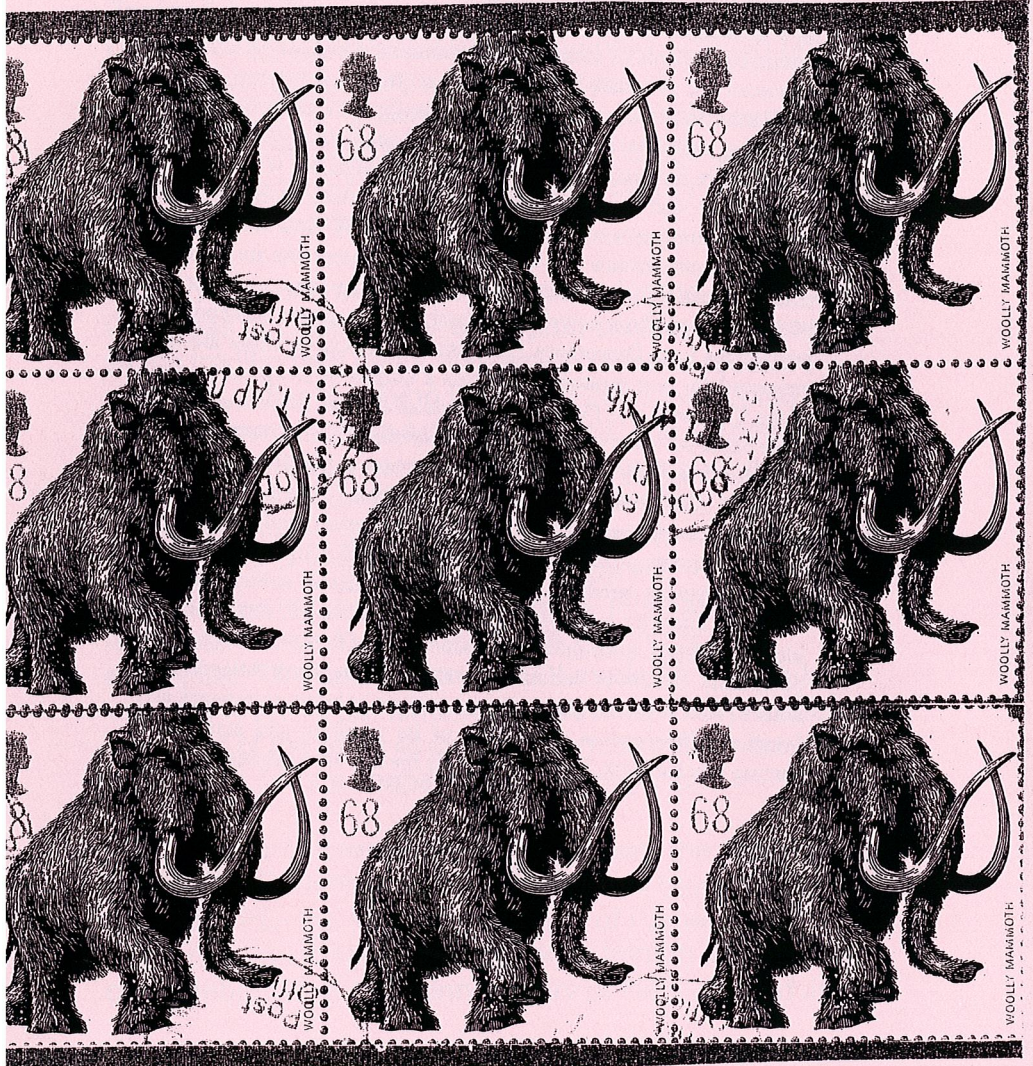


# LOESS LETTER 58

An INQUA Newsletter for Students of Loess Material, Loess Deposits, Loess Ground, Loess Soils & Loess as a 'Climate Register'. Founded in 1979 at the New Zealand Soil Bureau.



Mammoth - its a Loess animal

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Chinese loess is widely regarded as one of the most detailed and complete terrestrial archives of late Cenozoic climate change, providing continuous records of atmospheric circulation over East Asia. Reconstructions are generally grounded in age models developed through correlation to marine oxygen-isotope stratigraphy or through using grain-size variation as an indicator of accumulation rate. Such approaches are facilitated by the view that sedimentation is mostly continuous and that loess is subject to limited diagenesis. Optically stimulated luminescence dating applied at high vertical sampling resolution (10 cm) reveals however, that these assumptions are often untenable. Detailed, independently dated and time-continuous records of past sedimentation as well as grain-size and magnetic susceptibility proxies for Late Quaternary East Asian monsoon variation are here presented for four typical sites across a northwest-southeast transect of the Chinese Loess Plateau. Comparison of these reconstructions to those based on widely applied, non-independent dating methods demonstrates that many previous Late Quaternary paleoclimatic interpretations at millennial-centennial time scale from Chinese loess will be incorrect. In addition, the application of an entirely independent age model to climate proxies in loess enables crucial insight into the forcing mechanisms behind monsoon climate change. Abrupt shifts in monsoon intensity occur over  $10^2$ – $10^4$  yr timescales, supporting the idea of a lagged, non-linear monsoon response to orbital forcing, and potentially, to abrupt variation associated with North Atlantic variability. This suggests that monsoon climate exhibits significant geographic differences in the timing of its variation and response to forcing mechanisms. Potential reasons for this are explored.

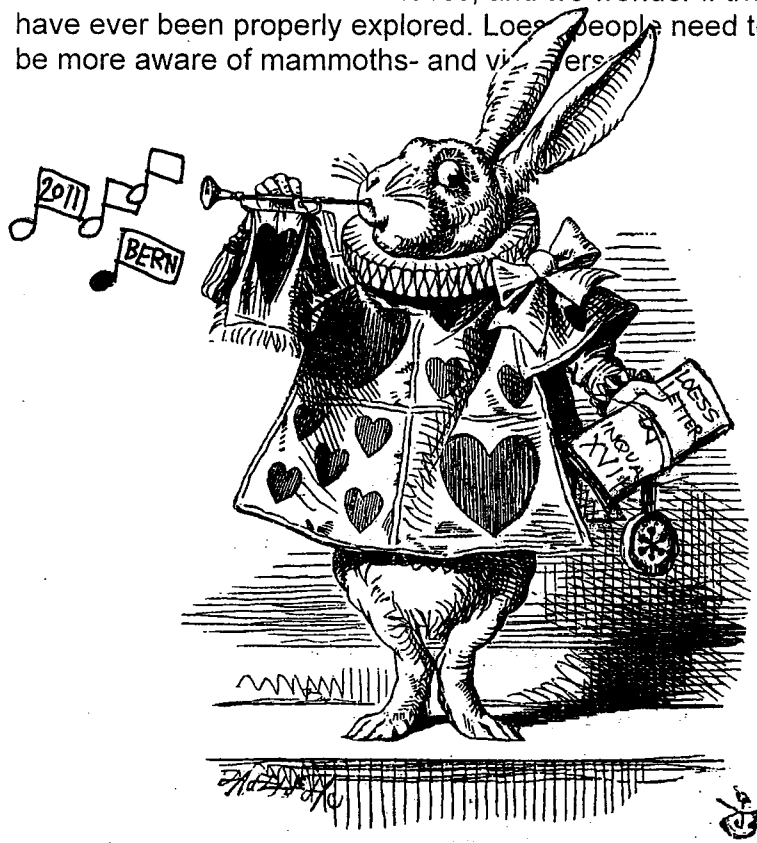
LL. Loess Letter is an INQUA newsletter for students of loess and airborne dust. It is published twice a year, in April and October, by the Giotto Loess Group of the Waverley Materials Project at Nottingham Trent University ([ian.smalley@ntu.ac.uk](mailto:ian.smalley@ntu.ac.uk)). It was founded in 1979 at the New Zealand Soil Bureau; it is complemented by Loess Letter Online (at [www.loessletter.com](http://www.loessletter.com)) and Loess Lexicon (at [www.loess-lexicon.net](http://www.loess-lexicon.net)). INQUA details at [www.inqua.tcd.ie](http://www.inqua.tcd.ie). LL was originally the newsletter of the Western Pacific Working Group of the Loess Commission, then it served the Loess Commission proper; now it looks to the entire Quaternary world.

58 is the second of the special issues for the 17<sup>th</sup> INQUA Congress at Cairns. This is the post conference issue which traditionally offers a selection of loess related abstracts. After the Reno INQUA in 2003 loess/dust abstracts appeared in two issues of LL and a special supplement. This year we will concentrate abstracts into 58- this means that an element of choice has to be deployed. We focus somewhat on loess in Australia but try to do justice to China and East Europe etc. The Cairns abstracts were beautifully presented- this has to be the most impressive format for INQUA Abstracts yet attempted. The special issue of QI made an accessible vehicle for the large number of abstracts. This provides a snapshot of the state of Quaternary research in the World in 2007; LL58 is a snapshot from a snapshot.

2008: a year of events and anniversaries; the International Geological Congress takes place in Oslo ([www.33igc.org](http://www.33igc.org)), and it's IYPE- the International Year of Planet Earth ([www.esfs.org](http://www.esfs.org)). Konrad Keilhack was born in 1858 so we can celebrate the 150<sup>th</sup> anniversary of his birth, and Julius

Fink, founder of the INQUA Loess Commission, was born in 1918- so we celebrate him as well. Of course, every issue of LL celebrates Fink, his influence still spreads out from Vienna and inspires us all. Admire the new picture of Fink in the bLLog section of Loess Letter Online; we need more and better pictures of Fink- please send to [ian.smalley@ntu.ac.uk](mailto:ian.smalley@ntu.ac.uk)

The 18<sup>th</sup> INQUA Congress will be held in Bern, Switzerland in 2011; not too far from the loess lands of the Danube basin. We thank Sir John Tenniel again for providing LL pictures. Mammuthus primigenius Blum. is on the cover; we see M as a loess animal; there are connections between M and loess, and we wonder if they have ever been properly explored. Loess people need to be more aware of mammoths- and vice versa.



0005

### Reinterpreting climate proxy records in Chinese loess

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The physical properties of Chinese loess and Red Clay deposits have been extensively utilised to develop detailed and continuous Neogene climate records. Much of this evidence is tied to assumptions concerning the nature of loess sedimentation and past climate signal acquisition. For example grain-size variations are suggested to record changes in winter monsoon wind speed, with sedimentation rates controlled by source aridity. In addition, it is widely suggested that grain-size changes can be used as an indicator of sedimentation rate. Here, Optically Stimulated Luminescence (OSL) dates obtained at 10–20 cm intervals from four typical sites along a transect across the Chinese Loess Plateau are used, in combination with detailed grain-size and magnetic susceptibility analyses, in order to examine the complex nature of loess sedimentation and diagenesis. The findings are used to develop a clearer understanding of what climatic signals are preserved in loess and how they impact on the use of traditional climate proxies. OSL dating has recently shown that loess sedimentation is more episodic than continuous in nature and that erosional events, site-specific factors and pedogenesis can obscure climate records. These findings are expanded upon while evidence concerning the relationship of grain-size changes to sedimentation rate, along with their physical causes, is explored. In addition, the potential influence of site-specific conditions and non-aeolian sedimentation is explored. The findings from such an exercise are crucial in determining the proper interpretation of widely applied climatic proxies in loess research.

0020

**Pedogenetic differences between Australian and New Zealand loess deposits, as distinguished by micromorphological analysis**

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For some time now, the nomenclature describing Australian and New Zealand dust deposits has differed, seemingly because of mineralogical and pedological contrasts between the dust materials of the two countries. In Australia, the term "parna" has generally been used to describe red, clayey, sometimes calcareous deposits of dust laid down in thick layers during the late Pleistocene. This contrasts with the widespread term of "loess" in New Zealand to describe aeolian dust deposits derived from a variety of sources. Recently, there has been growing support for the recognition of "parna" as desert loess, given the mode of transport and deposition of the material, and the similar particle size features that more traditionally recognised "loess" profiles also possess. Nevertheless, it remains clear that morphologically, Australian and New Zealand loess deposits are quite easily distinguishable. This is presumably because the dust sources are different in the two countries and because the climatic regimes of the loess-covered areas of the two countries are quite different. In this paper, we seek to compare micromorphologically the topsoil and subsoil of two loess profiles of southern New South Wales (Australia) with topsoil and subsoil of four New Zealand loess profiles. The New Zealand loess profiles, all located on the North Island, include three derived from re-worked fluvial sediment and one derived from tephric materials. All six profiles showed considerable evidence of pedogenesis, including distinct horizonation, strong development of mottles and nodules in some horizons, strong microstructure in some horizons, the presence of argillans and clay plugs, and varying degrees of mineral transformation. In keeping with the redder colour of the Australian soils, ferriargillans and Fe-nodules are much more prevalent in these subsoils than in the New Zealand profiles, while the New Zealand loess profiles contain a greater amount and variety of unweathered primary mineral grains. Although significant populations of wind-entrainable particles were present in all profiles, there was no evidence of silt-sized pellets of clay in the Australian soils, which is believed to be the transport mode of "parna". There was little microstructural difference between the more clayey New Zealand loess and the Australian loess, although the more silty New Zealand loess profiles tended to be massive rather than well-aggregated. The slightly younger age of the New Zealand loess, plus the cooler climate of that country, appear to be responsible for the less advanced pedogenic development of those profiles compared to the Australian loess profiles examined.

0023

**A terminal Last Glacial Maximum (LGM) loess-derived palaeoflood record from South Australia?**

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Late Pleistocene fine-grained valley-fill formations have been reported in the uplands of present-day desert margins, including the Great Escarpment of Namibia, the Sinai Peninsula of Egypt, the Matmata Hills of Tunisia, and the Flinders Ranges of South Australia. The valley-fills or *Silts* mantled the underlying irregular bedrock topography and now form gently sloping terraces incised by ephemeral traction-load streams. Their homogeneous silty texture and massive to crude horizontal bedding, with occasional fine laminations that can be traced laterally for tens of metres, have prompted a number of conflicting depositional models (Haberlah 2006, [http://crclme.org.au/Pubs/Monographs/regolith2006/Haberlah\\_D\\_Final.pdf](http://crclme.org.au/Pubs/Monographs/regolith2006/Haberlah_D_Final.pdf)). Reworked desert loess has been invoked as a source for these homogeneous *Silts* at all locations (Coudé-Gaussen et al., 1984 *SGB* 37:1050; Eitel et al., 2001 *QI* 76/77:57; Rögner et al., 2004 *LNES* 102:79; Williams and Nitschke, 2005 *SAGJ* 104:25). This realisation has major implications for their palaeoenvironmental interpretation. While most recent sedimentological studies suggest that the *Silts* represent loess-derived alluvium (Rögner et al., 2004; Srivastava et al., 2006 *QR* 65:478), their ages are still contested and for example range at the Homeb *Silts* stratigraphic type section in Namibia from LGM (Vogel, 1982 *Palaeoecol Afr* 15:201; Eitel and Zöller, 1996 *MÖGG* 137:245) to mid-Holocene (Bourke et al., 2003 *QSR* 22:1099). However, a chronostratigraphy based on 37 AMS <sup>14</sup>C-ages and 7 OSL dates, exists for *Silts* in the Flinders Ranges (Williams et al., 2001 *QI* 83–85:129). New results from a continuous monolith 8m long obtained from the dated stratigraphic type locality of the Brachina Creek are presented. Hyperspectral mineralogical logging at 1cm intervals targeting alternating light- and dark-coloured bands are linked with results of Coulter Multisizer particle size and XRF/XRD analyses, suggesting slackwater deposition due to backflooding of a tributary mouth upstream of the loess-choked Brachina Gorge. Stable isotope and mollusc assemblage studies on carbonate shells are consistent with this model of palaeoflood deposition. Calibrated <sup>14</sup>C-ages indicate three episodes of rapid aggradation

at ~20.2 ka, ~19.4 ka and ~18.2 ka which, when compared with independent regional palaeoenvironmental proxy data, suggest early deglacial orographically enhanced frontal precipitation events causing rapid erosion of LGM loess slope mantles. Other occurrences of Silts can now be compared with these fine-resolution sedimentological studies and palaeoenvironmental data embedded in a well-established chronostratigraphy. The loess-derived palaeoflood record also sheds new light on palaeoclimatic processes operating in southern Australia during one of the most complex intervals of the Late Pleistocene.



"12 or 13?" (58)

### Does a climosequence of loessic soils exist across southern New South Wales?

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It is widely accepted that the main source of aeolian sediment for the extensively distributed loessic soils of southern New South Wales are the aeolian and riverine environments of western New South Wales, northwestern Victoria and eastern South Australia. The main expression of these loessic soils is so-called "parna", a clay-rich material believed to have been transported eastward predominantly as silt-sized pellets. Although there is little strong evidence for this transport model, the presence of these loessic soils is demonstrable in various districts. A significant deficiency in our understanding of these loessic soils relates to their physico-chemical and structural attributes. Although some isolated profiles have been characterised, there is little understanding of how these profiles may change in character with distance eastward, away from the arid to semi-arid source regions and into more humid, higher rainfall regimes. It is not unreasonable to expect that with distance eastward aeolian dust deposits should generally be finer-grained, less thick, more weathered and better differentiated pedogenically. This paper looks at a number of previously-identified loessic profiles in southern New South Wales, including some which contain several metres of aeolian sediment and others which contain only dust inclusions. The profile locations have annual average rainfall of between 520 and 670 mm, and occur in different geomorphic environments. Within each profile a range of morphological, physico-chemical and structural attributes were determined for each major horizon. Results show that the deepest profiles in the driest (western-most) locations are characterised by whole-coloured, slightly alkaline, slightly saline and sodic subsoils with moderate cation exchange capacities. Profiles in the wettest locations tend to be acidic, non-saline and non-sodic, exhibiting lower cation exchange capacities and possessing abundant nodules and sesquioxides. Structurally all profiles tend to be quite stable when saturated, despite the differences in various physico-chemical properties. Presumably this structural stability is, at least partly, due to the ubiquitous presence of iron oxides which act as effective aggregating agents for clay particles. These data appear to support the contention that the pedologic nature of contemporaneously deposited loessic profiles in southern New South Wales is (or has been) significantly influenced by small variations in climatic conditions.

0168

### Thermally-transferred (recuperated) OSL dating in Chinese loess: from signal to method

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Luminescence dating of sedimentary quartz grains using the fast component of the optically stimulated luminescence (OSL) signal has become a useful tool for dating the Malan loess (of last glacial age) from the Chinese Loess Plateau. However, saturation of the fast OSL component means that this signal cannot be used for dating loess from the penultimate glaciation and older. Recently, we have found that there is an OSL signal that does not saturate until much large doses are given. Part of the thermally transferred OSL signal (termed the recuperated OSL) has an increasing dose response back to more than 3000 Gy for fine grained quartz that has been chemically isolated from the polymineral fine-silt fraction; this would permit dating of samples with an age of 1 million years if they had a dose rate of 3 Gy/ka. In a series of experiments, we have investigated the recuperated OSL in order to optimise the measurement conditions to obtain the dose that grains have received since they were last exposed to sunlight, i.e. the time when they were deposited. We have developed two methods, one using multiple aliquots of quartz and one using single aliquots of quartz, analogous to the measurements made on the OSL signals for the Malan loess. We report on the feasibility of using these two methods for obtaining ages for the loess and paleosol sequences at Luochuan and Xifeng on the Chinese Loess Plateau. The reliability was tested using known age samples from the last and penultimate glacial-interglacial loess-paleosol sequences. In addition, samples from close to the Brunhes/Matuyama boundary at the same sites were measured. There was good agreement between our new dates based on the recuperated OSL signal and the independent ages. We thus infer that this new method is applicable to Chinese loess over the whole of the Brunhes epoch.

0281

### Climatic conditions recorded by terrestrial mollusk assemblages in the Loess Plateau during marine oxygen isotope stages 12-10

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Past analogues for our present interglacial have been sought in order to better understand our present and future climate. Marine Isotope Stage 11 (MIS 11) has long been considered to be a good candidate and gained more and more attentions in recent studies of marine and terrestrial records. In the Chinese loess-paleosol sequences, S4 soil, the equivalent to MIS 11, is one of best terrestrial paleoclimate records of environmental changes during this period. In this study, two high-resolution terrestrial mollusk records from the Loess Plateau have been studied to characterize climate variability during the periods of MIS 12-10. The processes of ecological and climate changes, as indicated by the variations in abundance of land mollusk species, have been documented in the loess and paleosol sequences during this period. Our mollusk results show that the L5 loess, the equivalent to MIS 12, was formed under relative cold and dry conditions. Climate at this period was not so severe as indicated in marine isotopic record. An episode of warmer and humid condition occurred at the middle time of the MIS 12, reflecting a summer monsoon strengthened during the glacial interval. The same scenario was seen in the middle part of the MIS 10. Our mollusk records also provide insight into the climate conditions of the Loess Plateau during the MIS 11. A general warm-humid climate dominated during the formation of S4 soil. But at least four fluctuations happened at Xifeng region, reflecting an unstable climate condition and regional climate difference in the Loess Plateau during this period. Our study shows that the early part of S4 formation spanning over 30 ka was very warm-humid climate condition, being a unique long interglacial during the Quaternary climate history. While the late part was characterized by mild-cool conditions in the Loess Plateau. Comparison of the MIS 11 and the Holocene climates based on mollusk species compositions reveals different climatic conditions. The early part of MIS 11 was warmer and more humid than the Holocene optimum period, but similar or cooler in the late part of MIS 11. Our study indicates that the extent of warming at present day might be far less than the condition of the MIS 11 Interglacial period.

**Phytoliths as quantitative indicators for the reconstruction of past environmental conditions in China: Palaeo-environmental reconstruction in the Loess Plateau**

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Quantitative reconstruction of the climatic history of the Chinese Loess Plateau is important for understanding present and past environment and climate changes in the Northern Hemisphere. Here, we reconstructed mean annual temperature (MAT) and mean annual precipitation (MAP) trends during the last 136 ka based on the analysis of phytoliths from the Weinan loess section (34°24'N, 109°30'E) near the southern part of the Loess Plateau in northern China. The reconstructions have been carried out using a Chinese phytolith-climate calibration model based on weighted averaging partial least-squares regression. A series of cold and dry events, as indicated by the reconstructed MAT and MAP, are documented in the loess during the last glacial periods, which can be temporally correlated with the North Atlantic Heinrich events. Our MAT and MAP estimations show that the coldest and/or driest period occurred at the upper part of L2 unit (late MIS 6), where MAT dropped to ca. 4.4°C and MAP to ca. 100 mm. Two other prominent cold-dry periods occurred at lower L1-5 (ca. 77–62 ka) and L1-1 (ca. 23–10.5 ka) where the MAT and MAP decreased to about 6.1–6.5°C and 150–370 mm, respectively, ca. 6.6–6.2°C and 400–200 mm lower than today. However, the highest MAT (average 14.6°C, max. 18.1°C) and MAP (average 757 mm, max. 1000 mm) occurred at S1 interval (MIS 5). During the interstadial of L1-4–L1-2 (MIS 3) and during the Holocene warm-wet period, the MAT was about 1–2°C and MAP 100–150 mm higher than today in the Weinan region. The well dated MAT and MAP reconstructions from the Chinese Loess Plateau presented in this paper are the first quantitatively reconstructed proxy record of climatic changes at the glacial-interglacial timescale that is based on phytolith data. This study also reveals a causal link between climatic instability in the Atlantic Ocean and climate variability in the Chinese Loess Plateau.

**Extracting geomagnetic signal from an 80ka <sup>10</sup>Be record in Chinese loess**

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Numerous previous studies have measured remnant magnetism or cosmogenic <sup>10</sup>Be concentrations in loess. While these have provided useful information about climate or about fluctuations in the orientation of the geomagnetic field, attempts to extract paleomagnetic intensity records from loess have largely been unsuccessful. Although <sup>10</sup>Be flux is regulated by geomagnetic field intensity, extracting an intensity record from loess <sup>10</sup>Be is complicated by reworked dust that contains <sup>10</sup>Be which fell at some time in the past. An additional complication results from the fact that the local flux of new <sup>10</sup>Be fallout recently generated by cosmic ray interactions in the atmosphere depends on the local rainfall rate. A new approach is taken in this work to remove these effects by observing that loess magnetic susceptibility also has an inherited dust component as well as a pedogenic component which also depends on moisture availability, e.g. rainfall amount. To constrain the fraction of <sup>10</sup>Be resulting from reworked dust we observe loess magnetic susceptibility plotted against loess coercivity defines a two component mixing curve between dust and pedogenic end-member components. This allows us to define the dust end member for loess susceptibility which corresponds to loess generated during the driest time frames. We define the <sup>10</sup>Be dust end member as that concentration found in the same loess horizons that define the dust end member for susceptibility. To remove the dependence on rainfall amount, we make use of the correlation between <sup>10</sup>Be concentration and loess magnetic susceptibility, which both depend on wet precipitation amount. After removal of the dust and precipitation-amount effects, we then observe the residual variance in <sup>10</sup>Be concentration which is due mainly to geomagnetic modulation of <sup>10</sup>Be production rate, and variations in sediment accumulation rate. Converting these concentrations to flux using sediment accumulation rates, we produce a high-resolution <sup>10</sup>Be production rate record from the Luochuan loess for the past 80 ka. After normalization to modern flux we convert this production rate record to magnetic field intensity. The resultant record exhibits strong coherence with the SINT200 and NAPIS 75 records, and shows two geomagnetic low intensity events which we believe to be the Laschamp and Mono Lake events.

**Late Quaternary Climatic Changes in Northern China - New Evidences from Sand Dune and Loess Records based on Optically Stimulated Luminescence Dating**

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In Northern China, areas of desert, sand field, Gobi and loess account for nearly two million square kilometers of the landscape. Because of the relatively simple transport and unique deposition process, these aeolian deposits preserve good records of climatic changes during recent geological times such as the Late Tertiary and the Quaternary. There have been many investigations on the loess and the sand dune depositional sequences corresponding to climate and environmental changes. These studies have advanced our understanding of regional palaeoenvironment changes; however, previous studies on chronological framework, especially the absolute chronological controls with high-resolution on the loess and the sand dunes, are still very limited. Thus those conclusions on climatic and environmental changes based on investigations of these aeolian deposits, especially changes at millennial-centennial time scale, are still largely open to discussion. In this study, four typical loess sections of the Late Quaternary on Chinese Loess Plateau and more than 20 sand-paleosol sections in Mu Us, Otindag and Horqin sand fields are examined in order to reconstruct wet-dry climate variations in North China under absolute age controls. On the basis of optically stimulated luminescence ages from more than 150 samples and the proxy indexes of grain size distribution, magnetic susceptibility, and organic matter content obtained from more than 200 samples, which are directly related to the climatic variations, we refine the regional wet-dry climate changes in orbital time scale during the Late Quaternary. The loess and sand dune records reveal similar changes to closely reflect the climatic changes: It was relatively dry during 57.5~52.5 ka, wet during 41.5~37.3 ka, and gradually drying

0384  
during 29~22 ka, followed by an extremely dry episode during 22~18 ka and then dry again during 15~10 ka. The climate gradually became humid in 10~8 ka and was wet during 8.0~2.4 ka. The climate was dry again in the recent 2.4 ka. There were several desiccation episodes during 8.0~2.4 ka and the climate had high-amplitude changes in the recent 2.4 ka. These climatic changes have lagged 3~4 ka to the solar radiation variations which is believed driven by the Earth's orbital trajectory changes.

## 0538

**The timing, source, and flux of Last Glacial loess accumulation in the North American midcontinent**

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Terrigenous dust can be both a product and an agent of climate change. Ice core records show increased levels of continental dust during glacial periods compared to interglacials, with exceptional levels of dust being recorded during the last glacial maximum (LGM). The terrestrial deposits of wind blown dust known as loess also support these observations, preserving records of changes in climate and in atmospheric circulation, and documenting the changing sources and flux of dust over time. The greatest thicknesses of Last Glacial loess are preserved in the North American midcontinent, and termed 'Peoria Loess'. On the basis of thickness alone, these Peoria Loess deposits suggest high dust accumulation rates during the Last Glacial period across a large area of North America. Using optically stimulated luminescence (OSL) dating, we have previously shown that mass accumulation rates (MARs) for non-glacigenic Peoria Loess in western Nebraska are much higher than any other pre-Holocene location worldwide, and that these MARs fluctuate over time. This paper builds upon this earlier work, extending the area of study across the North American midcontinent along a west-east transect and presenting new data for sites in eastern Nebraska and western Iowa which have both glacigenic and non-glacigenic sources. A combination of optically stimulated luminescence (OSL) dating and geochemistry is employed, providing a powerful tool for the reconstruction of what prove to be dramatic changes in the timing, flux, and source of dust. These loess records may not only serve as passive testimony to the response of dust to climate change, but may also provide evidence to support the active role of dust in forcing climate change.



**Provenance and pedogenesis in an Australian loess deposit: environmental implications**

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Loess deposits have been identified in several localities in the tablelands of south-eastern Australia based on their sedimentology and geochemistry. While the dust has been shown to be sourced, predominantly, from the arid and semi-arid interior of the Murray-Darling Basin (a large internal Cainozoic basin) there is debate about the contribution from the very large playas of the Lake Eyre Basin of central Australia and which elements of the landscape (playa, dunes, floodplains) have dominated dust supply. We investigated the sedimentology and trace element geochemistry of a 4.5 m loess profile at Mackenzie's Waterholes Creek (MWC), 200 km west of Sydney, which has been OSL dated to the last 50,000 years (Hesse et al., 2003, *Aust. J. Soil Res.* 41: 1115). We also examined surface soil samples from possible source areas within the Murray-Darling and Lake Eyre Basins. Provenance could not be determined from the loess trace element geochemistry because of the strong pedogenic modification. Strong leaching is evident in the profiles of most elements while accumulation of others occurs within iron and manganese fragipans evident in the profiles. Trace element geochemistry was successful to some degree in distinguishing possible dust source regions and landforms but these could not be related to the loess, presumably because of the pedogenic effects. Pedogenic overprinting in the loess includes iron and manganese leaching and precipitation, strong colour development and a texture contrast topsoil but without significant in-situ weathering of clastic minerals, formation of clays or accumulation of calcium carbonate. The MWC loess has a dominant coarse silt (40 micron) mode and minor clay mode (<5 microns). The clay fraction is widespread in the potential source regions but we could not identify any source areas in which coarse silt formed more than a minor component. We surmise that the coarse silt is extremely efficiently sorted during transport. The extreme uniformity of particle size distribution in the MWC loess profile, despite large changes in the accumulation rate, is evidence of relatively steady winds through the Late Quaternary despite significant changes in aridity. The strong pedogenesis is the product of the generally low accumulation rate and a (modern) warm, moist climate. However, the cumelic profile has not preserved any palaeosols and the visible pedogenic features are related to long-term and continuing processes.

**Loess stratigraphy and palaeoclimate changes during Quaternary in Northeastern Tibetan Plateau revealed by long loess cores**

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As the highest land in the world, Tibetan Plateau has undergone surface erosion in recent geological time, so that unconsolidated sediments are not well preserved and detailed Quaternary palaeoenvironmental and palaeoclimatic records in this immense area have not been well studied. In the northeastern Tibetan Plateau, there is thick loess deposit, which offers a good opportunity for studying palaeoclimate and palaeoenvironment changes during the Pleistocene and the Holocene, like the loess deposit in Chinese Loess Plateau. However, the thick loess deposits in Tibetan Plateau are not well investigated because they are usually covered by reworked loess, and the pedostratigraphy is not well exposed. During the August–November of 2004, we undertook a drilling project at the site with the thickest loess, the core penetrating the loess deposits and reaching fluvial gravels and pebbles underlying the loess. Two continuous cores with thickness of 232 m and 182 m were obtained, and the coring recovery is over 95%. Here, we report pedostratigraphy, magnetostratigraphy and magnetic susceptibility of these two cores. The preliminary results show that age of the loess deposit is around 2 Ma, the stratigraphy of the loess-paleosol sequences in the Tibetan Plateau can be correlated with the typical loess-paleosol stratigraphy in central Chinese Loess Plateau, but the Tibetan Plateau loess deposits have more sedimentary hiatuses. Based on our age control, the climate change during the Quaternary period in this high land can be reconstructed, and compared with the glacial-interglacial alternations in North Hemisphere. However, climate changes in Tibetan Plateau seems to have larger amplitude and higher frequency during the Early Pleistocene. On the basis of comparison with time.

0432

**Upper Pleistocene loess deposits of the Middle Dnieper area, Ukraine**

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Results of the investigation of the Upper Pleistocene loess deposits of the Middle Dnieper area are given in the paper. In the Upper Pleistocene sequence of the Middle Dnieper area, the loess units predominate over the soil units in their thickness. The characteristic features of the Uday loess unit (70–58 ka) are its small thickness and high percentage of clay particles. Pollen data indicate that the Uday unit was formed under more mesophytic steppe vegetation than the later loess units. Cryophytes were represented in the vegetation. The micromammal complex of the Uday unit yields *Dicrostonyx guliemi* and *Arvicola terrestris*. The upper loess deposits of the Upper Pleistocene are subdivided into two unequal parts by the Dofinovka interstadial soils: the Bug loess unit – the thickest (up to 18 m) of the Pleistocene loesses of Ukraine, with all characteristic loess features, and the Prychernomorsk loess unit, with a larger admixture of clay and sand particles than the silty Bug loess. The Dofinovka soils are weakly developed turf-carbonate soils. In the northern part of Ukraine, they have a very limited distribution, and the Bug and Prychernomorsk units combine to form a single loess sequence. Pollen spectra derived from the Dofinovka soils indicate boreal steppe. The micromammal complex of the Vytyachiv-Bug stages contains *Citellus severnensis* and *C. citelloides*, while that of the Dofinovka-Prychernomorsk stages has only modern species. The Bug, Dofinovka and Prychernomorsk units are dated by TL and <sup>14</sup>C as being younger than 27 ka BP old. At the stratotype localities of the Dofinovka unit, in the southern part of Ukraine, its <sup>14</sup>C age is between 13.7 and 16.1 ka BP.



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0506

**New evidences for a rapid climatic warming at about 37.5 ka BP in Western Europe: the thermokarst processes from the Nussloch loess sequence (Germany)**

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The impact of millennial climatic changes on continental environments during the Last Glacial (D/O cycles), has been intensely studied in loess sequences since the last 10 years. Between 60 and 30 ka BP, these D/O cycles are generally represented by the alternation of loess layers and arctic brown soils horizons. Nevertheless, owing to sedimentation gaps during loess deposition, the number of these soil horizons is always lower than the number of D/O cycles during the same period, making the correlations very difficult. The discovery in the Nussloch loess sequence (Rhine Valley Germany) of a unique thermokarst feature provides new evidences of the impact of rapid climatic warming. The feature itself is characterised by a large and elongated erosion thermokarst gully incising into the underlying deposits. The very sharp and irregular lower boundary that characterises this incision feature and the occurrence of a deformed ice-wedge relict at its base show that it has been created thermal erosion linked to a rapid melting of the permafrost ice. The infill of the feature is composed by strongly stratified and very heterogeneous hillwashed deposits including sand beds, redeposited loess layers and organic silts layers, angular soil pebbles (frozen blocs), alternating with peat beds. The whole sequence includes numerous and well preserved vegetal remain, molluscs shells and beetles. The vegetation is mainly composed by *Salix* sp., 74%), *Pinus sylvestris* (21%, including pieces up to 8cm in diameter), *Betula* sp. (2%) and very abundant mosses remains. The 17 molluscs species suggest an open environment (mosaic of dry and sunny places with short vegetation), and more humid patches of bush or wood, which can correspond to Interstadial conditions. Thus biological data allow to evidence interstadial conditions strongly contrasting with the over and underlying loess environment. Four radiocarbon dates (average 32.26 <sup>14</sup>C BP / 37.4 ± 1 cal BP) allow the correlation of this thermokarst infill with GS-8 from the GRIP Ice core, just following the H4 event. On the base of this discovery, similar features showing strong thermal erosion process have been evidenced in the Nussloch sequence and in other western European loess sequences at the base of the Middle Pleniglacial (GS 16/17). Finally, these observations allow to underline the importance of "thermokarst events" in the investigation of W-European loess sequences and to launch an original "TK-Events stratigraphy".

19

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Loess deposits were the first terrestrial sediments to which luminescence dating was systematically applied, tested, and developed. These deposits provide a direct record of atmospheric circulation, and their temporally extensive nature means that they provide one of the most detailed and significant terrestrial records of climate change found on Earth. However, establishing a reliable absolute chronology is essential if different loess records are to be compared, and teleconnections investigated. The great strength of luminescence dating is that it is applied to the minerogenic component of the sediment itself, enabling the time of sediment deposition to be dated directly. Coupled with this, the current range of the luminescence technique makes it potentially one of the most valuable absolute dating techniques available for the study of loess deposits. Equally, the length of many loess records presents a unique testing ground for the challenge to extend the maximum age range of luminescence techniques. Thus, luminescence dating and loess records complement each other strongly, and the development and testing of luminescence techniques and their application to loess deposits has gone hand-in-hand. Inevitably, because so much pioneering luminescence research has been carried out on loess deposits, this means that some luminescence ages produced during this developmental phase are questionable. However, recent improvements in luminescence dating have brought about increased accuracy and precision, and so confidence in luminescence dating is increasing among the luminescence and the user communities alike. Indeed, luminescence dating is now frequently cited as the method of choice for determining an absolute chronology, particularly for aeolian deposits. Recent developments in luminescence dating of loess, and the subsequent palaeoenvironmental conclusions reached as a result of the successful application of luminescence dating will be discussed. Future research directions and challenges facing luminescence dating will also be considered.

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A series of Holocene loess-palaeosol sequences (JY, JZT, and YX) were investigated on the Chinese Loess Plateau. Two layers of loess deposition interrupted the Holocene palaeosol S0 on all the studied sections, indicating that at least two drought events took place during Holocene palaeosol development. Optical dating was applied to these sections at every loess-palaeosol unit boundary. For one studied sequence YX, the samples were collected densely from two parallel sections and measured in different luminescence dating laboratories to inspect the reliability of dating results. It concluded that OSL dating method could be applied to loess-palaeosol samples very well. The Loess-palaeosol sequence YX and JZT recorded two main dry episodes (3.7~2.4 ka ago and 1.2~0.8 ka ago) during Holocene with the present of two layers of loess in Holocene palaeosol deposition. And the Loess-palaeosol sequence JY recorded two dry episodes of 7.2~6.4 ka ago and about 1.0 ka ago during Holocene. These three aridity events were also consistent with the other global climatic records in Holocene. It is suggested that Holocene loess-palaeosol sequence in China could record global climate change even though one section may not record all the drought events. On the other hand, the same structure loess-palaeosol sequences record different climate events; the continuously dating points present big age gap; the LGM Malan loess shows the lowest mass accumulation rate. All these phenomena indicate that the loess did not deposit continuously in millennial time scale.

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Dating sediments using the optically stimulated luminescence (OSL) signal from quartz is now applied widely. The quartz signal has been shown to be made up of several components which vary in strength from sample to sample. The fast OSL component that occurs in many sedimentary grains, particularly those from desert environments, has been studied in detail and is the signal used in the single-aliquot regenerative-dose (SAR) protocol that can be used for an aliquot made up of a few thousand grains or just a single grain. The fast OSL component is almost always the most light-sensitive OSL signal and it is sufficiently thermally stable for it to be used for dating samples back to 0.5 Ma when dose rates are very low (~0.5 Gy/ka). However, the fast component saturates with dose in such a way that for dose rates of ~3 Gy/ka, typical of loess, OSL ages over 100 ka are unlikely to be attainable. In order to use light-sensitive luminescence signals for older dating samples, it has been necessary to extract other signals from either quartz or potassium feldspars. A new signal has been discovered in quartz extracted from Chinese loess. The recuperated OSL (ReOSL) saturates at doses about ten times higher than those obtained for the fast component from the same grains. The ReOSL signal has been shown to be capable of dating the Brunhes-Matuyama boundary. Several other signals, including luminescence emitted at different wavelengths than the blue-UV emission of the OSL, have also been investigated in order to obtain older ages. Luminescence signals from K-feldspars also have high saturation doses, but as previously found when using their thermoluminescence (TL), dating with either optically- or infrared-stimulated luminescence (IRSL) gives rise to age underestimation of 30% or more. This underestimation has been linked to the loss of signal observed in laboratory experiments known as anomalous fading. However, there is experimental evidence that part of the IRSL signal from K-feldspars is stable. This part of the signal appears to be related to the internal beta dose rate, and an age can be calculated using IRSL signals from grains of different diameter in an isochron method known as iIRSL. This can be used to date grains for which the environmental dose rate is unknown or problematic. Some applications of these new luminescence dating techniques will be presented.

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The loess-paleosol sequences in Hungary provide an excellent Upper-Pleistocene climate archive for the Carpathian Basin. Loess deposits up to 25 m thick cover the Sütto travertine complex, located in the very northern part of Hungary, next to the right bank of the Danube River. The loess is intercalated by a pedocomplex, including a reddish B-horizon covered by a chernozem-like palaeosol, two thinner brownish steppe-like soils and two greyish horizons. In the first step Infrared Optically Stimulated Luminescence (IRSL) dating was applied on polymineral fine grain material using the multiple-aliquot additive dose (MAAD) protocol to determine the deposition age of the loess. The uppermost loess yielded IRSL MAAD age estimates ranging from 15 to 40 ka. The loess on top of the pedocomplex yielded IRSL MAAD age estimates ranging from 48 to 60 ka. The pedocomplex most likely correlates with the Marine Isotope Stage (MIS) 5 interglacial period. The loess from below the pedocomplex was deposited during the penultimate glaciation, as evidenced by amino acid racemization (AAR) results. On the upper part of the profile – above the pedocomplex – the AAR and the IRSL MAAD investigations are in excellent agreement. The IRSL MAAD age estimates from the pedocomplex and from the underlying sediments, are not in agreement with the AAR results. It is very likely that IRSL MAAD age estimates are significantly underestimated. This age underestimation is investigated in more detail. The age estimates determined by multiple-aliquot method are compared with the age estimates determined by single-aliquot protocols. The double single-aliquot regeneration (double SAR) protocol is applied on the polymineral fine grain material to determine the IRSL and post IR - OSL (Optically Stimulated Luminescence) age of the feldspar and quartz grains of the material, respectively. The newly developed Red TL (thermoluminescence) and the Thermally Transferred (TT) OSL procedure of the quartz grains will be applied on 3-3 samples from the pedocomplex and from the underlying sediments. These procedures are suitable to date the sediments older than 100 ka. Independent age control is provided by uranium-series (<sup>230</sup>Th/<sup>234</sup>U) dating correlating the travertine from below the loess with MIS 7 (8).

0815

### Paleoenvironmental implications of microscale carbonate nodule isotope variability of Chinese Loess Plateau paleosols of the past 1.4 Ma

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Thick successions of interbedded loess and paleosols from the Chinese Loess Plateau provide a continuous terrestrial record of climate variability for the past 2.6 Ma. The C and O isotope compositions of pedogenic carbonate nodules associated with the paleosols have been used as paleoenvironmental proxies. However, pedogenic carbonate nodules can be overprinted leading to artificial homogenization of their bulk isotopic composition. To evaluate the C and O isotopic complexity of pedogenic nodules from selected paleosols from the interval of 70 ka to 1.4 Ma (S1–S17) of the Jiaodao section, we carried out a high-resolution (micrometer scale) analysis of various micromorphological features (matrix, peloids, pore coatings, in-fillings) within nodules, and compared these results to homogenized bulk carbonate samples from the same nodules. The  $\delta^{13}\text{C}$  values of most micromorphological components range between  $-3.0$  and  $-7.0$  ‰, whereas  $\delta^{18}\text{O}$  values range between  $-8.4$  and  $-10.4$  ‰ VPDB. Few pore coatings and in-fillings, however, have  $\delta^{13}\text{C}$  values as negative as  $-8.5$  ‰ VPDB. Variability within an individual nodule (intranodule) in  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values is  $<1$  ‰ VPDB in small nodules ( $<50$  mm), and up to 2 ‰ or more in larger nodules. Intranodule isotope variability is similar to variability between several nodules within each soil (internodule) as well as to that between nodules from paleosols of different ages. Bulk isotope compositions ( $\delta^{13}\text{C} = -5.1$  to  $-6.5$  ‰,  $\delta^{18}\text{O} = -8.9$  to  $-10.0$  ‰ VPDB) record average long-term conditions at the site, but they mask smaller-scale temporal variations. The  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  isotope values of both bulk and micromorphological features covary suggesting higher presence of C4 plants during times of enhanced summer monsoon precipitation. Measured soil organic matter  $\delta^{13}\text{C}$  values from some of the examined paleosols indicate elevated C4 vegetation at the site during peak paleosol formation periods. The collected nodule and organic matter isotope data suggest that the bulk of nodule formation occurred under warm and wet soil forming conditions (Interglacials).

0973

### Antarctic timing of South American Quaternary climate?

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With the data we present in this study we try to stimulate the discussion on the importance of the Southern Hemisphere in global climate change. Present-day precipitation data (New et al., 2001) for South America, Africa and Australia, which show a clear seasonal latitudinal shift of the rain-bearing Southern Westerlies of about  $9^\circ$  latitude, are compared with palaeo-aridity data from Chile; We present grain-size distributions of the terrigenous sediment fraction from cores from the Chilean continental margin in the SE Pacific. The grain-size distribution data of two sediment cores were 'unmixed' into subpopulations, and interpreted as 'coarse' aeolian dust, 'fine' aeolian dust and fluvial mud, respectively. The downcore ratios of the proportions aeolian dust and fluvial mud represent palaeo-continental aridity records of Chile's winter rainfall region for the last 20,000 yr, showing relatively wet conditions during the Last Glacial and drier conditions during the Holocene. Synchronous changes in the Sajama ice core (Bolivia) suggest that the source of moisture – the Southern Westerlies – extended northward during the LGM up to  $18^\circ\text{S}$ . Further North, ice cores record a clear Atlantic signal (Quelccaya ( $14^\circ\text{S}$ ) and Huascarán ( $9^\circ\text{S}$ ), Peru). We hypothesize that a hemisphere-wide atmospheric circulation system influenced climate along the entire Chilean coast up to about  $18^\circ\text{S}$  during the Late Quaternary; the northward displacement of the Southern Westerlies during glacial times was also observed in southwestern Africa and most likely also influenced palaeoclimate in Australia.

0862

### Abrupt climate change in the Sahel caused by changes in thermohaline circulation?

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A marine sediment core from offshore Senegal records abrupt changes in marine- as well as continental environmental conditions in the Sahel region throughout the last 57 kyr before present. Due to its unique location directly offshore the Sahel zone and under the major dust path from Northwestern Africa into the Atlantic Ocean, it can be used to study Late Quaternary palaeoenvironmental conditions in this sensitive semi-

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0862

arid environment. In addition, due to its bathymetric position of about 2000 m water depth, it also registers Late Quaternary changes in deep-water circulation. Here we present a study of both the marine and terrestrial environmental conditions in subtropical Northwest Africa using a suite of proxies including stable isotopes as proxy for deep- and surface water circulation and grain-size analyses as proxy for terrigenous sediment composition, related to continental climate. We infer abrupt changes in the hydrologic cycle that governs precipitation in the Sahel zone that are contemporaneous with abrupt changes in the global thermohaline circulation: This observation has major implications for the moisture balance in the Sahel region should global warming persist.



0968

**Seasonal variability of present-day aeolian dust collected off NW Africa inferred from a multiproxy study combining grain size, chemistry, mineralogy, n-alkanes, C and N isotopes and satellite observations**

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Atmospheric dust samples collected along a transect off the West African coast aboard research vessels during different sampling campaigns, during different seasons, have been investigated using a suite of analyses including grain-size distribution, mineralogy, major-element chemistry, n-alkanes, and C and N isotopes.

On the basis of these data the samples were grouped into sets of samples that most likely originated from the same source area. In addition, shipboard collected atmospheric meteorological data, modelled four-day back trajectories for each sampling day and location, and the Aerosol Index data of the Total Ozone Mapping Spectrometer for the time period of dust collection were combined and used to reconstruct the sources of the dust samples, and their seasonal variability. It appears that the bulk of the wind-blown sediments that are deposited in the proximal equatorial Atlantic ocean is transported in the lower-level (~ 900 hPa) NE trade-wind layer, which is a very dominant feature North of the Intertropical Convergence Zone (ITCZ). However, South of the surface expression of the ITCZ, down to 5°S, where surface winds are from the South and West, we still collected sediments that originated from the North and East, carried there by the NE trade-wind layer, as well as by easterly winds from higher altitudes. We conclude that –although it is a major advantage to have a relative control on the stability of the dust-source areas– it is difficult to express the size of the aerosols in absolute wind speed since the latter depends on (1) the strength of the transporting agent, (2) the distance to the source, as well as (3) the vertical distance the particles have travelled.

Finally, after comparison between atmospheric dust and terrigenous sediments collected in submarine sediment traps off the West coast of NW Africa, we conclude that knowledge of the composition of aeolian dust is a prerequisite for the interpretation of palaeo-records obtained from sediment cores in the equatorial Atlantic.

**Atmospheric circulation changes evidenced by cyclic dust deposition in the US Great plains (Nebraska, USA).during Upper Pleistocene**

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The Peoria Loess unit is a well-defined stratigraphical unit in the Upper Pleistocene of the North American Quaternary. Deposited between 30–25 ka and about 12 ka ago. It has been indicated that this unit shows the highest ever-worldwide depositional rate for eolian deposits, as its thickness varies, near the source area, between 19 m and 46 m, extreme values that are not even recorded in the Chinese sequences. The results of our present investigation indicate that this particular unit is not homogenous. It shows different subunits where lithological variation can be observed through the occurrence of embryonic gley horizons alternating with laminated loess. Furthermore the analysis of the grain size shows cycles corresponding to variations in the eolian dynamics responsible of the dust transport and deposition. A grain size index interpreted as characterizing the eolian dynamics (higher values corresponding to stronger wind conditions) shows higher values than those observed in Europe. A comparison of this index is proposed with the Greenland dust and  $\delta^{18}\text{O}$  records. It shows that the main climatic history, as corresponding to events occurring mainly in North Atlantic domain, is recorded in the Peoria Loess deposits. However, the variation in the magnitude of the eolian events indicates a different behavior than in European loess sequences. The strong North Atlantic coolings as expressed by the Heinrich events, recorded in Europe by the coarser deposits, are not discriminated in the sequence by coarser material in the studied sequence, and so better follow observations obtained off California for the north East Pacific domain.

**Glacial and interglacial eolian dust dispersal patterns across the Chinese Loess Plateau inferred from decomposed loess grain-size records**

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Previous studies have indicated that a genetically meaningful decomposition (unmixing) of loess grain-size distributions can be accomplished with the end-member modelling algorithm EMMA. The independent decomposition of two series of loess grain-size records from the NE Tibetan Plateau and Loess Plateau spanning the last glacial-interglacial cycle indicates that the two data sets are described by very similar mixing models. The average mixing model presented here is regarded as representative for the vast loess region in northern China, and allows quantification of the contribution of three loess components to the loess grain-size distributions. A genetic interpretation and the paleoclimatic significance of the average mixing model has been provided by comparison of the modelled loess components with modern dust samples in terms of their grain-size distribution and flux rates, and by the distribution patterns of the loess components across the Loess Plateau reconstructed for the last two glacial-interglacial cycles. The sandy and silty loess components represent the coarse dust fraction supplied by saltation and short-term suspension processes over the proximal part of the Loess Plateau during major dust outbreaks in spring and early summer. The low-level winter monsoon (north-westerly wind system) is the likely transporting agent for these dust events. A clayey loess component represents the fine dust component supplied over the entire Loess Plateau by long-term suspension processes during major dust outbreaks and as part of a background supply system. The clayey loess component in the glacial loess deposits is dominantly supplied during major dust outbreaks by the north-westerly winter monsoon, whereas the clayey loess component in the Interglacial paleosols is mainly supplied by non-dust-storm processes, presumably with a significant contribution by the high-level subtropical jet stream (westerly winds).

### Climatic signature and chronology of the Late Pleistocene loess-palaeosols successions from Central and Eastern Europe

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During the last decade relevant data on palaeoenvironment were gained for the Late Pleistocene loess-palaeosol successions of Central and Eastern Europe based on detailed pedostratigraphic and palynological records. Within this large geographic area, key-sections were selected, respectively in the Middle Danube Basin, in the East Carpathian area, in Western and Central Ukraine and in the Middle Don Basin, allowing the establishment of a well documented correlative scheme linking these five regions. In Central and Eastern Europe the period of time from the last interglacial to the early pleniglacial records a complex succession of ten episodes of soil development including brown forest soil with Bt horizon, grey forest soil with Bth horizon, chemozem, brown boreal soil and weak humiferous soil. Moreover, the palynological data gathered in Central Ukraine for this pedostratigraphic succession shows a consistent signature of the vegetation with regard to the soil development, ranging from broad-leaved forest to dry forest-steppe. For what the middle and late pleniglacial are concerned, these periods are documented for the best at Willendorf, Stranska Skala, Dolni Vestonice and Grubgraben in the Middle Danube Basin, at Molodova, Mitoc-Malu Galben and Cosautsi in the East Carpathian area and at Kostienki in Central Russia. Each group of sites constitutes the core of a renewed regional pedosedimentary sequence with a strong chronological frame fixed between 49 ka and 12 ka uncal by way of a long series of consistent radiocarbon dates mainly produced on charcoal. The conjunction of these complementary data provides an almost complete palaeoclimatic succession recording about twenty-five short interstadials usually related to humiferous soil horizons developed under forest-steppe. Finally, the Late Pleistocene palaeoenvironmental sequence established for Central and Eastern Europe which integrates pedological and pollen data, confirms the predominance of highly unstable environmental conditions during the whole Late Pleistocene on the scale of the European Continent. It allows for the first time, to correlate vegetation development phases from the loess-palaeosol sequences with those of long lacustrine reference pollen sequences of Europe, as well as with the marine sequence of the Iberian margin. This correlative scheme not only demonstrates the remarkable reproducibility of the high-resolution climatic signal over long distance from the centre of the Russian Plain to the Atlantic Front, but also leads to combine the pedostratigraphic records and palynological data within a single structure on a large geographic scale.

### Contrasting dust supply patterns across the north-western Chinese Loess Plateau during the Last Glacial-Interglacial cycle

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Loess grain-size distributions of four loess-palaeosol sequences, located on a west to east transect from the north-eastern Tibetan Plateau (TP) to the north-western Chinese Loess Plateau (CLP), are unmixed with the end-member modelling algorithm EMMA. The unmixing results indicate that the loess is a mixture of three components representing very fine sandy, coarse silty and medium silty loess. The proportional contributions of the loess components in conjunction with loess mass accumulation rate estimates reveal that during the last glacial-interglacial cycle two contrasting dust supply patterns were active over the north-eastern TP and the north-western CLP: a constant supply of medium silty loess and an episodic supply of coarse silty loess and fine sandy loess. The variable input of the two coarse dust components is the main cause for the variation in grain size patterns and mass accumulation rates between the studied sites. Alluvial fans and fluvial systems in the intra-mountainous basins of the Tibetan Plateau and the deserts of Inner Mongolia are the main dust source areas for loess deposits of the north-eastern TP and the CLP, respectively. Sensitivity of these dust source areas to climate variations determines the timing of dust transport and deposition. In general, high dust fluxes are recorded during the last glacial period (MIS 2 to 4) and low dust fluxes during the last interglacial (MIS-5). However, the loess sections in the two regions (TP, CLP) show contrasting dust flux patterns during MIS-3. The records from the CLP show a relatively low dust input in this period, most likely related to increased humidity in the northern dust sources (deserts) where an increased vegetation cover 'prevented' dust deflation. In contrast to this, the Tibetan Plateau records appear to



**Has loess sedimentation in Middle Asia been controlled by changing atmospheric circulation patterns during the Pleistocene?**

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Loess sequences provide a direct proxy for the sedimentation dynamics of atmospheric dust, giving important information about the origin of the mineral aerosols and past palaeoclimatic conditions at that time of deposition. The conditions that determine the areas of origin, the transport and distribution of the aeolian material, are being accentuated by the dynamic process structures at the interface of the land surface and the atmosphere. Eventually this may allow the reconstruction of past atmospheric circulation patterns through high resolution loess investigations at different loess sites.

The thick loess-paleosol sequences along the Western and Northern slopes of the Tien Shan Mountains in Uzbekistan and Kazakhstan include a detailed palaeoclimatic record. Within the arid Eurasian loess belt these loess sequences represent an important link, connecting and correlating the European, the Central Asian and Chinese loess records. These loess deposits have not yet been investigated in detail despite of its thickness and wide spread distribution. The data presented demonstrate the great potential of these loess archives to reconstruct climate and environmental change in Central Asia during the Pleistocene.

In this paper we present the first results of highly resolved multi proxy studies of the loess sections Remisowka (Kazakhstan) and Yangi Basar (Uzbekistan). During the fieldwork samples for grain size and magnetic susceptibility were taken at 2 cm and 5 cm intervals from the loess. Particle size measurements of all samples were made on Beckman Coulter LS 13320 PIDS laser sizer with auto-prep station to provide a dynamic range that spans from 0.04 to 2000 µm and ensure accuracy and reproducibility.

The granulometric results show a maximum in the fine and coarse silt fraction and allow a clear distinction between cold and warm cycles. They show an important coherence between the type of dust sedimentation and the prevailing climate. In Central Asia the Westerlies transport fine dust over a long distance, whereas regional and local winds induced by the strong north or north-eastern winds from the Siberian-mongolian high pressure cell mainly transport large dust. It can be assumed that the sedimentological variations resemble a direct palaeoclimatic proxy for the atmospheric circulation system consisting of the differing climates, wind systems and their type of dust sedimentation.

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**Mineralogy of loess and paleosols along the precipitation gradient across the Chinese loess plateau with implications for provenance and weathering history**

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Loess and paleosols of the Chinese loess plateau record Quaternary climatic change in high resolution. Most previous studies focused on the development of proxies to extract palaeoclimatic and palaeoecological information from the deposits, but there were few mineralogical works which have a great potential in refining climatic proxies and tracking the provenance of the loess. Four loess(L1,L2)-paleosol(S1) sections were selected from the loess plateau along the gradient of annual precipitation (ZJT 280 mm; DDL 371 mm, BS 580 mm, LJP 700 mm) to investigate mineral and chemical compositions, microfabric, weathering history after deposition, and provenance. JZT and DDL loess-paleosol sections were very slightly weathered, showing the dissolution and precipitation of calcite in paleosol, while in LJP section, silicates including plagioclase, chlorite, and illite were severely weathered to form kaolinite and expandible clay minerals. BS section was transitional in mineralogy and geochemistry. The degree of weathering of paleosol and loess follows the current precipitation gradient, indicating that current climatic regimes and monsoon systems lasted through past Glacial-Interglacial times with some fluctuation of the intensities of winter and summer monsoon. The provenance of loess is suggested as the arid regions of northwestern China and Mongolia, which are largely covered by Cenozoic to Paleozoic sedimentary rocks.

### Record of the Dansgaard-Oechger events in European eolian deposits

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Loess deposits are covering a wide part of Northern Europe, an area expanding from the coasts of Brittany to the Russian plain. Since ten years or so, efforts have been concentrated in selecting European loess sequences along a main W-E transect at roughly 49°N of latitude, from Northern France to Ukraine. First it has been demonstrated that the main eolian deposition over Europe occurred during the time interval comprised between 38 and 15 kyrs. Second, the high-resolution study of the sequences indicates the alternation of well-developed soils, embryonic or tundra gley paleosols and loess deposits. The succession of these different units show a particular pattern which is correlated with the DO sequence including Greenland IS 8 to 2, even if other shorter intervals, not labeled as DO events, are expressed in the eolian deposits. This correlation is supported by (i) OSL and AMS dates on the organic matter preserved in the loess units, (ii) mollusk assemblages variations, (iii)  $\delta^{13}\text{C}$  on organic matter preserved in the loess, and (iv) grain size analysis. We present here the last results of our investigation showing that the DO events preserved in the European loess sequences correspond to interval of low eolian regime, showing higher moisture than during the deposition of the dust. The duration of the DO events also influence the nature of the associated units (paleosol, tundra gleys or embryonic soils, loess) whereas the Heinrich events in between DO events are intervals of dry and windy conditions expressed by coarser material.

### Loess-/Paleosol Sequences of the Upper and Middle Pleistocene in NW-Austria

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Investigations on paleopedology and Quaternary stratigraphy were carried out in the area of fluvio-glacial terraces of the rivers Inn and Traun/Enns. Research projects have been financed by the German Research Foundation (DFG) and the ICSU Grant Programme. Detailed studies were carried out on paleosols and loess sequences of different ages.

The investigations were focused on loess/paleosol sequences located on top of Riss terraces (OIS 6 and older) as well as in areas with Mindel and Günz terraces.

Loess records of the last glacial/interglacial cycle can be well observed in the study areas.

Generally, the Eemian soil (O/S 5e) is developed as a reddish Bt-horizon in fluvio-glacial gravels. U/Th-datings of calcites in the fluvio-glacial sediments are indicating that soil formation took place in the catchment area about  $113.000 \pm 4.400$  ka. The interglacial paleosol was truncated and a redeposited colluvial layer was deposited on top of the Bt-horizons containing charcoal with characteristic relicts of coniferous trees. After this land surface destabilisation phase, sedimentation of loess became the predominant process. Pedogenesis in form of a brown paleosol occurred, which partly has been redeposited. The pedocomplex is characterized by intense bioturbation of steppe animals. OSL-datings show that this part of the sequence belong to the Middle Würmian stage. The pedocomplex is overlain by a Cambisol corresponding to the youngest Middle Würmian interstadial. The paleosol is covered by thick loess deposits of the Upper Pleniglacial. Well-developed Tundragleysols subdivide the loess deposits. The uppermost soil corresponds to the Holocene Luvisol that includes hydromorphic properties.

Older fluvio-glacial terraces of Mindel and Günz age (in the classical stratigraphy) show a completely different structure of the covering layers. In this case, several thick interglacial paleosols are embedded within records of loess loam and redeposited material. However, four to five interglacial paleosols are developed inside the studied sequences.

Paleomagnetical investigations are leading to the assumption that different Middle Pleistocene excursions could provide chronological data in the future.

### 850 Millennia of paleoclimatic history recorded in the loess sequences of Vojvodina Region, Serbia

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Loess sequences in the Vojvodina region, Serbia, are among the oldest and most complete series of loess deposits in Europe. They provide a detailed record of climate changes during the last 850 ka. At least 8 major shifts from glacial to Interglacial conditions preserved in the loess-paleosol sequences of Vojvodina region.

Our stratigraphic model, based on investigations at various loess exposures in Vojvodina, uses lithologic and pedogenic criteria, magnetic susceptibility variations, position of the boundary between Matuyama and Brunhes paleomagnetic Epochs, luminescence dating, and amino acid geochronology as the primary bases for correlation. We designate the Vojvodinian L (loess) and S (paleosol) stratigraphic units, numbered in order of increasing age. In previous publications, we used the prefix "SL", referring to the Stari Slankamen site as a standard section for the region in our stratigraphic labelling scheme. However, to avoid confusion in our loess and paleosol labelling system, we now use the prefix "V" to refer to the standard Pleistocene loess-paleosol stratigraphy in Vojvodina.

The data presented in this study demonstrate the great potential of Vovjodina's loess archive for the reconstruction of local as well as global Pleistocene climatic evolution. The multi proxy paleoclimatic record derived from loess sequences in the Vojvodina region provides an important link between the classical Central European loess sites to the North, West and Southeastern Europe on the one hand and the Central Asian and Chinese loess provinces on the other hand.

The onset of loess deposition in Vojvodina region indicate direct link to the temporally and spatially progressive aridiza-

tion of interior Eurasia since the lower Pleistocene. Loess thickness, paleosol characteristics and enviromagnetic pattern point to significant increasing of aridization since the last 300 ka. Loess-paleosol couplets from VS3 to VS5 show decreasing of loess accumulation, in same time intensity of pedogenesis dramatically increased. The middle Pleistocene climatic optimum, similar to other Eurasian loess regions, occurred during the more than 150 ka formation of VS5 pedocomplex. Paleoclimatic evidence from loess-paleosol sequences older than soil VS6 indicates possible signature of shift from eccentricity to obliquity forced climate fluctuations.



## A preliminary dating study of loessic deposits in northwest England and the implications for Holocene soil erosion

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In northwest England shallow loess deposits occur on outcrops of Carboniferous limestone. More detailed investigation of these materials on the limestone around Morecambe Bay demonstrated similarity to loess deposits elsewhere, and it was thought that the silt derived from deflation of glaciogenic sediments in the Bay as Lake District and Irish Sea ice wasted following the Last Glacial Maximum (LGM). In several locations in the region, fine quartz is also included within the matrix of cemented screes below the limestone scars, although there is limited information about its origin and characteristics. The lack of overlying soil cover at one site (Giggleswick Scar), at least, suggests that aeolian processes may be significant in transporting included quartz material to the cement. Initial Optically Stimulated Luminescence (OSL) dates are reported for loessic sediments at three sites and loess incorporated into the cement of cemented scree at two sites from northwest England, as part of an ongoing project to provide a chronology for these sediments. At two sites (New Close and Farleton Fell), the samples recovered from the loessic sediments show multimodal distributions of repeat palaeodose (De) measurements, suggesting considerable post-depositional disturbance of these deposits. The quartz from the calcareous cement of the screes is indicative of multiphase deposition and/or poor resetting of the luminescence signal at the time of inclusion. Notwithstanding the large uncertainties from these methodological difficulties, it remains clear that the depositional ages of all but one of the samples fall entirely within the Holocene period, and indicate a more complex pattern for accumulation of these materials than previously hypothesized. Aeolian reworking, overland flow and subsoil piping on the karstic substrate are possible mechanisms of secondary reworking of loess. Human impacts on the landscape and climate shifts, either separately or in combination, are considered to have been the most likely mechanisms that triggered loess erosion. Whatever the process(es) and underlying cause(s), it is evident that significant amounts of soil erosion occurred on the limestone uplands earlier than previously thought.