



Composition, properties and formation of Pseudogley on loess along a precipitation gradient in the Pannonian region of Croatia



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ABSTRACT

Three Pseudogley profiles – Stagnic Cutanic Albeluvisol (Dystric, Siltic), Stagnic Cutanic Albeluvisol (Eutric, Siltic) and Luvic Stagnosol (Hypereutric, Siltic) – were studied along the 700–1000 mm mean annual precipitation (MAP) gradient in the Pannonian region of Croatia. The aim was to compare their composition and properties and to determine the major processes of their formation, as well as to show whether investigations of Pseudogley climosequences in this part of Pannonian Basin are feasible. All three soil profiles were formed in situ from initially vertically homogeneous, previously cycled and post-depositionally modified loess deposits of same provenance (given their morphology, texture, geochemical ratios and mineralogy). Substantial morphological and physical (A horizons colors; Eg horizons thicknesses, colors, bulk densities and porosities; Btg horizons redoximorphic features) as well as chemical soil properties (pH, base saturation, topsoil organic C content) corresponded to the precipitation gradient. On the other hand, due to slight differences between their parent materials, clay content and CEC values of the investigated profiles did not increase with the increase of MAP. Nevertheless, processes of acidification and pseudogleying were found to be least pronounced at the location with the lowest MAP, and most pronounced at the location with the highest MAP. Intensity of lessivage, as one of major pedogenetic processes in all three investigated Pseudogleys, did not correspond to the precipitation gradient, since it was more a function of soil pH and clay mineralogy, than MAP. The three pedogenetic processes were recognized on the basis of obtained pH, base saturation, CIA (Chemical Index of Alteration) and Ti/Al values, as well as soil texture, morphology (presence and characteristics of clay coatings and redoximorphic features) and phyllosilicate dynamics (comminution of chlorite into the clay fraction, vermiculitization, smectite translocation) observed along the investigated profiles. Given the uneven environmental conditions of loess depositions across the Pannonian region of Croatia and the resulting incomplete uniformity of loess parent materials, investigations of Pseudogley climosequences in this part of the Pannonian Basin should be approached with caution.

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1. Introduction

Pseudogley is the second most frequent soil type in Croatia, mainly widespread in its Pannonian region (Fig. 1). In the Croatian soil classification it is considered a hydromorphic soil type excessively moistened with surface water (mainly rainfall), which periodically stagnates from autumn to winter on/in the subsurface soil horizon with a clay content higher than that of the horizon above it. Periodic water stagnation results in occasional soil wet phases, duration of which largely depends on climate. As a consequence, redox processes occur, resulting in characteristic soil morphology, sometimes labeled marmorization, but more often as mottling, redoximorphic features (RMF) or stagnic color pattern (e.g. IUSS Working Group WRB, 2006; Vepraskas, 2008).

The largest part of Pseudogley soils in the Pannonian region of Croatia formed in Pleistocene loams, and a smaller part in brown loess. According to Haase et al. (2007), both geologic substrates can be regarded as polygenetic loess sediments or loess facieses different from typical loess due to modification by syngenetic and/or postgenetic processes, and are described below. The former is a loess derivate free of coarse-grained material and in situ modified by diagenetic and pedogenetic processes. It is non-calcareous and usually contains an increased clay content. The latter also differs from the typical loess by a higher clay content and absence of carbonates, as well as by its dark brownish color, stratification and depth less than 5 m. Brown loess is considered to have been deposited in a humid environment and not to be affected by processes of secondary transportation or significantly modified by pedogenesis. Even though Pleistocene started some 2.6 Ma BP, only sediments deposited during the period of last glacial are of interest in this study. The last glacial (Würm) started some 115 ka BP, reached its maximum (pleniglacial) 30–18 ka BP and ended

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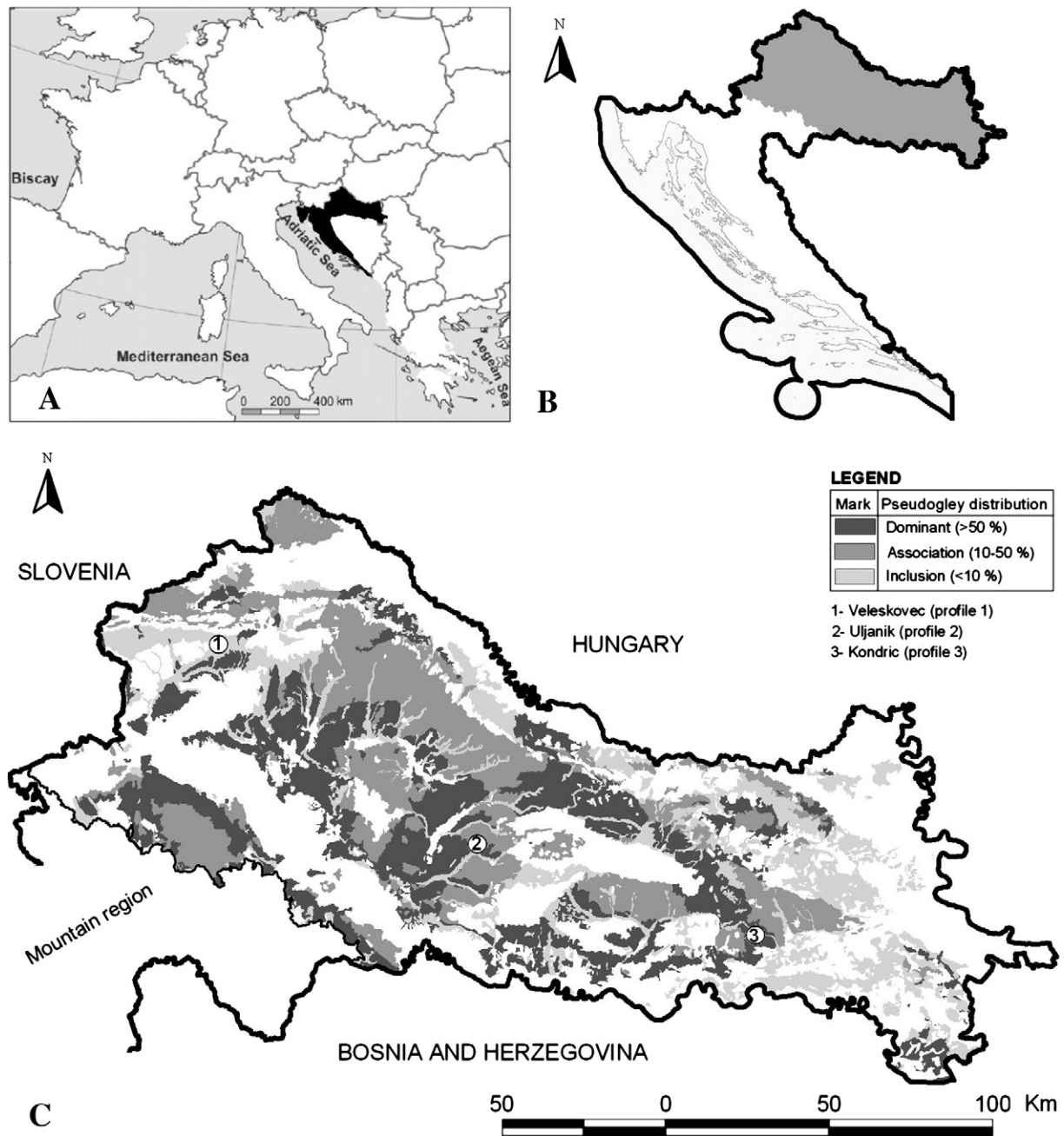


Fig. 1. A – position of Croatia in Europe, B – Pannonian region of Croatia, C – Pseudogley distribution in the Pannonian region of Croatia.

with the late glacial, followed by the onset of Holocene roughly 11 ka BP (in accordance with Ivy-Ochs et al., 2008).

Although some researchers relate Pseudogley formation to actual hydrogeological regime rather than to lessivage (e.g. Zaidel'man, 2007), most consider texture-differentiated soils to be formed mainly as a result of natural evolution through advanced chemical weathering and lessivage (Phillips, 2004). Namely, the removal of clay particles downwards in the soil profile may lead to development of a slowly permeable illuvial horizon with significantly more clay than the horizon above it and, consequently, to periodic water stagnation and pseudogley formation. However, vertical texture contrasts in soils can very well be initially created by two geogenetic deposits of different textures, and with post-depositional pedogenetic processes increasing the initial texture contrast (Phillips, 2004). Janeković (1960) even suggested that the typical Pseudogley profile of the southwestern Pannonian Basin

was in fact a pseudo-profile, consisting of two Holocene age upper horizons (A and E horizons) laying above compact paleo-horizons formed in Würm.

Despite notable scientific contributions, the knowledge on mineral and geochemical composition of Pseudogley soils and their formation in Croatia remains insufficient. This is especially true regarding investigations of the influence of climate on Pseudogley characteristics and genesis. Since clay formation and migration in soils may vary in response to increasing precipitation (in accordance with Alvarez and Lavado, 1998; Dahlgren et al., 1997), soils developed on loess substrates of the Pannonian region of Croatia may also show distinct climatic zonality from the drier east to the wetter west.

In this paper we investigate morphological, physical, chemical and mineralogical features of three representative Pseudogley profiles (namely profiles 1, 2 and 3) developed on loess in three different

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