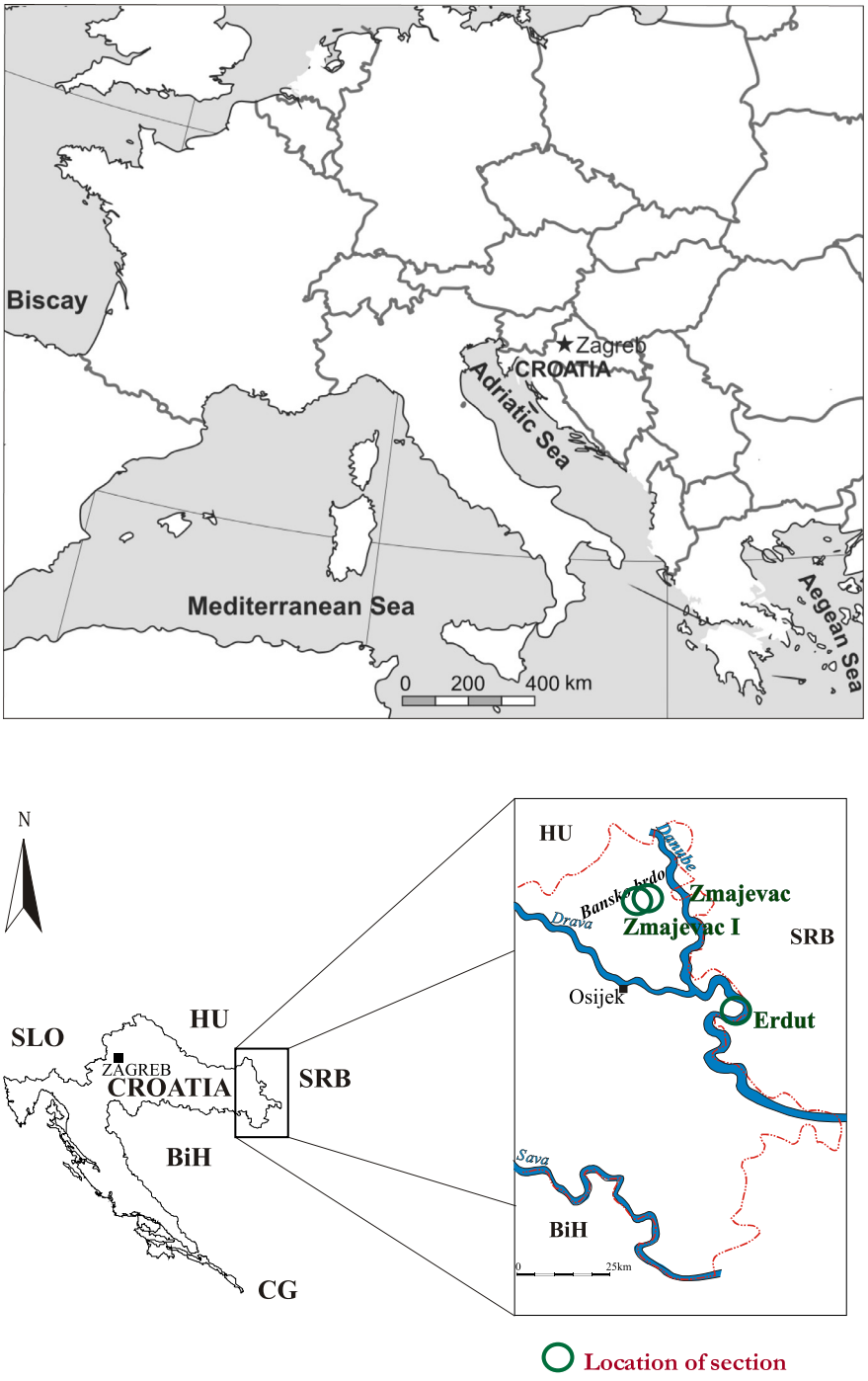

Fig. 1. Map showing positions of sections under investigation in the Eastern Croatia.

organic carbon content (TOC) and $CaCO_3$ content) (Galović et al., 2009) and geochemical and sedimentological characteristics of the Šarengrad section (Galović et al., 2011) highlighted the main characteristics of paleosols and degree of their pedogenesis. Based on these results, another aim of this study is to provide the sedimentological/pedological base for these excellent archives of climate change, entailing environmental change in Croatia. These sequences provide very detailed records of climate change correlating to MIS 2–8, especially if compared with other sections in the Carpathian Basin (Antoine et al., 2009; Bokhorst et al., 2009; Buggle et al., 2008, 2011; Fitzsimmons et al., 2012; Frechen and Pécsi, 2004; Marković et al., 2009, 2011, 2012; Singhvi et al., 1989; Újvári et al., 2014).

2. Geological setting

During the Pleistocene, aeolian sediments were deposited in lakes, pools and shallow marshes in the Croatian Lowland (Bačani et al., 1999) (Fig. 2). Part of these sediments were eroded by the Danube, Drava and Sava Rivers and/or re-deposited downstream as alluvial sediments. Similar deposits were reported and investigated from the Abony section in Hungary (Frechen and Pécsi, 2004).

The Zmajevac I section is described in this publication in detail, while detailed lithostratigraphical subdivisions of the Zmajevac and the Erdut sections are given by Galović et al. (2009).