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Loess–palaeosol sequences in China and Europe: Common values and geoconservation issues

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ABSTRACT

Loess–palaeosol sequences preserve the most significant continental record of climatic and environmental changes during the Quaternary available for scientific study. The Eurasian loess belt in particular could be regarded as one of the most important Quaternary terrestrial records of climatic and environmental changes on a global scale. The Preliminary stratigraphical correlation has determined that loess sections in south-east Europe and China have, perhaps surprisingly, shown many similarities. Unfortunately, these sites, due to their economic (e.g. agriculture and brickyards) and functional (e.g. remote sections as waste disposal sites) values, share the same (both human-induced and natural) threats and are constantly endangered by numerous causes and could be naturally degraded or permanently exploited as a georesource.

Conversely, this valuable segment of Earth's geodiversity has gained much attention within the nature conservation community. There are certain individual attempts to protect and promote loess to the general public, which is the case in China (National Geoparks with protected loess, e.g. Luochuan, Huoshi Chai, Kungdongshan, Jingtai, Yellow River), and also in Serbia and Poland. These could serve as good platform for establishing common strategies towards national and international recognition of important loess sections. Thus, the aim of this study is to provide a preliminary and universal strategy concerning conservation, interpretation and promotion (geotourism) of significant Eurasian loess–palaeosol sequences. Once implemented and tested, they could serve for all similar soft-rock exposures and soils.

1. Introduction

Geodiversity can be defined as the natural range of rocks, minerals, fossils, geomorphological forms and processes, and soil features; it includes their assemblages, relationships, properties and systems (Gray, 2004), or more simply the diversity of geological and geomorphological phenomena in a defined area (Johansson, 2000). The endeavour of trying to conserve geodiversity is defined as geoconservation (Sharples, 2002) and it has been recently discussed in some detail, especially with regard to landscape tourism, by Hose et al. (2011) and Hose (2012) and specifically defined by him as "*the act of protecting geosites and geomorphosites from damage, deterioration or loss through the implementation of protection and management measures*" (Hose, 2012, 16). In broader terms it is the actions taken with the intention of conserving and enhancing geological, geomorphological and soil features, processes, sites and specimens (geodiversity), including any associated promotional and awareness raising activities and the recording and rescue of data or specimens from features and sites threatened with loss or damage (Burek and Prosser, 2008; Prosser, 2013).

Nature conservation has become an important contemporary issue for society. Although there are two equally integral parts of the natural environment (Gray, 2005), biotic (living, biodiversity) and abiotic (non-living, geodiversity), there is a general opinion that the latter does not enjoy governmental support and public appreciation at a satisfactory level (Erhartič and Zorn, 2012; Erikstad, 2013; Gray, 1997, 2004, 2008; Pemberton, 2007; Prosser et al., 2011). Because it is almost always, but incorrectly, considered a robust and persistent part of the Earth's crust, geodiversity has been pushed aside with regard to fundamental conservation activities (Gray, 2004; Prosser, 2013).

One of the parts of Earth's geodiversity which has been lately recognised as of considerable importance regarding its (geo)scientific,

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cultural, economic and aesthetic values are loess–palaeosol sequences (Solarska et al., 2013; Vasiljević et al., 2011a, 2011b). This widely spread sediment has proved to be of the utmost significance for scientific, archaeological and agricultural reasons within the Eurasian loess belt. Accordingly, this study provides an insight into some of the key issues regarding loess area treatment from the two case study areas: the Chinese Loess Plateau as the most developed loess region in the world; and the European loess sections (predominantly from the Vojvodina region, North Serbia) with some specific examples of its most important segments.

2. The Eurasian loess belt

Loess and loess-like sediments cover 10% of Earth's land surfaces (Heller and Evans, 1995; Pecsi, 1990; Smalley et al., 2011) mostly deposited over extensive areas in mid-latitudes. Typical geographical zones for its deposition, and the areas with the thickest loess–palaeosol sequences, are plains (e.g. Pampean Plain, Russian Plain), plateaus (e.g. Chinese Loess Plateau) and along river basins (e.g. Danube Basin, middle Rhine Basin, Mississippi Basin, middle Yellow River Basin).

The Eurasian loess Belt covers the whole Eurasian continent, from the Atlantic to the Pacific coasts (Fig. 1). Eastern Asia represents the area with the most extensive and continuous loess sediments, mostly deposited in the highland area of north-central China and the Chinese Loess Plateau (Hoang Fagerström et al., 2003a). The formation of these continuous loess–palaeosol sequences by dust deposition began 22 My ago (Guo et al., 2002). According to some authors (e.g. He et al., 2003; Liu, 1985; Zhu, 1989) the material has been transported from the north-western Gobi desert by winds and has accumulated on the Loess Plateau since the beginning of the Quaternary. These processes eventually created the world's largest loess plateau (Derbyshire, 2001) which covers 8° of latitude (35–41°N) and 13° of longitude (102°–114°E); this is an area of more than 530,000 km^2 (Liu, 1999), at an altitude of some 1000–1600 m above sea level, the surface of which is covered by an average of 100 m thickness of loess–palaeosol sequences (He et al., 2003). The Plateau belongs to the Shaanxi, Gansu, Quinghai, Ningxia, Qinhai and Neimeng provinces in China (Liu, 1999), but the most complete and thickest loess deposits are found in the provinces of Shanxi, Shaanxi, and Gansu (Stevens et al., 2007, 2008).

In Europe, loess and loess-like sediments cover almost 1/5 of its total land surface (Haase et al., 2007, Fig. 2) and are thus a major sediment type as a soil parent material. Dust accumulation emanated from the maritime areas of north-western Europe, over central Europe, and as far eastwards as the Ukraine and the Russian plains (Fig. 2). Much of the loess cover in eastern and central Europe has been re-deposited by the Danube River and its tributaries. Other major areas of loess are associated with other large rivers such as the Po in Italy, the Rhine in Western Germany, and the Rhone in France (Smalley, 1995). A magnified sequence of the European loess map (as shown in Fig. 2) clearly indicates that the greatest thickness of loess deposits occurs in the area of the lower Pannonian Basin (marked in orange colour (loess >5 m) and dark yellow) that belongs to the Vojvodina Province of northern Serbia. Accordingly, loess–palaeosol sequences situated in the Vojvodina region represent the most detailed archive of climatic and environmental fluctuations during the Middle and Late Pleistocene on the European continent (Marković et al., 2005, 2009, 2011).

3. Loess as geoheritage–geoconservation importance

As protecting the whole geodiversity would be too extreme or "geocentric" (Gray, 2004), let alone unaffordable, there needs to be a clear understanding of geoconservation terminology and principles. Therefore, all parts of geodiversity that are of great importance for humankind and thus are specifically identified as having conservation significance are determined as Earth's geological heritage or geoheritage (Sharples, 2002). This importance is recognised by numerous authors as geodiversity values and is mainly used to assess the parts of geodiversity directed towards geoheritage (Komac et al., 2011; Vujičić et al., 2011). The most relevant and applicable division of geodiversity values was given by Gray (2004, 2008); he identified over 30 different values of

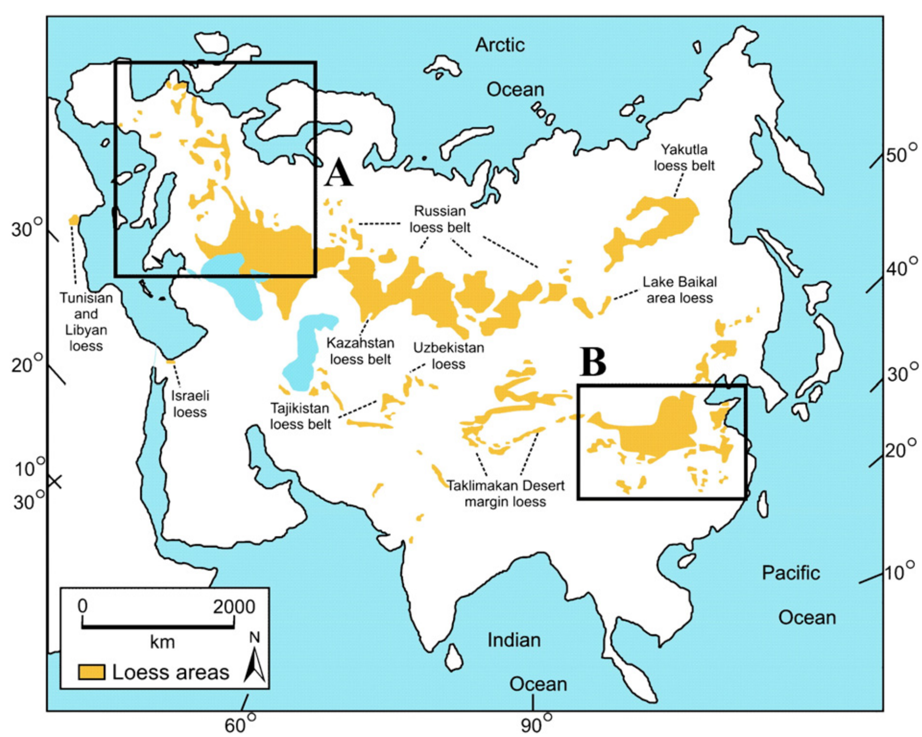

Fig. 1. Distribution of loess in Eurasia with the localities and areas of thickest loess deposition according to Muhs (2007, modified) with locations indicated the European Loess Belt (A) and the Chinese Loess Plateau (B).