Radiation Measurements 81 (2015) 23–31

Contents lists available at ScienceDirect

Radiation Measurements

journal homepage: www.elsevier.com/locate/radmeas

OSL chronostratigraphy of a loess-palaeosol sequence in Złota using quartz and polymineral fine grains

Piotr Moska [a,*], Zdzisław Jary [b], Grzegorz Adamiec [a], Andrzej Bluszcz [a]

[a] *Institute of Physics – Center for Science and Education Konarskiego 22B str., 44-100 Gliwice, Poland*
[b] *Institute of Geography and Regional Development, University of Wroclaw, 50-137 Wroclaw, Poland*

HIGHLIGHTS

- 21 OSL dates were obtained for one of the most important loess profile in Poland.
- OSL signals from medium grains quartz extracted from loess were investigated.
- For polimineral grains size fraction post-IR IRSL 290 protocol was used.
- Obtained results form a good basis for further OSL studies of Polish loess.

ARTICLE INFO

Article history:
Received 26 October 2014
Received in revised form
26 March 2015
Accepted 14 April 2015
Available online 24 April 2015

Keywords:
Luminescence dating
Chronostratigraphy
Polish loess stratigraphy

ABSTRACT

Loess deposits are one of the most important sources of information about palaeoclimatic changes for the whole Quaternary. In general, loess is typical for cold and dry, periglacial climate and environment. The intercalated palaeosols are indicators of warmer and more humid climate representing interstadials or interglacials. In Poland, loess and loess-like formations occur in the southern part of the country, mostly in the south Polish uplands, i.e. in the Lublin, Sandomierz, and Cracow Uplands. In addition, such deposits are found in the forelands and foothills of the Carpathians and Sudetes. Luminescence dating is one of the leading techniques to establish chronologies for loess-palaeosol sequences and has been successfully applied to different minerals and grain size fractions by several research groups. OSL chronostratigraphy over the last two decades became very popular especially for loess deposits around the world, meaning that there are hundreds of new luminescence dates associated with those deposits. Our investigation is focused on the determination of chronostratigraphy for Polish loess deposits from the last glacial cycle in SE Poland up to about 130 ka. Twenty-one samples from the loess profile in Złota (21°39′E, 50°39′N) were collected for luminescence dating and six for ^{14}C dating. Two different fractions were investigated, the polymineral fine grains (4–11 μm) and silt-sized quartz grains (45–63 μm). In addition, analyses of the magnetic susceptibility, grain-size distribution, carbonate and organic carbon content were conducted. Although further investigations are needed, our results show the suitability of the Polish loess for OSL dating and very good agreement between obtained luminescence and ^{14}C dating results.

1. Introduction

Among the terrestrial archives, loess sequences represent the most complete records of climatic changes for the whole Quaternary. Many of those sequences have continuous nature with preserved records of both glacial and interglacial periods. However, many times in the past loess deposits with incomplete sequences of sediments have been found. This is indicative of by the occurrence of gaps in the process of accumulation and the events leading to the destruction of the loess cover (erosion, denudation) (Frechen, 1999; Maruszczak, 1986). The presence of stratigraphic gaps is often sufficiently clear but sometimes unreadable due to the high homogeneity of the sediments, which creates a major problem of reliable correlation of sequences or loess levels between different profiles. In order to chronologically align sediments originating from various outcrops it is necessary to use absolute dating methods. Despite the existence of many different absolute dating methods for Quaternary sediments, only ^{14}C and luminescence

* Corresponding author.
E-mail address: Piotr.Moska@polsl.pl (P. Moska).

http://dx.doi.org/10.1016/j.radmeas.2015.04.012
1350-4487/

methods can be widely used, due to the availability of research material. Those methods are complementary up to about 40–50 ka. Numerical time scales are crucial to calculate sedimentation rates as proxies for palaeoenvironmental change. Generally, luminescence dating of loess sediments is applicable to a wide range of grain sizes, from fine grains (Timar et al., 2010; Kreutzer et al., 2012) to coarse grains (Moska et al., 2012; Kreutzer et al., 2012). Ideally, the grain size selected for luminescence dating should reflect the modal grain size of the deposit in order for the grains to be representative. Usually the most dominant fraction in loess deposits consists of grains from 2 μm up to about 60 μm (Pye, 1995; Wright, 2001) therefore for luminescence dating of loess deposits a fraction from this range should be used.

The two existing independent stratigraphic schemes of the Late Pleistocene loess-soil sequence in Poland were proposed more than 30 years ago. The first chronology of Polish loess deposits was created by Jersak (1973) and it was mainly based on pedostratigraphy and correlation of successions of comparable features in different profiles. The second chronology was proposed by Maruszczak (1991). This chronology was fully based on thermoluminescence (TL) age determinations. Late Pleistocene loess-palaeosol sequences were examined in loess areas situated in the uplands of south Poland, i.e. in the Lublin, Sandomierz, and Cracow Uplands but such deposits are also found in the forelands and foothills of the Carpathians and Sudetes. Loess in this part of Poland is relatively thick reaching up to 20 m and occurs as an almost continuous cover, whereas the loess cover in SW Poland is much thinner and forms a number of isolated patches which differ in sediment thickness, stratigraphy and physical properties. This east–west differentiation most probably reflects present and past regional climatic conditions being more continental in the east and more oceanic in the west (Cegła, 1972; Jersak, 1973; Jary et al., 2002; Jary, 2007).

A large amount of information about regional climatic conditions can be provided by magnetic susceptibility (MS) measurements (Antoine et al., 2009; Markovic et al., 2009). On both the Chinese loess plateau and European loesses it is observed that sediments showing low magnetic susceptibility were accumulated under cold and dry conditions during glacial periods, while relatively high MS is seen in paleosols which accumulated and developed on top of loesses during warmer and more humid interglacial periods (Maher, 1998). Hence, the wide use of the magnetic susceptibility signal as a proxy climatic indicator.

The aim of the current study is to create a detailed chronostratigraphy of the investigated profile to enable future comparison with those that will be available for other investigated loess profiles from Poland (Biały Kościół, Tyszowce and Strzyżne – currently under investigation). It is important to compare the results obtained for loess deposits from this part of Poland with results obtained in other parts of Europe. Our chronostratigraphy is expected to be similar to those created by other researchers in Europe, especially in the Czech Republic, Germany and Ukraine (Fuchs et al., 2013; Antoine et al., 2009; Fedorowicz et al., 2013; respectively).

The profile in Złota was sampled in a continuous vertical section at close intervals of ca. 5 cm and documented in respect of its sedimentology, palaeopedology and stratigraphy. In addition to high resolution OSL dating, grain-size distribution, carbonate and organic carbon contents, geochemical composition and magnetic susceptibility were determined. For the upper part of the profile 6 samples for radiocarbon dating were also collected.

2. Study area, the geological setting

The investigated loess section, discovered in 2011, is located in the Złota village, on the northern side of the valley of the Vistula river (21°39′E, 50°39′N), at an altitude of approximately 170 m a.s.l. and the top of the profile is located about 20 m above the current level of water in the Vistula river. The thickness of the loess cover in this area exceeds 12 m and the investigated profile had a thickness of 13 m. Loess formations in Poland and the location of Złota loess profile are presented in Fig. A in the supplementary material.

2.1. Description and interpretation of the main litho- and pedostratigraphic units

The Złota loess-soil sequence contains the Late Pleistocene record of loess sedimentation and soil processes development. It displays a structure similar to those of other Late Pleistocene loess sections situated in the European loess belt. To avoid confusion (in terms of complicated stratigraphic nomenclature) the labelling system proposed by Kukla and An (1989), slightly modified by Markovic et al. (2008) for Late Pleistocene litho-pedostratigraphic units in Vojvodina is used (Jary and Ciszek, 2013).

The loess-soil sequence in Złota consists of five units: two polygenetic palaeosol complexes (L1S1 and S1) and two calcareous loess units (L1L1 and L1L2). In the upper part of L1L1 loess unit recent soils have developed (S0).

2.2. The S1 pedocomplex

The S1 palaeosol complex in Złota is characterized by a high degree of alteration of the parent material (loess and alluvial loamy deposits in the lowermost part) by the intense and prolonged soil forming processes. It consists of two main genetic horizons: a thick welded humus A horizon (chernozem type – subunit 3, Fig. 1) and a Bt horizon (subunit 2) of a leached brown forest soil. The parent material of the pedocomplex consists of alluvial loam in the lowermost part (subunit 1) and loess deposited during the final phase of penultimate glaciations and/or in the onset of Early Weichselian. Perhaps due to the sudden climate deterioration, the topsoil parts of the S1 pedocomplex were strongly eroded.

2.3. The L1L2 loess unit

The thickness of the L1L2 unit in the Złota section exceeds 3 m. The L1L2 loess unit is separated from the lower S1 unit by an erosional boundary. The upper part is covered by the L1S1 soil. The lower parts of the L1L2 loess consist mainly of banded lithofacies with signs of gley processes and numerous humic intercalations. In the middle and upper parts of the L1L2 occur mostly laminated and massive lithofacies.

2.4. The L1S1 soil unit

The pedocomplex L1S1 separates two main phases of aeolian silt accumulation during the Last Glacial. It has developed within the upper parts of the L1L2 loess. The upper boundary of L1S1 unit is sharp suggesting its erosional character. Similar erosional surfaces are probably present within the L1S1 soil unit. They were obliterated by further soil processes. The tundra-gley phase of paedogenesis had a principal influence on the L1S1 morphology. However, it was only the latest of several phases of L1S1 growth. The long-lasting tundra period parallelled the permafrost advance that almost completely erased the traces of earlier warmer stages.

2.5. The L1L1 loess unit

The thickness of L1L1 loess unit in Złota section exceeds seven metres. The L1L1 unit has a sharp lower boundary (between