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The Agh Band loess-palaeosol sequence – A terrestrial archive for climatic shifts during the last and penultimate glacial–interglacial cycles in a semiarid region in northern Iran

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ABSTRACT

The Northern Iranian loess profiles host important information on Quaternary climate and palaeo-environmental changes in the region. They build an important link between the Eurasian loess belt and European and Central Asian archives. Due to a climatic gradient with decreasing precipitation from the west to the east and from the south to the north, loess-palaeosol sequences formed synchronously under different climatic conditions can be studied over short distance in the Iranian Caspian Lowland. The Agh Band profile is located in the so called Iranian "Loess Plateau", a semi-arid region with 200–350 mm annual precipitation. The loess deposits at Agh Band reach a thickness of >60 m. An about 50 m thick step-profile was prepared and the litho/pedostratigraphy was investigated. Samples for laser-diffractometry grain-size measurements were taken every 2 cm. The magnetic susceptibility was measured in 4 cm intervals and the $CaCO_3$-content in 8 cm intervals. To establish a chronological framework a $pIRIR_{290}$ luminescence dating approach was applied to the 4–11 μm polymineral fraction.

The results show that the Agh Band profile yields a climate archive reaching from MIS 7 to MIS 2. Several chronological hiatuses of some 10 ka show that periods of intense loess accumulation were interrupted by phases of only minor loess sedimentation and/or erosion. The Agh Band profile is sub-divided by several shifts in grain-size distribution. The coarsening- and fining up trends correlate with increasing and decreasing wind-velocity, respectively. In the central part of the Agh Band loess sequence a weakly developed palaeosol is preserved which was developed at around 80 ka. Furthermore, the loess deposits formed from about 100 ka to 60 ka ago show banded structures. A pedocomplex including two well-developed palaeosols consisting of Bw(y) horizons and a CB-horizon as well as intercalated loess can be found in the lower part of the sequence also evidenced by the increased values of magnetic susceptibility. The corresponding luminescence age estimates indicate that the palaeosols represent a period of increased humidity and landscape stability during late MIS 7 and MIS 6. Hence, in the Agh Band loess, various changes in the palaeo-sedimentary system, triggered by changes in climate can be observed. This yields important information on the sensitive response of sedimentary systems and landscapes within semi-arid regions to shifts in moisture and possibly temperature.

1. Introduction

Loess-deposits react sensitively to changes in climate. Thus loess-palaeosol sequences often yield detailed archives for Quaternary palaeoenvironmental reconstruction (e.g. Pecsi, 1990;

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Frechen et al., 1997; Boenigk and Frechen, 2001; Marković et al., 2008; Buggle et al. 2009, Novothny et al. 2009;Wacha et al., 2011). Accordingly, the Northern Iranian loess palaeosol-sequences are valuable archives to study palaeoenvironmental changes in the region. Furthermore, they build a link to better correlate European and Central Asian loess-palaeosol sequences. Hence, these archives deliver important information to obtain a more comprehensive understanding of the response of sedimentary and ecological systems to changes in climate in different parts of the Eurasian Loess Belt.

Loess in Northern Iran was deposited along the northern foothills of the Alborz Mountains where up to 30 m thick loess deposits can be found. Even thicker loess-sediments are preserved in the so called Northern Iranian loess-plateau with >60 m thick loess deposits.

Northern Iranian loess profiles have already been studied in detail by Kehl et al. (2005), Frechen et al. (2009), Kehl (2010), Karimi et al. (2009, 2013) or recently by Vlaminck et al. (2016), Lauer et al. (2016) and Shahriari et al. (this issue). Fig. 1 gives an overview on the distribution of major loess deposits in Northern Iran and shows the location of sections investigated by the authors mentioned above. These loess-sections were focusing on loess-palaeosol sequences mainly correlating to the last glacial–interglacial cycle.

A new study on last glacial Iranian loess deposits from the Northern Iranian loess plateau dealing with grain-size fluctuations, aeolian transport mechanisms and potential source areas of the dust is published by Wang et al. (2016b).

In a recent paper, Wang et al. (2016a) investigated early Pleistocene loess in the northeastern Iranian Golestan Province (Northern Iranian loess plateau) and suggested the deposition and preservation of loess being ~2.4–1.8 Ma old.

It was demonstrated that several climatic shifts from more humid and warmer climate conditions including soil formation and only minor dust accumulation to more arid and cooler climate-periods with increased dust accumulation are documented in the archives. The recently published studies by Vlaminck et al. (2016) and Lauer et al. (2016) on the Toshan loess section near to Gorgan City (Fig. 1) have illustrated that especially for the last glacial–interglacial cycle, several climatic shifts are recorded and also several interstadials could be documented predating the last interglacial (MIS 5e). Palaeosols of different development degrees ranging from strongly developed ones indicated by Bt to weakly developed represent by CB(k) horizons correlate with several periods of higher morphodynamic stability and corresponding soil formation. More arid climate led to increased dust accumulation. Especially from about 60 ka on, increased loess sedimentation rates were documented for the Toshan loess section.

The modern gradient in precipitation in Northern Iran with decreasing precipitation from the west to the east and also from the south to the north (e.g. Khormali and Kehl, 2011; Khormali et al., 2012; Shahriari et al., this issue) allows studying loess and palaeosols which were probably formed synchronously under different palaeoclimatic conditions. Whereas e.g. in Neka, the annual precipitation is at around 750 mm, the precipitation in the semi-arid loess plateau is at only 200–350 mm/year. Especially in the semi-arid loess plateau, past changes in moisture most likely led to changes in the palaeoenvironmental system. A decrease in precipitation might have caused a reduction of the vegetation cover and led to increased morphodynamic activity. Hence, the loess-palaeosol sequences in the Northern Iranian loess plateau are especially valuable archives to study the response of the sedimentological and palaeoecological system to aridification.

The aim of this study was to establish a litho- and pedostratigraphy for the Agh Band loess sequence located in the Northern Iranian loess plateau. A chronological framework for periods of loess deposition, soil formation and probably erosion was established by luminescence dating applied to polymineral fine-grains. Furthermore, highly resolved grain-size analyses intend to obtain detailed information on changes in the palaeo-sedimentary system and the palaeo-wind activity. In addition, magnetic susceptibility was used to obtain information on soil-formation in the study area.

It was also intended to correlate the Agh Band loess palaeosol sequence with other sediment-archives in the region and to discuss especially the dating-results with previous findings obtained by Frechen et al. (2009) and Kehl et al. (2005), also from the Agh Band area and with the luminescence dating results obtained by Lauer et al. (2016) for the Toshan loess section (Fig. 1).

These information can further complete the knowledge on palaeoenvironmental changes in Northern Iran and will contribute

Fig. 1. Study area; map showing the distribution of loess in northern Iran and the locations of loess sections studied before on the foothills of the Alborz Mountains and in the so-called loess-plateau of Northern Iran. The new section at Agh Band presented here, is located at less than 100 m distance from locations studied by Kehl et al. (2005) and Frechen et al. (2009).

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