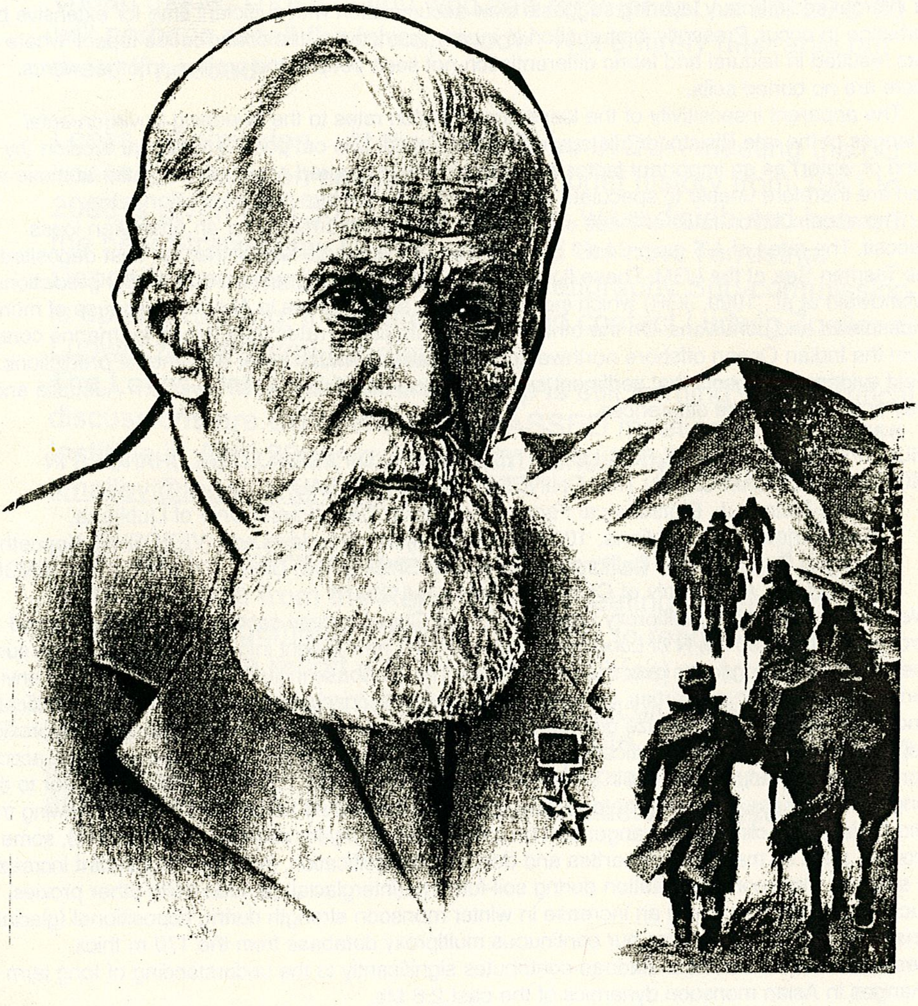
LL51 April 2004 ISSN 0110-7658

LOESS LETTER 51

The Nottingham Trent University

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.



ACCUMULATION RATES OF TWO AUSTRALIAN LOESS DEPOSITS; CORRELATIONS AND CLIMATIC IMPLICATIONS

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Basal optical (OSL) ages of 40 to 60 ka in two loessic (parna) mantles on the Central Tablelands of New South Wales indicate significant silt (c. 30 µm mode) deposition commenced well before the onset of the last glacial maximum. Both dated sections show no detectable change in mass accumulation rate around the LGM. The basal ages coincide with both major paleochannel and source-bordering dune activity in the western slopes and plains of NSW and the first dated linear sand dunes of the last glacial cycle, but not strong evidence of dramatic aridity.

The linear age-depth relationship suggests constant accumulation over the last 40-60 ka, rather than a single LGM deposition event. In detail, each mantle consists of > 1m of reddish silty clay loam with an earthy fabric which sits atop manganese and iron/silica hardpans and saprolite. Mixing of saprolitic derived material into the hard pan and also into the silty layer and destruction of internal sedimentary layering suggests slow accumulation with sufficient time for extensive bio-turbation to occur. Presently, bioturbation is mostly restricted to the conspicuous topsoil where it has resulted in textural and fabric differentiation not seen deep in the profiles. In other words, there are no buried soils.

The apparent insensitivity of the loess accumulation rates to the sweeping environmental changes of the late Pleistocene is surprising. We cannot rule out post-depositional erosion (by wind or water) as an important factor in producing the measured accumulation rates at these sites and are therefore unable to speculate about changes in the true dust deposition rates.

The accumulation rates of these deposits are the first determined for an Australian loess deposit. The rates of 4-5 g.cm-2.ka-1 are an order of magnitude higher than for dust deposited in the Tasman Sea at the LGM. These figures are in quite good agreement with model predictions (Mahowald et al., 1999, JGR) which include broader source areas in Australia because of more widespread arid conditions. On the other hand, accumulation rates determined for marine cores from the Indian Ocean offshore northwestern Australia are much lower than model predictions. Field evidence suggests that sediment supply restricts dust loads in northwestern Australia and may account for these differences.

MULTIPROXY EVIDENCE FOR LONG-TERM AND MID-PLEISTOCENE CHANGES IN MONSOON DYNAMICS ON THE CHINESE LOESS PLATEAU

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We have assembled a multiproxy database for the Chinese loess section at Jiaodao, Shaanxi Province, China (50 km N of Luochuan), that provides new insight into the dynamics of the summer and winter monsoons over the past 2.6 Ma. The database includes information about environmental magnetic properties, pedogenic and total iron concentrations, color indices (rubification and melanization), particle size distribution, and carbonate content. Several paleoclimate proxies, especially soil color index rubification, show a gradual long-term decrease in temperature accompanied with a gradual increase in winter monsoon strength from 2.6 Ma to present, similar to the long-term increase in oxygen isotope values seen in the marine record. In addition, following the mid-Pleistocene climate rearrangement (in loess/paleosol layers younger than 0.65 Ma), some proxies, such as magnetic properties and depth of decalcification, indicate a significant increase in summer monsoon precipitation during soil-forming (interglacial) periods while other proxies, such as particle size, show an increase in winter monsoon strength during depositional (glacial) episodes. This evidence from our continuous multiproxy database from the 170-m thick loess/paleosol section near Jiadoao contributes significantly to the understanding of long term changes in Asian monsoon dynamics of the past 2.6 Ma.

LL51. When LL was launched in NZ in 1979 it was (jokingly) suggested that it should run for 50 issues; but you are holding in your hand LL51...

LL has been, in general, well received; there were even a few passing compliments made during the discussions of the great and the good at Reno INQUA Council Meetings... So we press on into the unknown.

There are some unknowns: the finance which carried us nicely to 50 is virtually exhausted so we may be reformatting into our cheap mode. Those of you who can remember LLs 28, 29 & 30 will perhaps recall the 'cheap mode'. Not entirely desirable but there if needed.

Loess Commission. At the 2003 Reno INQUA meeting the old Loess Commission ceased to exist (a brief history from 1961 to 2003 is given in LL50). Loess interests were distributed between the new Stratigraphy Commission and the new Terrestrial Deposits Commission. The Loess Stratigraphy Sub-commission is up and running; if you are interested contact Ludwig Zoeller at Ludwig.zoeller@uni-bayreuth.de.

The Loess Materials Working Group is still forming; some critical discussions are expected at the PASSED meeting at the Hanse Institute in April 2004; in the interim contact Ian Smalley at smalley@loessletter.com.

Reno 2003. Following the usual LL practice we reprint some loess abstracts from the Reno INQUA meeting. No selection criteria; no judgements made. If you want to read a report on Reno INQUA (a report with a slight loess bias) go to the ICS website at www.quaternarystratigraphy.org.uk. This report can also be accessed via the CAMQUA website. The Reno abstracts are useful abstracts with a very sensible presentation – some authors emails are available – make contact if interested.

Obruchev: almost a centenary. V.A.Obruchev was born in 1863 and died in 1956. He was the most prominent Russian student of loess. In 1904 he was 41 and working at the Tomsk Technological Institute. If you look in the bibliography of N.I.Kriger's classic 1965 book 'Loess, its characteristics and relation to the geographical environment' you will find a significant entry at 1904, a very important Obruchev paper- some might say the most important paper, the one which we have identified as launching the idea of 'desert loess'; as starting the 'two types of loess' concept. Obviously worthy of a celebration 1904-2004. The Kriger entry reads:
V.A.Obruchev. The question of the origin of loess (in defence of the aeolian hypothesis). Izv. Tomsk Tekhnol. In-ta t.13, no.1. 1904. Also in 'V.A.Obruchev. Collected Works on Asian Geography' t.3. Geografgiz 1951 (LL trans.)

If you can't get hold of Kriger 1965 the bibliography was reprinted as Loess Letter Supplement 13 for the 1987 INQUA Congress in Ottawa.
A paper from the Tomsk Technological Institute; Obruchev was there 1901-1912. The journal is 24528 on the World List, published 1903-1924; continued as Izv. Sibirskogo. Tekhnol. Inst 1925-1932 (World List 24502). The 1904 paper is LPB 676 in 'Loess-A Partial Bibliography' by I.J.Smalley (1980).

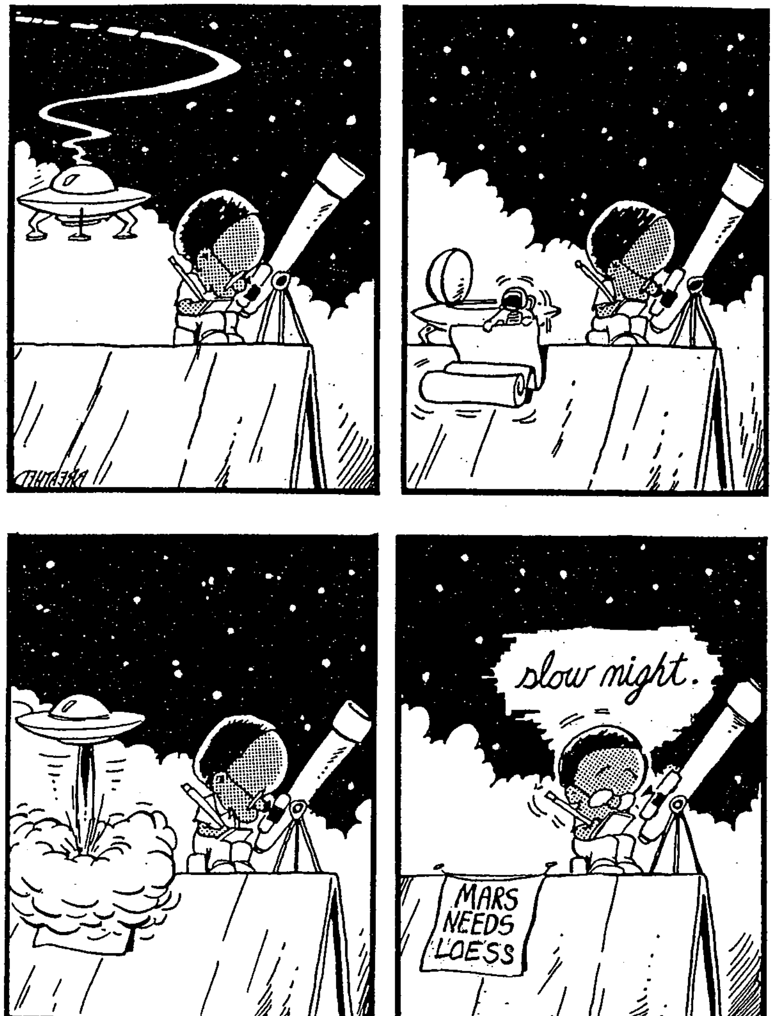
So 1904 marks the beginning of the 'desert loess' debate which still entertains us? No, probably not; the entry on the Kriger list was almost certainly a mistake, the date is more likely to be 1911. This is unexpected; Kriger was by far the best of the Russian loess scholars with respect to bibliographic endeavour. It seems probable that the correct reference (LL 2004 version) is:
V.A.Obruchev. The question of the origin of loess (in defence of the aeolian hypothesis). Izv. Tomsk Tekhnol. Inst. T.33, 38 str. S 1 tabl. 1911.

Seven years adrift- almost a centenary. Kriger cited 42 Obruchev references in his great list; we can forgive a small error in one of them. Some Obruchev pictures in this 'almost centenary' issue of Loess Letter.

Dirtmap. **D**ust **I**ndicators and **R**ecords of **T**errestrial and **MA**rine **P**alaeoenvironments: the Dirtmap data base, written about occasionally in LL, and discussed at length at Reno INQUA. Now a definitive report is published via Quaternary Science Reviews (vol.22, nos 18-19, Sept.2003), and extracts from this will form a major part of LL51. LL congratulates all those involved in the Dirtmap project- it was announced at the great LoessFest in March 1999 and contained a very impressive discussion meeting at Jena in October 2000; the Loess Commission and LL were pleased to be involved.

LL is an INQUA newsletter. It serves the entire Quaternary Community- but in particular members of the Loess Materials WG of the Aeolian Processes Sub-commission of the Terrestrial Processes, Deposits and History Commission and members of the Loess Stratigraphy & Palaeopedology Sub-commission of the Stratigraphy & Chronology Commission. LL is published by the School of Property & Construction, Nottingham Trent University, Nottingham NG1 4BU, UK; the editors are Ian Jefferson (ian.jefferson@ntu.ac.uk) and Ian Smalley (Smalley@Loessletter.com). Published twice a year, in April and October.

LL51 is particularly concerned with the PASSED meeting at the Hanse Institute for Advanced Studies in Delmenhorst (14-20 April 2004) and the 32nd International Geological Congress in Florence (20-28 August 2004). Neither of these meetings is exclusively devoted to loess but loess will be discussed at each one- and each meeting is useful in providing a setting in which loess can be discussed. We saw at 16th INQUA in Reno in 2003 the huge level of interest in loess (over 50 papers in the Abstracts volume) and it is important to direct interest to forums where discussion can take place. Its not too early to start planning for 17th INQUA in Cairns in Australia in 2007 where there will be discussions on the nature and distribution of the Australian loess, and probably a field trip to see the New Zealand loess. Full details of 32nd IGC at http://www.32igc.org., and a few possibly relevant symposia listed on the Loess Letter Online website at www.loessletter.com.



PROVENANCE OF LOESS MATERIAL AND TRANSPORTATION OF EOLIAN DUST TO THE LOESS PLATEAU AND THE NORTH PACIFIC

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Results of a multiple, isotopic, chemical and mineralogical analysis of loess from the three north-western inland basins (including the Junggar Basin, the Tarim Basin and the Qaidam Basin) and the Loess Plateau region of China are summarized. It is argued that the gobi desert in Mongolia and China, rather than the three inland basins, are the dominant source areas of the Loess Plateau. However, although these gobi and sand deserts are regarded as the main source regions, they serve as dust and silt holding areas rather than dominant producers. The mountain processes (e.g., glacial grinding, frost weathering, salt weathering, tectonic processes) in the Gobi Altay Mts., Hangayn Mts. and the Qilian Mts. have played an important role in producing the vast amounts of loess-sized material for forming the Loess Plateau. Dust entrained from different geomorphological units of China has different contributions to the proximal and distal regions. Dust derived from the Junggar and Qaidam basins is transported by near-surface winds, and thus mainly accumulates on the windward slopes of the local mountains (local dust). For the Tarim Basin, dust can be transported not only by the near-surface winds, but also by the westerlies whenever the dust is entrained to an elevation of > 5000 m asl. In the latter case, dust from the Tarim Basin (the Taklimakan Desert) can be transported out of the basin and ultimately to the remote Pacific (long distance dust). In most cases, dust entrained from the gobi desert in Mongolia and China is transported by near-surface winds, serving as medium distance dust, but occasionally (about 10%), it can be transported by the westerlies to the remote Pacific Ocean and even to the United States (long-distance dust).

PALAEOPEDOSEDIMENTARY AND ANTHROPOGENIC CHARACTERISTICS IN HOLOCENE LOESS PROFILES OF CHINA

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Holocene loess-palaeosol profile is of special importance in loess-based palaeo-climatic studies as it usually serves as the basis for interpreting the eco-environmental conditions under which the older loess-palaeosol sequences were developed. In China, a long agricultural history on the Loess Plateau has caused extensive destruction of natural vegetation cover and led a profound modification on the Holocene loess profiles. Micromorphology, heavy minerals, pollen and soil properties are examined in three typical Holocene loess profiles at three locations along a south-north transect across the Loess Plateau. Results show that the profile consists of a palaeosol layer developed in the middle Holocene, which is underlain by the Malan loess and covered human disturbed fresh loess. The palaeosols were well preserved, consisting of an upper humus-rich (AB) horizon and a clay-rich (Bt) horizon. The humus-rich horizons are intensely weathered, contain precipitated calcitic material derived from the overlying modern loess, and have both high pollen content and diversity. Clay coatings are common in the clay-rich horizons. The pedogenetic types of the palaeosols varied from Ustalfs to Argiustolls and Haplustepts in the USA system along the S-N transect with paleo-bioclimatic pattern of the middle Holocene. The cover layers (Ap horizons) are newly-deposited loess of the later Holocene, 10%-25% of which in the south area was caused by human activities such as application of plaggen manure and irrigation with sediment"Crich water.

ƎE ASIAN MONSOON VARIABILITY DURING DURING THE LAST 250,000 YRS IN THE -UOCHUAN LOESS SEQUENCE, CHINA

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-oess deposits from the Chinese Central Plateau have been interpreted as representing a contin-ɹous record of the past 2.4 Myr climatic changes. Among the pioneer work, the measurement of he magnetic susceptibility was interpreted as providing a reliable record of past climatic changes, ɘspecially paleomonsoons. The chronology was independently determined by considering a con-ɜtant deposition rate of magnetic mineral balanced by the value of the low field magnetic suscep-ibility. This time scale however does not match Pacific Ocean records based on d18O or eolian luxes implying refinement of the dynamics of the deposition of dust, during glacial intervals, or of he soil formation, during interglacial times, in China. Here we present the study of terrestrial mol-usks from the loess sequence in Luochuan which indicate alternating strengthened summer and vinter paleomonsoons during the last two climatic cycles. These variations - based on the content of xerophilous, hygrophilous, and oriental species are in very good agreement with the variation nferred from pedology, sedimentology and climate modeling for the last 130,000 yrs. The compar-son between mollusk records and pedological indices for the last 250,000 yrs indicate some dis-crepancies in the magnetic susceptibility chronology as suspected by marine records. We pro-pose a new interpretation of the last 250,000 yrs record from the Chinese Loess Plateau in term of solar induced monsoon events which is supported by a comparison with the available data rom the African and Indian monsoons.

VOLUTION OF ASIAN DESERTIFICATION SINCE 22 MYR AGO INFERRED FROM EOLIAN EPOSITS IN CHINA

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ı northern China, the loess-soil sequence of the last 2.6 Myr, the Hipparion Red-Earth of eolian rigin and the recently reported Miocene loess-soil sequences provide a near continuous conti-ental record of Asian desertification history for the past 22 Myr. The onset of loess deposition by 2 Myr ago indicates the existence of sizeable deserts in the interior of Asia and of a energetic inter monsoon by that time. The alternations of loess and soils indicate cyclical changes in the tensity of winter and summer monsoons. The Himalayan-Tibetan complex was extended ough and sufficiently elevated by 22 Myr ago to cause desert formation and to produce winds rong enough to carry eolian particles. Loess accumulation rate during the Miocene was much wer than for Quaternary, suggesting moderate levels of aridity and winter monsoon strength. igher accumulation rates are observed at 15-13 Myr and 8-7 Myr, which may represent tempo-ry instabilities of climate or land-surface conditions in the source region.

Desert lands and winter monsoon must have been constantly maintained since then, as evi-ənced by the Hipparion Red-Earth and Quaternary loess-soil sequences. The inland aridity was ronger from ~6.2 to ~5 Ma BP and weaker from ~5 to ~3.6 Ma BP.Two major drying steps are bserved at ~3.6 and ~2.6 Ma BP, respectively. The enhanced aridity at ~3.6 Ma BP is synchro-ous with a suggested uplift of portions of the Tibetan Plateau. The general aridification history is so highly consistent with the ongoing high-latitude cooling and the consequent expansion of rctic sea-ice/ice sheets since 6.2 Myr BP. These suggest that both Tibetan uplift and ice-building ocesses in the northern hemisphere were two prominent driving forces behind the long-term əsertification in the interior of Asia.

GEOGRAPHIC DIFFERENTIATION OF THE LAST INTERGLACIAL PALEOSOL S1 IN THE CHINESE LOESS PLATEAU

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The net eolian deposition attenuated while the pedogenesis intensified southeastward during the last interglacial in the Chinese Loess Plateau. Consequently, the last interglacial paleosol S1 gradually differentiated from the southeast to the northwest as follows. In the southeastern part, multiple soil-forming events occurred in a single completely welded soil profile. Towards the north-west, climate becomes drier and the loess becomes thicker, and the multiple soils become partial-ly welded (i.e., subsequent soils "annexed" the upper portions of previous soils). Moving further towards the northwest, each one of the multiple soils becomes completely separated. In the northwestern part, not only are the multiple soils completely separated, but also the loess units between the soils are well preserved. In all cases investigated, the coarse fraction content well defines the upper and lower boundaries of the S1 parent material and can be used to estimate the time-transgressive nature of the S1 paleosol relative to its parent material. Soil welding, biotur-bation and material translocation (e.g., clay and carbonate) within the S1 profiles make it impossi-ble to preserve the high-resolution information of the last interglacial (128-73 ka) climate changes in most parts of the Chinese Loess Plateau. First, clay translocation within the S1 profiles has moved some of the magnetic minerals downward so that the susceptibility only reflects the post-translocation distribution of the susceptibility-producing minerals. Second, the best-developed paleosol S1S3 (i.e., MIS 5e) at most of the sections is not expressed by the susceptibility because the S1S3 developed into underlying coarser and lower-susceptibility loess (i.e. L2). Third, the carbonate concentration dilutes the susceptibility signature. At most of sections investigated, the post-depositional in situ weathering and the post-weathering clay translocation within the S1 profile occurred and post-depositional carbonate leaching and accumulation are observable throughout the S1 profiles. Equally important is the downward development of the S1 into the underlying coarser loess (L2). These mean that both the susceptibility (summer monsoon proxy) and the particle size (winter monsoon proxy) are problematic as quantitative climatic proxies.

PERIGLACIAL STRUCTURES IN THE LAST INTERGLACIAL-GLACIAL LOESS SEQUENCES IN SW POLAND

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The loess in SW Poland occurs in several isolated patches, which differ one from another in sedi-ment thickness, stratigraphy and physical properties. The most representative loess sequences provide a good record of climate changes during the last interglacial-glacial cycle (Eemian – Weichselian). One of the most spectacular features of loess sequences in SW Poland is the occurrence of well preserved relicts of periglacial horizons. Within the Eemian - Early Weichselian pedocomplex two periglacial horizons exist: the older one consists of indistinct polygons of narrow frost cracks bent downslope in their upper part by slow solifluction processes; the younger repre-sents polygons of frost wedges with primary (loess) infilling, associated with wind-abraded sur-face with ventifacts. The upper horizons of pedocomplex are deformed by cryostatic pressure and frost heave and finally straggled by solifluction (third periglacial horizon). Small (1-2 m) ice-wedge casts formed in loess stratum underlying the complex of tundra-gley soils constitute the fourth periglacial horizon. Interpleniglacial complex of tundra-gley soils is markedly reworked under the influence of cryohydrostatic pressure and solifluction in its upper part (fifth periglacial horizon). The uppermost (sixth) periglacial horizon consists of large (2-4 m) ice-wedge casts and associat-ed thermokarst structures connected with degradation of permafrost. Periglacial horizons record-ed in loess sequences of SW Poland were formed as a result of extreme climatic conditions and/or rapid environmental changes during cold events of the last glacial period. Some of these horizons can be used as a stratigraphical markers.

ƎVIDENCE OF MEGAHUMID CLIMATE OF THE MID-HOLOCENE IN THE WESTERN PART OF CHINESE LOESS PLATEAU

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Vid-Holocene climate in the arid-semiarid China was interpreted to be megathermal (Shi et al., 1993). But, an increased wetness was speculated to be responsible for producing the "megather-nal" signals (Wu et al., 1994). Here, we are presenting the stratigraphic evidence of a ubiquitously listributed sandwich layer of swamp/wetland deposits exposed in the first terrace cliffs in the vestern part of the Chinese Loess Plateau. The evidence shows that the mid-Holocene climate vas megahumid rather than megathermal at least in the western part of the Chinese Loess Plateau. Fourteen radiocarbon dates (including two earlier dates) from different sites show that he swamp/wetland layer was formed between ~10,000 and 4,000 cal. yr. B.P. The field-observed stratigraphic characteristics and laboratory-obtained proxy data show that an unequivocal wet period occurred between ~8,000 and 6,000 cal. yr B.P. Four possible mechanisms are proposed here to account for the mid-Holocene Megahumid climate. Firstly, the insolation peak at 65 oN occurred around ~9,000-8,000 cal. yr B.P. might have warmed up the oceans to set up the stage or the mid-Holocene Megahumid climate. Secondly, the increased late summer insolation about ,000 cal. yr B.P. in the Northern Hemisphere might have enhanced the summer precipitation. Thirdly, the shift of the long-term El Nino-like system towards the Asian side of the Pacific might have further enhanced the precipitation. Finally, the warm and wet mid-Holocene climate must have resulted in better vegetation coverage, which might have in turn induced more precipitation.

FEATURES OF THE CONSTRUCTION AND THE OPERATION OF WATER BASINS LOCATED ON LOESS TERRITORIES

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At the droughty territories of Uzbekistan agricultural production is possible only if reservoirs have been created. So far as precipitations falls on the territory of the Republic of Uzbekistan during a year is very uneven, the creation of conditions for uniform irrigation may be achieved by he accu-mulation of winter-spring high-flood waters in reservoirs. He researches, conducted at big reser-voirs (Charvak, Andijan, Tupalang, Gissarak and others), which are located in rivers Sirdarya and Amudarya, showed, that the construction and the operation of such hydro-technical objects is the reason of the rise of many unfavorable processes and phenomena.

Loess deposits of various geneses, in accordance with their nature, have weak water-stability. During the first years of operation of reservoirs, which were built on loess territories, the intensive remaking of the shores of these artificial reservoirs is observed.

In the first turn that is observed as the formation of a big number of landslides, which lead to the diminishing of reservoir's useful volume. Besides that, the change of hydro-geological condi-tions on all adjoining territory as a result of high filtration properties on loess rocks is marked. In particular, the steady raising of ground waters level is marked.

As a result, subsidence phenomena, flora's impoverishment on significant territories are observed, the engineering-geological conditions of the construction of ground objects get worse. One of important moments is the change of the seismic regime of reservoir and nearby territories.

According to instrumental observations the increase on order of origin intensity near the reser-voir is established. That has led to the rise of additional residual deformations on significant terri-tories near reservoir.

STRATIGRAPHY OF THE DANUBE LOESS

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Loess-paleosol sequences in the middle and lower reaches of the Danube river basin contain the longest and most complete climate records in central Europe from the last two million years. The Danube loess belt covers about 200.000 km2 in 11 countries: Germany, Austria, Czech Republic, Slovakia, Hungary, Croatia, Serbia and Montenegro, Rumania, Bulgaria, Moldova and Ukraine. Local loess-paleosol stratigraphic schemes have been defined in all these countries separately. The most important sites have been described at Krems, Stranzendorf, Cerveny Kopec, Paks, Stari Slankamen, Koriten and Novaya Etuliya (Map 1). Most of them reach into the geomagnetic Matuyama Epoch. Based on paleomagnetic, soil-stratigraphic and other paleoenvironmental data it is possible to correlate the sites and reconstruct the approximate climate development in the basin. Major environmental shifts affected the area in the middle Brunhes about 450,000 years ago and in the Upper Matuyama, about 800,000 years ago. We compare the combined Danube loess stratigraphic model (marked by a prefix D) with the record of the Chinese loess plateau and with the oxygen isotope variations recorded in deep-sea sediments (Table 1).

Table 1. Danube loess -stratigraphic model of the last approximately one million years and its relation to the Chinese loess, marine isotope stratigraphy (MIS), glacial cycles and local subdivisions at CK-Cerveny Kopec; K-Krems;P-Paks; SS-Stari Slankamen; KO –Korite and; NE- Novaya Etulia. Reversely magnetized units shaded.

Danube loess	Chinese loess	MIS	Glacial cycle	CK	K	P	SS	KO	NE
D S0	S0	1	A	A	KR1		SL S0		
D L1	L1	2-4	B	B3			SL L1		
D S1	S1	5		B2,B1		MF2	SL S1	S1	PK2
D L2	L2	6	C	C3			SL L2		
D S2	S2	7		C2,C1		BD	SL S2	S2	PK3.1
D L3	L3	8	D	D3			SL L3		
D S3	S3	9		D2,D1		BA	SL S3	S3	PK3.2
D L4	L4	10	E	E3			SL L4		
D S4	S4	11		E2,E1		MB	SL S4	S4	PK3.3
D L5	L5	12	F	E3			SL L5		
DS5	S5	13		E2,E1		Phe	SL S5		PK4
		14	G	G3					
		15		G2,G1		Mtp			
D L6	L6	16	H	H3			SL L6		
D S6	S6	17		H2,H1		hs2	SL S6	S6	PK5
D L7	L7	18	I	I1b			SL L7		
D S7	S7	19		I1a	KR4	PD1	SL S7		PK6
D L8	L8	20	J	J3			SL L8		
D S8	S8	21		J1	KR5	PD2	SLS8		PK7
D L9	L9	22-24	K	K3					incipient soil
D S9	S9	25		K1,K2	KR6				
D L10	L10	26	L						
D S10	S10	27		L1,L2					PK8

[1]*Financial support from the INQUA Excutive Commitee*

VARIATION OF ZR/RB RATIOS IN THE CHINESE LOESS SEQUENCES DURING THE LAST 130KYR AND ITS IMPLICATION FOR CHANGES IN WINTER MONSOON STRENGTH

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We have selected seven loess-paleosol sections covering the last 130kyr in the Loess Plateau of China for measuring concentrations of the trace elements Zr and Rb as well as the grain size. Variations of Zr/Rb ratio along the sequence in all of the sections display a generally similar pattern to that of the grain size which have been generally considered as a proxy of the East Asian winter monssn strength. This close relationship has been also verified by a spatial gradient distribution of the two parameters in the seven sections along the N-S transect across the Loess Plateau. Further analyzed data of Zr and Rb concentrations in five separated particle fractions show that the ratio of Zr/Rb increases as the grain size increases. This well explained a positive linear relation of the ratios and values of the mean grain size existed in all of the least weathered loess samples. Acid solution experiments indicated that both Zr and Rb are immobile elements during pedogenic processes. Therefore, the variations of Zr/Rb ratios in the sequences can be regarded as a better index for the winter monsoon strength than the mean grain size. Matching the Zr/Rb record with the mean grain size curve suggests that strength of the winter monsoon during the marine isotopic stage 3 is particular weak. This means the Asian monsoon could be driven by changes of the solar insolation on the precessional time scale.

NEW DATA FROM LOESSES AND PALEOSOLS OF THE US MIDWEST

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Loess/paleosol series of the US Midwest provide long-term proxy records of Quaternary sedimentation, climate and environments south of the glacial limits of North America. Three key sections were investigated at Wittsburg Quarry (Arkansas), Missouri Valley (Iowa) and Eustis Ash Pit (Nebraska) by geochemical, paleomagnetic and micromorphological analyses. Below the surface soil at each section, four loesses are present. They are separated by three well-developed paleosols.

The Crowley's Ridge loess is the oldest loess unit at the sections under study. At Wittsburg, it lies on Pliocene gravel, at Eustis it immediately overlies the Lava Creek B ash layer, and at Missouri Valley it lies directly on the Pre-Illinoian till surface. A well-developed paleosol modifies this loess at all three sections. This paleosol has not previously been reported in western Iowa or eastern Arkansas. At all three sites, it is immediately overlain by the Sangamon paleosol solum which itself represents pedologically-altered Loveland loess. This means that the Loveland loess is much thinner than previously suggested. The Sangamon paleosol is well developed and readily correlated between Wittsburg and Missouri Valley, but is probably partly eroded at Eustis. It has luvisolic properties but with much more clayey pedogenic texture than modern luvisols, and has no clear eluvial horizon. The overlying Roxana loess at Wittsburg and its equivalents at Eustis and Missouri Valley are mostly altered by soil formation. At Wittsburg and Missouri Valley, this soil is called the Farmdale paleosol. On the basis of its pedogenic features it correlates to the Gilman Canyon Formation paleosol at Eustis. This soil has chernozemic properties at all three sections, but at Wittsburg it is less developed. At all three sections, this soil has ancient krotovinas, hence the gley features observed must be interpreted as post-burial changes. In the upper part of all the sections, the thickest Peoria loess is developed and shows the properties most typical of loess. From the Peoria loess to the Loveland loess, the correlations proposed are well corroborated by numerous published TL and 14C dates. Below the Loveland loess, only a few TL dates are available. Mass-specific magnetic susceptibility and its frequency-dependence correlate well with lithology and have maxima at the top of each paleosol.

HOLOCENE LOESS SEDIMENTATION AND SOIL FORMATION IN THE MATANUSKA VALLEY, SOUTHERN ALASKA: A MODERN ANALOG TO PAST DUST DEPOSITION

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Although loess-paleosol sequences are among the most important records of Quaternary climate change and past dust deposition cycles, there are few modern examples of such sedimentation systems. One example exists in southern Alaska, however, where silts produced through grinding by the Matanuska and Knik glaciers are deposited as outwash, entrained by strong winds, and redeposited as loess in the Matanuska Valley. Stratigraphic studies and 22 new AMS radiocarbon ages on charcoal and wood show that loess deposition began sometime after ~6,500 radiocarbon yr BP and has continued to the present. Over a downwind distance of ~40 km, loess thickness, sand content, and mean particle size decrease, whereas medium-to-fine silt content and clay content increase. Loess deposition was episodic at distances >5 km from the loess source. Stratigraphic complexity is at a maximum (i.e., the greatest number of loesses and paleosols) at intermediate distances from the loess source. As many as four separate phases of loess deposition occurred in the past ~6,000 yr at a locality ~10 km from the source. Surface soils increase in degree of development with distance downwind from the source, where sedimentation rates are lower. Proximal soils are Entisols or Inceptisols with A/AC/C or A/E/C profiles whereas distal soils are Spodosols characterized by distinct A[O]/E/Bw [Bs]/C profiles. Chemical analyses show that distal Spodosols are more weathered than proximal Entisols and Inceptisols. Ratios of soluble Ca, K and Fe to insoluble Ti show decreases in surface horizons with distance from the source. The Matanuska Valley serves as a rare modern analog to loess systems of the past that record dust deposition cycles. Study of this region shows that particle size can vary over short distances, loess deposition can be episodic over limited time intervals, and soils on stabilized loess in a small area can show remarkable variability under the same vegetation.

UNPRECEDENTED AEOLIAN MASS ACCUMULATION RATES REVEALED BY LUMINESCENCE DATING OF LOESS FROM MIDCONTINENTAL NORTH AMERICA

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Loess deposits contain important records of variations in atmospheric dust, providing evidence which may be used to assess the role of dust in climate change. To examine these records, it is necessary to establish a reliable, high-resolution chronology. Using the radiocarbon ages from palaeosols developed in the loess gives only an average mass accumulation rate for the package of loess that they bracket, and any dust flux calculation based on these ages implicitly assumes that the accumulation rate has remained essentially constant over the period of deposition. However, luminescence dating is applied directly to the mineral grains that make up the loess deposit, and is therefore ideally suited to the investigation of the records of dust accumulation contained in loess.

My studies have applied optically stimulated luminescence (OSL) dating to Peoria Loess deposits from midcontinental North America. These are the thickest deposits of last-glacial loess in the world and were deposited during the time from the Last Glacial Maximum to the Holocene. The mass accumulation rates (MARs) for these last-glacial loess deposits were believed to be high on the basis of thickness, however, little was actually known of the fluctuation in dust accumulation rates both during the last glacial period, and spatially across North America. Luminescence dating of Peoria Loess at several sites in midcontinental North America has revealed that MARs were extremely high between 18,000 and 14,000 years ago - much higher than those calculated for any other pre-Holocene location worldwide.

These unprecedented MARs coincide with the timing of a mismatch between palaeoenvironmental evidence from central North America, and the palaeoclimate simulations from atmospheric global circulation models (AGCMs). The high atmospheric dust loading implied by these MARs may have played an important role, through radiative forcing, in maintaining a colder-than-present climate over central North America for several thousand years after summer insolation exceeded present-day values. These findings highlight the need both for the collection of further 'ground-truth' data to assess the role of dust in climate change, and for dust to be incorporated into climate models.

SPATIAL AND TEMPORAL PATTERNS OF QUATERNARY DUNE ACTIVITY IN THE ARID AND SEMIARID CHINA

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Episodic dune formations during the Quaternary were found in many deserts of China. Generally, desert evolutions on the orbital time scales were the response to the astronomical forcing, characterized by expanded deserts during glacial maxima. However, due to the close link between Chinese deserts and the adjacent high mountains (High Asia), the high mountain processes (e.g., glacial grinding, frost weathering, rock denudation) have also played an important role in controlling desert evolution through its effects on sand and silt production. The most striking tectonic control of desert expansion occurred at 1.1 and 0.9 Ma ago, and these tectonic control desert evolutions had durations longer than the Milankovitch cyclicity thus imposed on the glacial-interglacial climatic changes induced desert evolutions. Spatial scale studies on desert evolution indicate that the last two extreme scenarios of a glacial maximum and a Holocene climatic optimum marked extreme ecosystems in China. The deserts margin changed mainly in its longitudinal range due to changes in east Asia monsoonal circulations, and it shifted from 125°E of the last glacial maximum to 105°E of the climatic optimum. Historical desertification in the semiarid China is not a response to climate drought but largely associated with the human impacts (mainly over-cultivation) since about 2300 years ago. Over-cultivation combined with the high wind energy leads to the quick deflation of the 'protection layer' of the Holocene sandy loam soil and ultimately results in the reworking of the underlying LGM sands. Our view of the importance of land use-use practice suggests that, in the fragile ecological system, where a great quantity of sand is available for reworking and high wind energy is concentrated, any unreasonable human activities will greatly accelerate the sand reworking processes. Episodic conversion of nomadic livestock systems to cropping during historical time is the main reason for the reworking processes of relict dunes in the Mu Us Desert and other semiarid regions in China.

THE S1 PALEOSOL ENVIRONMENTAL RECORD INTERPRETED THROUGH SOIL DEVELOPMENT AND WEATHERING INDICES

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Pedogenic and weathering processes are intricately related to paleoclimate evidence in loess. Soil processes (clay formation and translocation, carbonate concentration, and iron alteration and translocation) are all tied to weathering reactions that occur in the soil. Proxy indicators reveal environmental change, but the environment itself may alter the proxy indicators. Is the paleoclimate evidence biased by inherent complexity? One way to address this quandary is to investigate specific soil formation and weathering processes. This study applies quantified soil development indices and weathering indices and compares these against existing climate proxy indicators for the S1 Paleosol in the Chinese Loess Plateau.

Six field locations were surveyed and sampled in two northwest-to-southeast transects in the Chinese Loess Plateau. A range of field data (horizonation, color, texture, structure, carbonate morphology) was used to calculate a profile development index modified from Harden's (1982). The index was applied to the entire S1 profile at each location, and to segments within the S1 profile. Samples were taken for chemical analysis to establish leaching trends. Inductively coupled plasma optical emission spectrometry (ICP-OES) achieved composition for 10 major elements of samples taken at 10 and 20 cm intervals in the profile. Weathering and leaching indices calculat-

LINKING THE LOESS – PALEOSOL RECORD OF PLEISTOCENE CLIMATE IN SERBIA WITH THE EXPANDING CENTRAL EUROPEAN AMINOSTRATIGRAPHY

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Numerous loess-paleosol sections have been investigated along Fruska Gora in Vojvodina, Serbia, and a detailed paleoclimate record for the mid to late Pleistocene is emerging for south-central Europe. In order to test regional stratigraphic correlations and correlate with loess sequences studied elsewhere in central Europe, we sampled fossil gastropod shells from loess units and measured D/L amino acid ratios in an effort to expand our evolving European aminostratigraphy into the Serbian loess region. Stari Slankamen, the longest continuous section that we have sampled, includes eight interglacial paleosols and intervening loess units recording alternating warm-moist and cool-dry climate oscillations. We also sampled loess-paleosol sections at Ruma, Petrovaradin, Irig, Miseluk, Kula, and Titel.

Gastropods sampled include the genera *Helicopsis*, *Trichia*, *Pupilla*, and *Succinea*. Using reverse-phase liquid chromatography, we measured D/L ratios in 10 amino acids. Our analysis and interpretations focus on D/L aspartic acid, glutamic acid, valine, phenylalanine, and allisoleucine/isoleucine ratios (alle/Ile). The range of racemization rates exhibited by these amino acids allows us to optimize resolution for different time periods. According to the present chronostratigraphic model, loess L1 and paleosol S1 were formed during glacial cycle B, corresponding with marine oxygen-isotope stages (MIS) 2-5. Horizons within L2 and S2 correspond with glacial cycle C and MIS 6 and 7, respectively. S2 is a double paleosol and is correlated with the Hungarian BD paleosol pair on the basis of racemization data. Loess and paleosol units L3 and S3 correlate with glacial cycle D and MIS 8 and 9, respectively. Older units in the sequence are similarly correlated with the Hungarian aminostratigraphy, although few outcrops are available for sampling and comparing data from stratigraphically lower units.

Present-day ground temperatures in loess of Hungary and Serbia show a significant increase in temperature from the northwest to the southeast. Mean annual temperature at one-meter depth rises from 10.5 °C near Budapest to 13.5 C in parts of Vojvodina. This increase in temperature explains the more rapid rate of racemization and the higher D/L ratios in loess of Vojvodina relative to the equivalent age loess units in Hungary.

STRATIGRAPHIC EVIDENCE OF EPISODIC GULLYING ON THE CHINESE LOESS PLATEAU

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Buried gullies are exposed along the margin of a loess tableland in road excavations near Tongchuan on the Loess Plateau of central China. They lie with in a thick loess/paleosol succession that spans at least the last 780,000 years. Constraining ages for gully cutting and filling are provided by the ages of loess and soil units cut by and capping the paleogullies. Gully cutting is initiated during the onset of interglacial conditions and ceases as the gullies begin to fill with colluvium and airborne dust during the transition from interglacial to glacial conditions. The episodic cutting and filling of gullies implies a basic astronomical (orbital) control of gully evolution involving cyclic changes in dominant summer and winter monsoon climates, surface hydrology, and vegetation cover.

COMPOSITIONAL STUDY OF THE LAST INTERGLACIAL PALEOSOL S1 LOESS MINERALS FROM CHINESE LOESS PLATEAU USING SYNCHROTRON X-RAY DIFFRACTION (XRD) AND SYNCHROTRON X-RAY ABSORPTION NEAR EDGE STRUCTURE (XANES)

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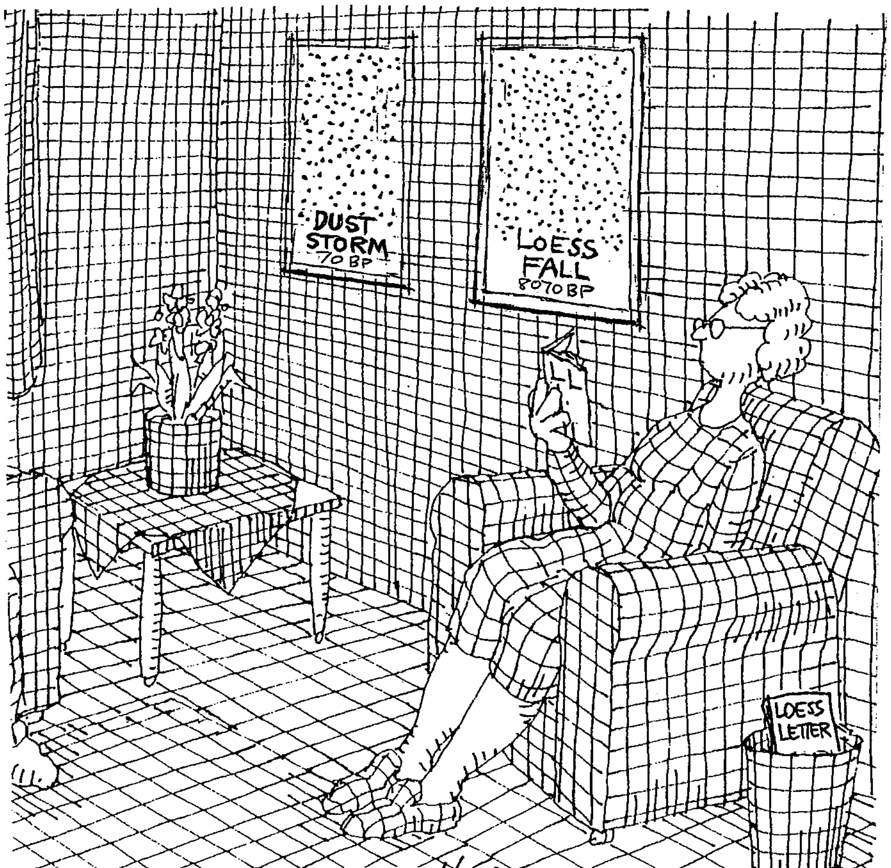
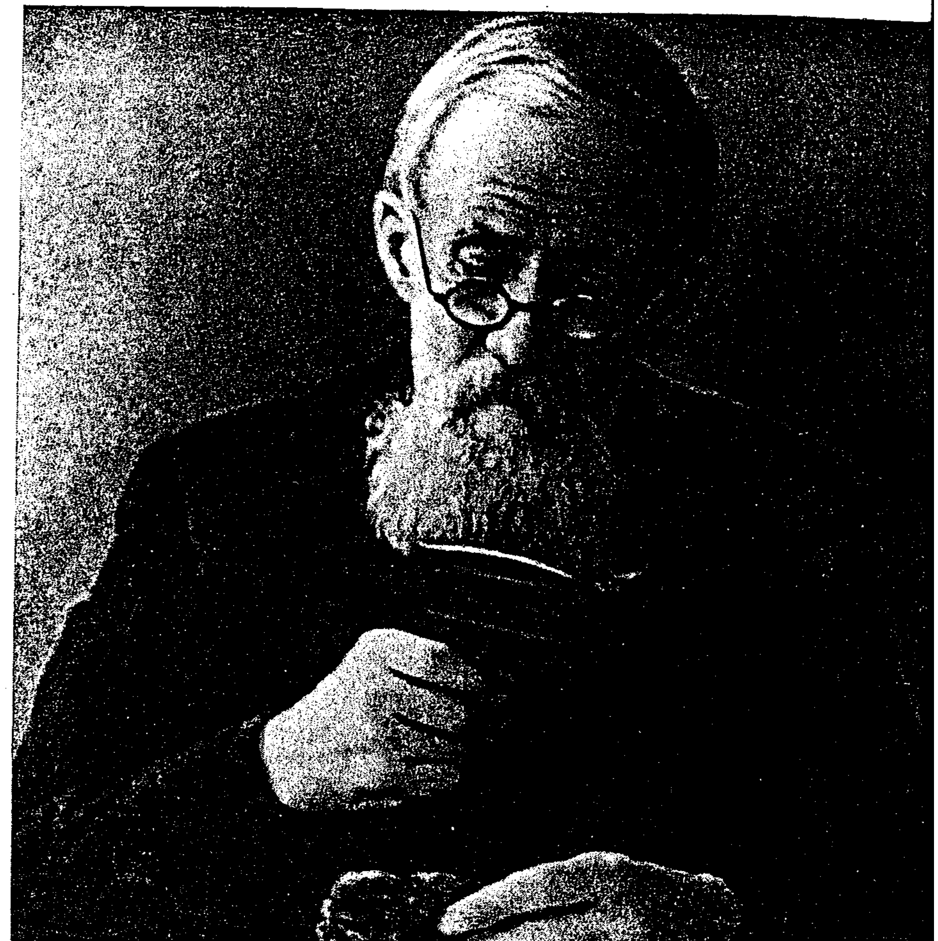
This study focuses on the paleosol S1 formed during the last interglacial (approximately from 125,000 to 75,000 years before present) in the Chinese Loess Plateau in an attempt to microscopically examine the mineralogical, chemical compositions, and redox state of iron-bearing phases. These microscopic properties will help us answer essential questions regarding the last interglacial climatic conditions under which the paleosol S1 was developed in the Chinese Loess Plateau. Understanding the S1 soil-forming processes and the processes-related East Asian Monsoon is critical to both improving the soil-related climatic proxies and providing regional information in reconstructing the global interglacial paleoclimate. In this study, we analyzed S1 samples from different geographic and bioclimatic zones with the hope that the geographic differentiation and bioclimatic dependency of the last interglacial paleosol S1 can be traced using synchrotron microbeam x-ray diffraction (XRD) and Synthrotron x-ray absorption near edge spectroscopy (XANES). We will present the results of the loess internal structure and mineral composition in a micrometer-length scale.





Владимир Афанасьевич Обручев в Свердловске в 1942 году
(кадр из фильма «Урал кует победу»)

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Quaternary Science Reviews 22 (2003) 1813–1819

QSR

Loess, and the Dust Indicators and Records of Terrestrial and Marine Palaeoenvironments (DIRTMAP) database

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Received 7 June 2003; accepted 14 June 2003

Abstract

Mineral dust is an important constituent of the solid load in Earth's atmosphere, the total atmospheric aerosol loading being both a function of, and a factor affecting climatic change. Human actions have progressively enhanced atmospheric dust loading, especially in the past century, so that both natural and human-induced effects of atmospheric dust on climatic change require more detailed research. Records of changing climate are preserved in cores from the ocean floors, glaciers and ice sheets, as well as in terrestrial sedimentary sections. Quantitative data on the present-day distribution of atmospheric dust are sparse, but simulation of dust transport and deposition has been modelled with some success. The dust indicators and records of terrestrial and marine palaeoenvironments (DIRTMAP) database was designed to serve as a global validation data set for use with earth system models of the palaeo-dust cycle. Loess, a wind-borne silt deposited on the continents particularly in the past 2.6 Myr, is an important potential source of information on past atmospheric dust accumulation. A recent initiative sought to improve the terrestrial data coverage within the existing DIRTMAP database by involving representatives from key loess regions in coordinating the data synthesis process, so as to facilitate interaction between the dust modelling and the data collection communities. The results are presented in this issue. In order to compare past minerogenic dust records (loess) with those in ice and ocean cores, mass accumulation rates (MARs) have been calculated as fluxes (in $g/m^2/yr$). The loess regions covered include North and South America, Europe, Siberia, eastern Asia, and Australasia. It is acknowledged that provision of age models for the calculation of realistic MAR values depends upon a number of conditions, most notably sound chronostratigraphy and realistic values of loess dry bulk densities. The MAR data sets presented here show some notable variation, both within and between the studied regions. Regional MAR coverage also varies, reflecting differences in the availability of key data on loess from one world region to another. Loess facies vary according to specific site and source conditions, as well as in response to post-depositional re-working of primary (wind-lain) loess by surface geomorphic processes. Mean particle size consistently declines downwind, and terrace, valley and upland sites generally yield the highest MAR values, characteristics noted in all regions discussed here. The loess accumulations in two major world regions, central and eastern Asia and the Great Plains region of North America, differ in some important respects from loess elsewhere in that they lie peripheral to deserts and are remote from the former sites of major Quaternary ice sheets. It is concluded that the MARs for terrestrial sites obtained from loess are consistently higher than those obtained from ocean and ice cores, so that future climatic models designed to study the role of global atmospheric dust will have to take full account of the present and past dust records over the continents.

Earth's atmosphere contains abundant solid particles, in addition to gases and liquids. Atmospheric dust includes material produced by organisms, including plant fibres, phytoliths (biogenic opal), pollen and spores. The burning of organic matter (biomass) produces black carbon, plumes of smoke generated by both natural and artificial fires often travelling through the atmosphere for thousands of kilometres. Mineral dust is another important component of the solid particles found in the Earth's atmosphere. Mineral particles are released by the physical and biochemical weathering of rocks and sediments, and by erosion by running water, glaciers and other agents.

Entrainment of dust by the wind (deflation) occurs in many parts of the world and, while numerous environments yield mineral aerosols, some landscapes constitute particularly important sources. Most notably, extensive tracts of sparsely vegetated terrain in the world's drylands are susceptible to significant deflation. Subtropical arid and semi-arid dust source regions cover

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doi:10.1016/S0277-3791(03)00209-9

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Quaternary Science Reviews 22 (2003) 1821–1834

QSR

Modeling the mineral dust aerosol cycle in the climate system

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Received 30 April 2001; accepted 25 July 2002

Abstract

Soil dust aerosol is an important factor of the climatic system. In order to evaluate the different aspects of the climatic effects of dust, estimates of its highly variable atmospheric distribution need to be computed by transport models. Such models also provide important means of evaluating the processes that govern changes in dustiness during different climatic periods. While models of the modern dust cycle are currently capable of simulating first-order patterns of its global distribution, the parameterization of dust emission in these models is still crude, since input information about soil properties and wind events cannot be resolved at a global scale. Regional models could be useful for evaluating emission parameterizations, as well as dust transport and depositional processes close to source regions. No single existing data set fully describes all aspects of the dust cycle. Validation of modeled dust distributions must therefore include comparisons with different types of observational data. While the compilation of such observational data sets is crucial for model development, model results can, in turn, provide guidance for new measurements of dust properties, which will be useful for future investigation of the dust cycle and its climatic effects.

1. Introduction

It is to be expected that atmospheric aerosols significantly impact upon the climate system by changing the energy balance of solar and thermal radiation (Intergovernmental Panel on Climate Change, 2001). Soil-derived mineral dust contributes significantly to the global aerosol load. Estimates of global dust emissions range from 60 to 3000 Mt/yr (Duce, 1995). Sea salt is the only other aerosol that has similarly high global emission rates (Andreae, 1995). Dust plumes are predominant features in satellite retrievals of global aerosol patterns (e.g., Herman et al., 1997; Stowe et al., 1997). The direct and indirect climatic effects of dust are potentially large, but still remain substantially unknown.

Radiative forcing (which is the perturbation of the radiation balance caused by an externally imposed factor) by soil dust aerosol is complex, since dust not only scatters but also partly absorbs incoming solar radiation, and also absorbs and emits outgoing long-wave radiation (the 'greenhouse effect'). Any changes in atmospheric dust loads would cause a change in the radiation balance, and consequentially, surface temperatures. The magnitude and even the sign of the dust forcing depends on the optical properties of the dust, which in turn depend on their size and refractive indices, on the vertical distribution of the dust, on the presence of clouds, and on the albedo of the underlying surface (Sokolik and Toon, 1996; Tegen et al., 1996; Claquin et al., 1998; Liao and Seinfeld, 1998). Mineral composition, particle mixing state, and particle shapes influence the refractive indices of dust particles. These vary regionally according to the soil properties in the respective dust source regions. The climatic response to this direct radiative forcing by dust will not necessarily follow the patterns of dust distribution, because the atmospheric circulation is likely to be changed by dust forcing. Recent results indicate that direct dust forcing results in cooling of the Earth's surface (Perlwitz et al., 2001).

Dust loads as indicated by dust sedimentation rates, reconstructed from ice cores and terrestrial and marine sediments were considerably higher during past cold climate periods (e.g., Petit et al., 1990; Legrand, 1995; Steffensen, 1997; Kohfeld and Harrison, 2001), and the effects of dust on climate were therefore probably stronger. Changes in dust loads could possibly have contributed to glacial–interglacial temperature changes.

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doi:10.1016/S0277-3791(03)00163-X

ERGAMON

Quaternary Science Reviews 22 (2003) 1835–1857

QSR

Loess in Europe—mass accumulation rates during the Last Glacial Period

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Received 4 May 2003; accepted 31 May 2003

bstract

Upper Pleistocene loess/palaeosol sequences provide excellent high-resolution terrestrial archives of climate forcing. Due to ıprovements in numerical age determinations, especially in luminescence dating methods, a more reliable time-based construction of the past climate and environmental change has become available for the loess record in Europe. Chronological formation was collected from 43 sites along a northwest to southeast transect in Europe. Thirty-three of these sites had sufficient ;e information to allow estimation of mass accumulation rates, and it was possible to isolate the mass accumulation rates of imary loess during the Last Glacial Period (~28–13 ka BP) at 21 of these locations. These sites fall along a coarse climatic gradient ɔm the relatively coastal climate of Belgium and France to the drier, more continental climate of Central Europe. Interpreting ass accumulation rates of loess in terms of this climatic gradient is not straightforward as these deposits are dominated by sources floodplains and large river systems. Thus accumulation rates are influenced strongly by regional wind and precipitation patterns, ıt mostly by the availability of glacially derived material from the Alps and the periglacial terrains that characterized European ıvial systems during and immediately following glaciation.

Introduction

The loess record of Europe provides a potentially portant archive of regional climate change. However, :erpreting the relationships between European climate d other parts of the Northern Hemisphere requires equate chronological control for determining the ative timing of various climatic events. It was Kukla ɔ70) who first attempted to correlate the terrestrial :hives of the loess deposits from Moravia with the ırine climate records for which the oxygen isotope ıe scale had been established (Emiliani, 1955). Fink d Kukla (1972) extended the record for the whole ıaternary. The difficulties involved in using such a rrelative approach in the absence of reliable indepen- ıt age control arise from the fact that terrestrial ords are frequently incomplete as a result of erosional ɛnts (e.g. Boenigk and Frechen, 1998).

The Last Glacial loess record has become of major interest because chronological methods such as luminescence dating make possible the direct determination of deposition ages of aeolian sediments and therefore circumvent some of the problems associated with simple stratigraphic correlation. High-resolution luminescence dating studies using a multiple sample approach have been successfully applied to Upper Pleistocene loess and loess derivatives (Frechen, 1992, 1999a; Frechen et al., 1995, 1997, 2001a; Frechen and Dodonov, 1998; Lang et al., 2003). Multidisciplinary research on thick accumulations of loess with intercalated palaeosols has become attractive because these sediments provide a detailed terrestrial archive of climate and environmental change throughout the Northern Hemisphere for the Quaternary Period (Kukla, 1975, 1977; Liu, 1985; Pécsi, 1990; Shackleton et al., 1995; Frechen, 1998, 1999b; Antoine et al., 1999; Boenigk and Frechen, 2001).

With the help of chronological information, primarily based on luminescence, the direct dating of depositional events makes it possible to compute mass accumulation rates for loess. The reason for calculating mass accumulation rates as fluxes (in $g/m^2/yr$) as opposed to

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10.1016/S0277-3791(03)00183-5

PERGAMON

Quaternary Science Reviews 22 (2003) 1859–1878

QSR

Glacial-interglacial changes in dust deposition on the Chinese Loess Plateau

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Received 14 July 2001; accepted 31 July 2002

Abstract

The Chinese Loess Plateau (CLP) contains an extensive record of aeolian deposition through multiple glacial–interglacial cycles. Independent chronologies based on pedostratigraphy, magnetic susceptibility, radiocarbon and luminescence dating were developed for 79 sites and used to estimate aeolian mass accumulation rates (MARs) for marine isotope stages 1–5. The regional median value of MAR for Stage 2 is 310 $g/m^2/yr$ compared to an estimate of 65 $g/m^2/yr$ for Stage 5. Estimated MARs from individual sites for Stage 2 are approximately 4.3 times greater than MARs for Stage 5 and 2.1 times greater than for Stage 1. MAR values at individual sites are consistently highest in the northwest and lowest in the southwest of the CLP during all marine isotope stages. MARs estimated on sections through loess terraces are consistently higher than MAR estimates at other sites, indicating that local recycling of loess material from exposed river valley deposits has been significant throughout the last 130 kyr. Although the spatial and temporal patterns in MAR are robust, there are uncertainties about the magnitude of these changes due to (a) lack of bulk density measurements and uncertainties in the chronologies for individual sites, (b) site and chronological biases in the sampling used to derive regional estimates, and (c) the unquantified nature of human impact on accumulation rates during the late Holocene. Nevertheless, the records from the CLP pose a number of challenges which could be addressed by numerical models of the palaeo-dust cycle.

1. Introduction

Loess deposits provide a quasi-continuous record of mineral dust deposition under changing climate regimes. Since loess deposits are generally found in regions close to major dust source areas, they provide a quantitative estimate of changes in the dust cycle that complements ice-core (e.g. Cragin et al., 1977; Hammer, 1977; Fisher, 1979; Petit et al., 1981, 1990, 1999; Hammer et al., 1985; Steffensen, 1997) or marine-core (e.g. Sarnthein and Koopman, 1980; Sarnthein et al., 1981; Clemens and Prell, 1990; Hovan et al., 1991; Sirocko and Lange, 1991; Rea, 1994; Ruddiman, 1997) records of far-travelled dust. This complementarity could be exploited to provide a more rigorous evaluation of model simulations of the palaeo-dust cycle than is currently possible (see e.g. Kohfeld and Harrison, 2001) provided the records can be synthesised at appropriate spatial and temporal scales.

The Chinese Loess Plateau (CLP) is one of the most extensive areas of loess deposition in the world. The CLP spans an area of approximately 440,000 km^2, predominantly in the provinces of Shanxi, Shaanxi and Gansu, between 33–40°N and 98–115°E (Liu, 1985a). The CLP deposits consist of between 100 and 300 m of intercalated loess and palaeosols, formed during alternating cold and warm climate phases (Liu, 1965; Liu et al., 1985; Kukla et al., 1988; Derbyshire et al., 1995). The earliest deposits, the so-called red clay, have been dated to approximately 7 Myr (Sun et al., 1997, 1998a; Ding et al., 1998, 1999; An, 2000) and thus it would appear that the CLP provides a multi-million year record of dust accumulation and climate changes. However, most of the studies carried out on the CLP to date have focussed on records covering recent glacial–interglacial cycles. Although many individual profiles from the CLP have been studied and there is an extensive literature on these records, much of our understanding of changes in dust accumulation during glacial–interglacial cycles is based on a relatively small number of key sites (see e.g. An and Xiao, 1990; An

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doi:10.1016/S0277-3791(03)00166-5

PERGAMON

Quaternary Science Reviews 22 (2003) 1879–1906

QSR

The Siberian loess record and its significance for reconstruction of Pleistocene climate change in north-central Asia

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Received 5 July 2001; accepted 26 July 2002

Abstract

The Siberian loess represents the most significant terrestrial proxy record of Quaternary climatic history in northern Asia. Loess is extensive in southern Siberia, between the Irtysh Basin in the west and the Angara Basin in the east. Palaeoenvironmental multi-proxy data (magnetic susceptibility (MS), grain size, % $CaCO_3$, % TOC, pollen, etc.) from high-resolution loess–palaeosol sections provide evidence for a strongly fluctuating climatic sequence in north-central Asia during the Late Quaternary, displaying the globally diagnostic sequences found in the deep-sea oxygen isotope records. MS provides the most continuous and detailed record (encompassing the last two interglacial–glacial cycles) in loess sections in the Minusinsk Basin (Yenisei area) and on the northern Altai Plains. Evidence for periodic atmospheric shifts is provided by gradual changes in the main vegetation zones, with parkland-steppe and mixed taiga during warm interglacial/interstadial stages being replaced by boreal tundra-forest and arid periglacial tundra-steppe during stadials. Climatic pulses from warm intervals to cold are recorded by incipient (forest/steppe)-tundra gleysols. The occurrence of the highest sediment accumulation rates in glacial stages (OIS 4 and OIS 2) in the southern plains and depressions indicates that the most intensive aeolian dust deposition followed the glacial maxima, with the most recent interval dated to ca. 19–15 ka BP. Because of its zonal distribution and pronounced climatic continentality, the Siberian loess region represents an important data source for reconstructing past climates in the Northern Hemisphere. It provides a key to the correlation of other loess regions within the West–East Eurasian continental zone.

1. Introduction

Studies of past climates and Quaternary environments in Siberia have advanced considerably in recent years, mainly because of increased awareness of the value of reconstructing geological and natural histories so as to improve understanding of present-day ecosystems, and as a means of predicting the probable extent and consequences of future climatic changes. Because of the multi-factorial nature of long-term climatic and environmental evolution, Siberian palaeoclimate-oriented studies have become increasingly interdisciplinary, integrating Quaternary geology and palaeogeography, palaeopedology, terrestrial and marine palaeontology, palaeobotany, palaeolithic archaeology and many other fields (e.g. Chlachula et al., 1999, 2003b; Chlachula, 2001a–c).

Because of its vast extent and geographical isolation between the major Central Asian (Himalayan) mountain system and the Arctic Ocean (Fig. 1), Siberia is a palaeoenvironmental archive of considerable potential, not only for northern Eurasia but also as a source of insight into general pathways and rates of change in the Northern Hemisphere. Southern Siberia, in particular, is of major significance because it lies in the transitional sub-arctic continental zone between the northern Siberian lowlands, south of the Arctic Ocean, and the southern Siberian mountain system situated north of the steppes and (semi-) deserts of Central Asia. Detailed Pleistocene terrestrial subaerial records have been documented in geological sections within the major river basins (the Irtysh, Ob, Yenisei, Angara and Lena rivers); many of these have been exposed by intensive slope erosion triggered by the construction of large dams. Equally significant sources of other Quaternary (geological, palaeontological and archaeological) palaeoclimatic proxy data have been revealed by large-scale industrial

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doi:10.1016/S0277-3791(03)00182-3

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PERGAMON

Quaternary Science Reviews 22 (2003) 1907–1946

QSR

Last Glacial loess in the conterminous USA

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Abstract

The conterminous United States contains an extensive and generally well-studied record of Last Glacial loess. The loess occurs in diverse physiographic provinces, and under a wide range of climatic and ecological conditions. Both glacial and non-glacial loess sources are present, and many properties of the loess vary systematically with distance from loess sources. United States' mid-continent Last Glacial loess is probably the thickest in the world, and our calculated mass accumulation rates (MARs) are as high as 17,500 $g/m^2/yr$ at the Bignell Hill locality in Nebraska, and many near-source localities have MARs greater than 1500 $g/m^2/yr$. These MARs are high relative to rates calculated in other loess provinces around the world. Recent models of Last Glacial dust sources fail to predict the extent and magnitude of dust flux from the mid-continent of the United States. A better understanding of linkages between climate, ice sheet behaviour, routing of glacial meltwater, land surface processes beyond the ice margin, and vegetation is needed to improve the predictive capabilities of models simulating dust flux from this region.

1. Introduction

Instrumental records of global warming over the past century have raised concerns over the role of anthropogenic greenhouse gas additions in climate change. Recently, atmospheric scientists are also considering that aerosolic dust may be an important component in the Earth's radiative transfer processes (Tegen et al., 1996; Harrison et al., 2001). Ice core and marine records show that atmospheric dust loading occurs in response to climatic and environmental changes (Petit et al., 1990; Rea, 1994). Atmospheric dust loading also affects the radiative properties of the atmosphere and the impact of these feedbacks could have strong effects in global, regional, and local palaeoclimate records (Arimoto, 2001). There has been a growing appreciation of the palaeoclimatic significance of loess sequences and their intercalated palaeosols (Hovan et al., 1989; Begét, 1991; Wang et al., 1998, 2000; Muhs and Bettis, 2000, 2003; Muhs and Zárate, 2001; Grimley et al., 2003). Some of these records are considered the best continental analog of the deep-sea oxygen isotope record as a palaeoclimate record (Hovan et al., 1989; Rea, 1994).

The conterminous United States of America contains a subcontinent-scale late Quaternary loess record that covers more than 4.5 million km^2 across 42° of longitude from the Cascades eastward to the Appalachians, and 20° of latitude from Minnesota southward to Louisiana (Fig. 1). This area encompasses a number of distinct physiographic and geologic provinces, and a wide range of climates and biomes (Fenneman, 1931, 1938; Bailey et al., 1994). In this paper we discuss the stratigraphy, lithology, chronology and mass accumulation rates (MARs) of loess dating to the Last Glacial period (Marine Oxygen Isotope Stage 2, MIS 2) in order to increase the spatial extent of records that may be used to evaluate models of the role of dust in climate change. We present stratigraphic, chronologic, and mineralogical data gleaned from the literature, as well as data from unpublished studies. The sedimentation system of loess in various parts of the country, including changing source areas through time, is also considered in this paper because of the impact on regional and local geographic and geochemical patterns that may influence atmospheric loading rates and radiative effects (Kohfeld and Harrison, 2000; Harrison et al., 2001).

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doi:10.1016/S0277-3791(03)00169-0

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ERGAMON

Quaternary Science Reviews 22 (2003) 1947–1986

QSR

Stratigraphy and palaeoclimatic significance of Late Quaternary loess–palaeosol sequences of the Last Interglacial–Glacial cycle in central Alaska

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Received 21 July 2001; accepted 6 August 2002

ıstract

Loess is one of the most widespread subaerial deposits in Alaska and adjacent Yukon Territory and may have a history that goes ck 3 Ma. Based on mineralogy and major and trace element chemistry, central Alaskan loess has a composition that is distinctive ım other loess bodies of the world, although it is quartz-dominated. Central Alaskan loess was probably derived from a variety of ɔk types, including granites, metabasalts and schists. Detailed stratigraphic data and pedologic criteria indicate that, contrary to ·ly studies, many palaeosols are present in central Alaskan loess sections. The buried soils indicate that loess sedimentation was sodic, or at least rates of deposition decreased to the point where pedogenesis could keep ahead of aeolian input. As in China, ss deposition and pedogenesis are likely competing processes and neither stops completely during either phase of the loess/soil mation cycle. Loess deposition in central Alaska took place before, and probably during the last interglacial period, during dials of the mid-Wisconsin period, during the last glacial period and during the Holocene. An unexpected result of our ɔchronological studies is that only moderate loess deposition took place during the last glacial period. Our studies lead us to ıclude that vegetation plays a key role in loess accumulation in Alaska. Factors favouring loess *production* are enhanced during cial periods but factors that favour loess *accumulation* are diminished during glacial periods. The most important of these is ;etation; boreal forest serves as an effective loess trap, but sparsely distributed herb tundra does not. Thus, thick accumulations of ss should not be expected where tundra vegetation was dominant and this is borne out by modern studies near the treeline in tral Alaska. Much of the stratigraphic diversity of North American loess, including that found in the Central Lowlands, the ɜat Plains, and Alaska is explained by a new model that emphasizes the relative importance of loess production factors versus ss accumulation factors.
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Introduction

ـoess is receiving much attention today in the aeoclimate community. Not only is loess thought to a terrestrial equivalent to the foraminiferal oxygen ːope record in deep-sea sediments (Kukla et al., 1988; Hovan et al., 1989), but it is also important in setting boundary conditions in atmospheric general circulation models, or AGCMs (Kutzbach et al., 1993). Loess records provide one of the few ways to test reconstruction of paleowinds that are simulated by AGCMs (Muhs and Bettis, 2000). In addition, however, dust is now also being considered as having a role as a climate forcing mechanism itself (Tegen et al., 1996; Mahowald et al., 1999; Kohfeld and Harrison, 2000, 2001; Harrison et al., 2001). Thus, there is considerable interest in loess

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ʹ-3791/03/$-see front matter Published by Elsevier Science Ltd.
ː0.1016/S0277-3791(03)00167-7

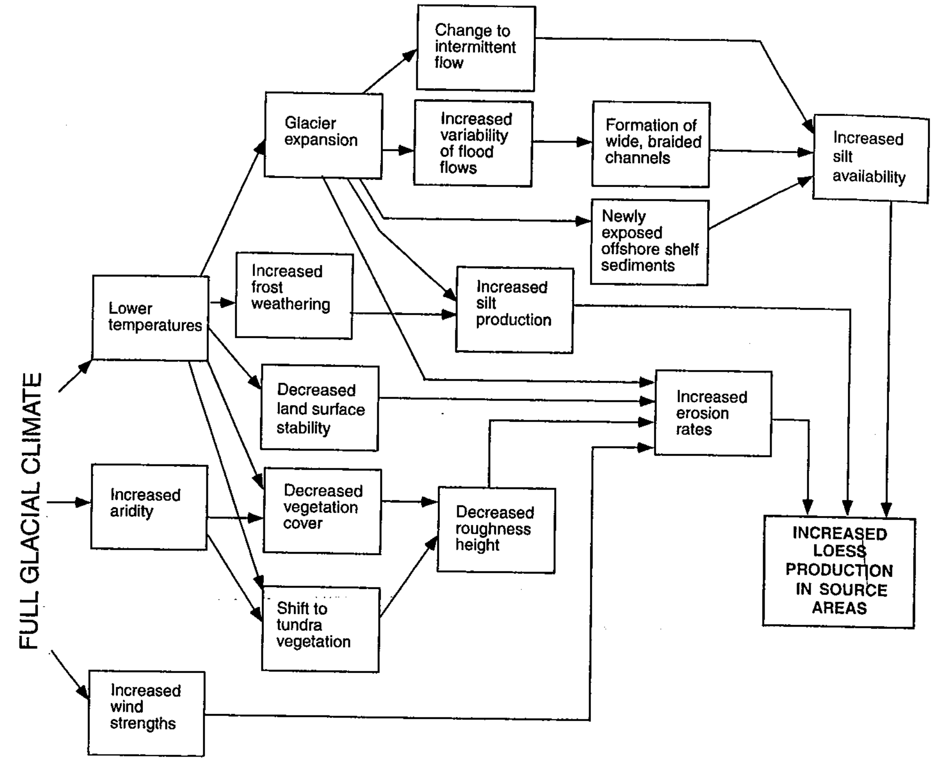

Fig. 20. Process-response model of enhanced loess production during the last glacial period in Alaska.

Alaska. In all areas we have observed that, immediately downstream from active glaciers in the Alaska Range, outwash valleys are extremely silt-rich, despite the fact that bedrock in the source areas is not siltstone-dominated (as it is in parts of the Great Plains). Furthermore, analysis of suspended sediment data from streams in Alaska has shown that sediment yields are positively correlated with the amount of glacial cover in a drainage system (Hallet et al., 1996). In fact, these studies have shown that basins with ≥30% glacier cover have sediment yields about an order of magnitude higher than the amount of sediment in basins without glaciers. We conclude from these considerations that most silt in Alaskan loess is glaciogenic and that, during the last glacial period, silt production by glaciers was greater than at present.

If conditions were conducive to greater silt production, greater silt availability and increased wind strength, it is surprising to find such a minimal record of last glacial loess deposition in central Alaska. Part of the explanation for this unexpected result may be related to the conditions favouring loess *production* versus conditions favouring loess *accumulation*. Some of the same conditions that would bring about greater sediment availability in loess source regions would also bring about a decreased likelihood of loess accumulation downwind. Hence, we have constructed another model (Fig. 21) that shows the effect of full glacial climates on the loess accumulation capability in areas receiving dust. The greater continentality, decreased moisture sources, lower temperatures, and increased aridity of central Alaska would have resulted in an herb tundra vegetation and it is possible that vegetation cover was not continuous over many parts of the landscape (Ager and Brubaker, 1985; Anderson and Brubaker, 1994). Herb tundra vegetation has a very low roughness

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Quaternary Science Reviews 22 (2003) 1987–2006

QSR

Loess of southern South America

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Received 15 July 2001; accepted 11 August 2002

Abstract

Loess and loessoid (loess-like, reworked loess) sediments extend across the Chaco–Pampean plains and the NW mountain environments of Argentina, and in neighbouring countries (Paraguay, Brazil, Uruguay, Bolivia). Loessoid sediments are much more abundant than primary loess. The beginning of the loessoid sedimentation cycle was related to a phase of Late Miocene orogeny in the Andes. The Plio-Pleistocene record is mostly composed of loessoid sediments modified by pedogenesis, which produced welded palaeosols. The Late Pleistocene/Holocene loess record reveals a heterogeneous composition across the region. Coarse textures and an Andean-derived volcanic composition prevail in the southern Pampas. Finer textures and material coming from the Andes and the other two sources (Sierras Pampeanas and the Paraná basin) characterize the loess deposits of the northern Pampas and the eastern Chaco. A southern Patagonian source is also suggested for the mountain valley loess of Tucumán, although a western Andean provenance has been proposed. It is believed that the material in the western Chaco was derived from the Bolivian Andes. Loess deposition was related to a multistage transport mechanism, involving fluvial and aeolian processes. Inferred westerly and southwesterly wind directions, as dominant carriers of the aeolian deposits, are in agreement with westerly palaeowind simulations using climate models. However, the role played by westerly tropospheric winds and northerly winds remains to be established.

1. Introduction

The largest loess deposits in South America extend from 23°S to 38°S in the southern plains of the continent. Initially reported as clay (d'Orbigny, 1842 in Frenguelli, 1955), and silt (Darwin, 1846; Ameghino, 1880), the sediments from the Pampas were first defined as loess (Heusser and Claraz, 1866) on the basis of the "stratigraphic and structural" similarities with European loess, particularly the Upper Rhine loess (Frenguelli, 1957). Later authors continued to refer to the Pampean sediments as loess (e.g., Doëring, 1882; Wright and Fenner, 1912; Keidel, 1916; Roth, 1920). During the first half of the 20th century, Frenguelli (1918, 1921, 1955, 1957) provided extensive information on the stratigraphy, grain-size, mineralogy, morphology and distribution of loess deposits. However, it was a paper entitled "The Nature and Origin of Argentine loess" by Teruggi (1957) that proved to be the seminal contribution, providing the fundamental basis for later studies.

During the past 20 years, renewed interest in loess has resulted in numerous contributions dealing with its distribution, composition, magnetostratigraphy, age, fossil contents, source areas and palaeoenvironmental implications. Recently, the Late Quaternary loess records of both South and North America were reviewed and analysed in respect of their palaeoclimatic significance (Muhs and Zárate, 2001).

The purpose of this paper is to provide a review of the loess record of southern South America. Identification of the loess, its distribution and the geological record it provides are considered first. Analysis focuses on the distribution, composition and source areas of the Late Pleistocene/Holocene aeolian deposits and their climatic and environmental implications.

2. Distribution

The terms loess and loessoid (equivalent to reworked loess or loess-like deposits) sediments have been loosely used in the geological literature. As a result, several deposits across southern South America were mapped as loess on the basis of their field characteristics (massive and homogeneous appearance, colour and relatively fine texture) and sometimes their mineralogical composition (*loessic mineralogy* referring to sediments with a high content of volcanic-derived particles). The problem of

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0277-3791/03/$ - see front matter
doi:10.1016/S0277-3791(03)00165-3

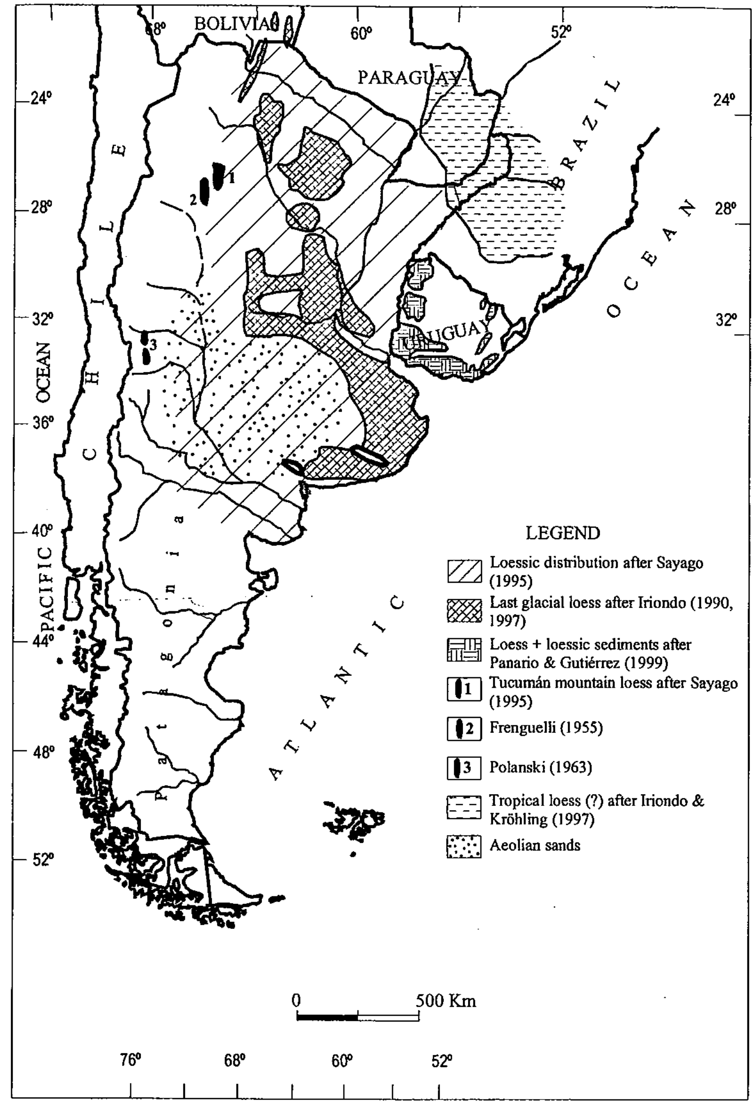

Fig. 2. Loess and loessoid distribution according to several authors. The late Holocene loess represented by Iriondo (1997) is not included. (1) Sayago (1995), (2) Frenguelli (1955), (3) Polanski, 1963.

distribution, as Teruggi originally indicated. Geomorphological and soil studies across the southwestern and western areas of the Pampas, also known as the *Pampa Arenosa* (Sandy Pampa), shows the occurrence of an extensive aeolian sand cover (Fig. 2). This region consists of a large and complex sand dune system (Cantú and Degiovanni, 1984; Gardenal, 1986; Hurtado and Giménez, 1988) that corresponds to the *Mar de*

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Quaternary Science Reviews 22 (2003) 2007–2035

QSR

Australian dust deposits: modern processes and the Quaternary record

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Received 17 May 2001; accepted 30 July 2002

Abstract

Dust raising and transport are common and important processes in Australia today. The aridity of the Australian continent and high climatic variability result in widespread dust raising in the arid and semi-arid areas and transport to the humid margins and surrounding oceans. The supply of erodible particles appears to be the greatest limitation on total flux of transported dust. Dust raising is greatest in the Lake Eyre Basin, including the Simpson Desert, and Murray-Darling Basin where internal drainage renews supplies of fine particles to the arid zone. In the west and northwest dust entrainment is low, despite considerable aridity. The marine record of dust flux shows at least a threefold increase in dust flux, compared with the Holocene, in the last glacial maximum in both tropical and temperate Australia, driven by weakened Australian monsoon rains and drier westerly circulation, respectively. Despite the widespread confirmation of aeolian dust deposits in southeastern and southwestern Australia, dated or quantified records are extremely rare. The dominant model of Australian dust deposits, the clay-rich 'parna', is shown to be poorly substantiated while modern and ancient dust deposits examined in detail are shown to bear a strong similarity to conventional definitions of loess.

We experienced this day the sirocco-like wind of Australia, which comes from the parched deserts of the interior. Clouds of dust were travelling in every direction; and the wind felt as if it had passed over a fire.

Charles Darwin, January 20th 1836, near Bathurst, Journal of Researches.

1. Introduction

As the driest continent on earth (excluding Antarctica), Australia has extensive dunefields formed by aeolian processes (Wasson et al., 1988). It is less well known that large quantities of dust were also entrained in dust storms during the formation of these dunefields and that, unlike the dune sands, these dusts were transported as dust plumes far beyond their desert source. It is even less well known that deposition of this dust was a contributor to the soils of much of southeastern Australia (Butler, 1956).

Evidence indicating that glacially derived loess occurs world-wide is overwhelming (Pye, 1996), but the desert loess evidence has been much more equivocal, and only in the last 10 years has it become accepted that desert loess is a widespread soil formation process. Australian scientists have had the potential to play a major role in the desert loess debate but, unlike those in the USA, this potential has not been achieved despite having some of the earliest and best-documented (Butler et al., 1942) examples of desert dust-derived soils. Butler (1956, 1974) avoided using the term loess to describe these soils, possibly because they differed from the classical glacial loess soils of the Northern Hemisphere and, secondly, because there was very limited unchallenged evidence of desert loess at that time. Instead Butler used the local term 'parna' to describe these soils. The use of this local term was unfortunate as, at a time when proven examples of desert loess were rare, these so-called parna soils were relegated to the position of a Southern Hemisphere curiosity, rather than representing early examples of desert loess.

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doi:10.1016/S0277-3791(03)00164-1

Since first described, the aeolian deposits were recognized as the products of past phases of arid climate (Butler, 1958). However, with few exceptions (Bowler, 1978), the exact relationship to global climate change or other climate proxies was not investigated until comparatively recently. In Australia there has been a revolution in the understanding of Quaternary time and environments brought about by the widespread use of luminescence dating. Desert dunes have now been extensively dated by luminescence methods (e.g. Wasson, 1987; Readhead, 1988; Nanson et al., 1992a, b, 1995), although the same is not true of aeolian dust deposits. Likewise, the concentration of research effort on the pedological effects of dust deposition (e.g. Walker et al., 1988) has overshadowed sedimentological and stratigraphic studies directed at palaeoclimatic reconstruction.

In this paper we aim to review advances in the understanding of aeolian dust processes and deposits in Australia since the last review of the subject (McTainsh, 1989). In particular, we consider the Quaternary palaeoclimatic record available in this new research, as well as older studies. Aeolian dust deposits have the potential to contribute proxy information on past climates and to the ongoing discussion of the nature of environmental response to past climate forcing. In addition, it is likely that mineral dust aerosols contribute to radiative forcing and perhaps directly to climate change (Harrison et al., 2001). The level of information required to test hypotheses of past climate change or models of dust transport is quite high, including the particle-size distribution, mineralogical composition, dust entrainment and deposition fluxes, sources of dust and transport pathways. This information comes from a combination of modern process studies and investigation of dust deposits. Therefore this paper discusses (a) present day dust processes including source areas, transport paths and depositional rates, (b) marine sediment records of dust flux and (c) continental (onshore) deposits of dust, their nature and their Quaternary record.

2. Modern dust processes

Bowler (1976) was first to identify two general dust paths in the Australian region, namely towards the southeast and the northwest (Fig. 1), both being associated with easterly moving frontal systems within the zonal westerly winds in the south and the easterly trade winds in the north. Information available on these dust paths and their Quaternary significance up to the late 1980s was reviewed by McTainsh (1989), who concluded that the scale of operation of these systems is such that the soils of eastern Australia must have received large inputs of dust during the Quaternary. The results of modern dust research in the 1990s provides further support for this contention.

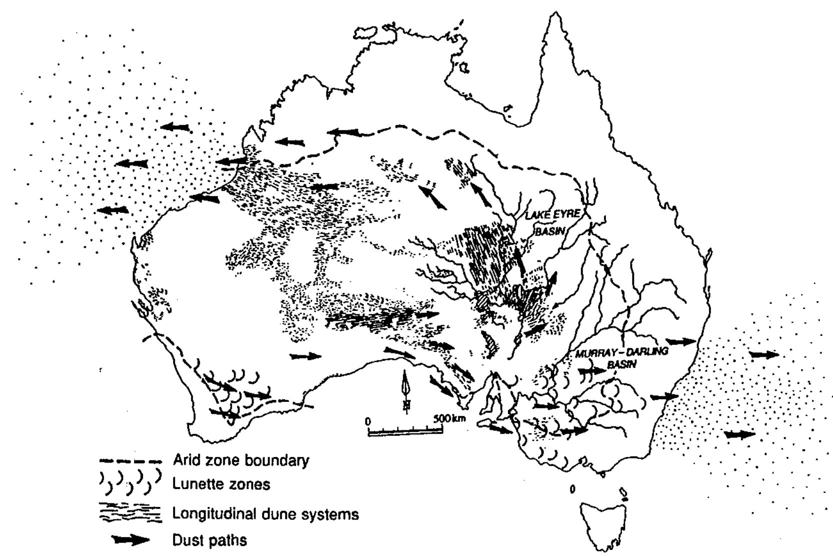

Fig. 1. Australian dust paths in relation to inland river basins and dune systems. Modified after Bowler (1976).

The southeast dust path has received by far the most research attention. Studies of individual dust storms indicate that large quantities of sediment are transported, but that individual dust plume trajectories are more complex than earlier thought. Knight et al. (1995) estimate that 1.9–3.4 million tonnes of dust passed off the Queensland coast in a single event in December, 1987. Raupach et al. (1994) conservatively estimated that 2 million tonnes of dust was transported in a dust storm, which passed through Melbourne in February 1983, and 10–20 million tonnes of dust was moved during three events across southern Australia in May 1994. The overall significance of dust transport in the evolution of the Australian landscape is summed up by the assertion of Knight et al. (1995), based upon an approximate comparison of the sediment yield of dust transport and river systems in the Lake Eyre and Murray-Darling Basins, that more sediment is lost from the continent in the air than in the river systems.

Event-based dust plume trajectory studies within the southeast dust path show a variety of dust plume trajectories. The southeast dust path actually covers a much larger latitudinal range than implied in Bowler's original map. It extends over 35 degrees of latitude, from Townsville in north Queensland to Macquarie Island in the Southern Ocean. However, the zone of most active dust transport is in the 25 to 40 degree latitude range, which corresponds with the Quaternary dust record in Tasman Sea cores (Hesse, 1994). Modern dust plumes also regularly reach New Zealand, with 19 published reports (McGowan pers.comm. 2000), but many more events have passed undetected.

Dust deposition rates have been measured at a number of sites within the southeast dust path (McTainsh, unpublished data). Deposition rate measurements from three locations during the 1995 dust storm season (August–November) provide a downwind spatial pattern of deposition. Birdsville, located in an active dust storm region, recorded 0.47 t/km^2/day dust deposition, whereas further east on a relatively stable site at Diamantina National Park, deposition rates were 0.24 t/km^2/day. Another 200 km eastwards, at Longreach, which lies outside the active dust entrainment region, the deposition rate fell to 0.14 t/km^2/day. These data do not, however, demonstrate the highly episodic nature of dust deposition. For example, during a two-week period at Birdsville, which included a moderately large dust storm (on 1 September, 1995), a dust deposition rate of 19.1 t/km^2/day was recorded.

Mean annual dust deposition rates in central and western New South Wales, a region where conditions for loess deposition are nearly optimal in Australian terms, range from 31.4 to 43.8 t/km^2 (McTainsh and Lynch, 1996). Global comparisons of deposition rates are inadvisable without taking into account time and space factors (McTainsh, 1999), but in general terms, these Australian deposition rates are in the low to moderate range, in global terms. Even based upon these modern rates, there is sufficient deposition to make a significant contribution to soils. For example, in a study of dust contributions to soils in northeastern New South Wales, Cattle et al. (2002) calculate that a post-LGM (last 13,000 years B.P) dust deposition rate of 31.4 t/km^2/yr would have increased soil depth by 20 cm, conservatively assuming a 50% dust stabilisation rate. If we accept the model-based assertion of Harrison et al. (2001) that LGM dust activity was an order-of-magnitude higher than today, then loess deposits of $\sim$1 m could easily have formed within the southeast dust path. This approach, which brings together detailed sedimentological analyses of deposits with modern dust process measurements and current LGM models of dust activity has merit.

Modern dust deposits are highly enriched in organic matter and soil nutrients. Therefore, even in areas where mass accumulation rates have been insufficient to produce recognizable loess deposits, dust deposition has provided a significant nutrient input. Boon et al. (1998) describe average dust deposit organic matter levels of 34% and, according to the study by Leys and McTainsh (1999) in the Gunnedah area of northern New South Wales, dust deposit organic matter levels in 1996/7 were 33%. Also, Total N and P were enriched 8 and 3 fold, respectively.

Meteorological records of dust storm occurrence show that the most active modern dust source areas are in the Lake Eyre Basin and the western sector of the Murray-Darling Basin (Fig. 2). The main dust source areas of the southeast dust path are the Simpson Desert-Channel Country in southwest Queensland, the Strzelecki Desert in South Australia and in western New South Wales extending south to the Mallee region in northwest Victoria. The dust source areas of the

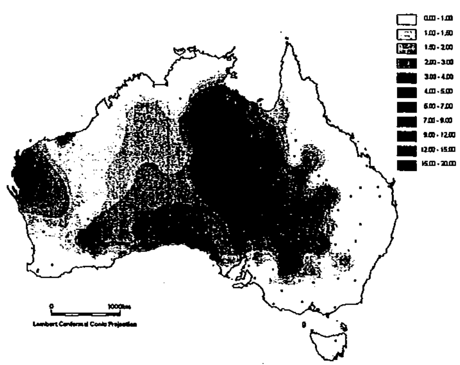

Fig. 2. Spatial pattern of dust entrainment in Australia (1960–1999) using the Dust Storm Index of McTainsh (1998).

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Quaternary Science Reviews 22 (2003) 2037–2052

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Dust accumulation in the New Zealand region since the last glacial maximum

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Received 9 July 2001; accepted 14 April 2002

Abstract

Loess is widespread in New Zealand; deposits >1 m thick cover 10% of the land area. It has mainly been derived from dust deflated from river floodplains during the last glacial maximum (LGM). Dust accumulation continues today downwind of major river floodplains. Most loess is quartzofeldspathic, having its origins in Mesozoic and Neogene rocks of the axial ranges and hill country. In the central North Island there are deposits of volcanic loess derived from aeolian reworking of tephras. Loess morphology and properties vary greatly due to diverse parent materials, post-depositional climates and drainage conditions. The widespread 26,170 cal. yr Kawakawa Tephra provides a datum for calculating mass accumulation rates (MARs). Rates are mostly within the range 70–150 g m^{-2} yr^{-1}, but enhanced deposition at one site gave a rate of 360 g m^{-2} yr^{-1}. Contemporary MARs of 40–100 g m^{-2} yr^{-1} were determined for distances of 1.75–0.4 km downwind of the Rakaia River. LGM MARs of quartz for two marine cores (P69 & Q858) drilled 100–300 km east of New Zealand are 40–70 g m^{-2} yr^{-1}. The MAR of the aeolian component of P69 is estimated to be ca 15 g m^{-2} yr^{-1}.

1. Introduction

New Zealand is unique among the world's areas of dust production and loess formation because of its maritime setting as relatively small, oceanic islands (ca 270,000 km^2). Also, the South Island of New Zealand lies across the contact between the Australian and Pacific crustal plates, and has been subjected to high rates of tectonism and volcanic activity. Erosion rates are high and New Zealand provides around 1% of the sediment input into the world's oceans (Carter et al., 2000). During Quaternary cold climate intervals, New Zealand's mid-latitude position, extending from 35 to 46°S, resulted in the South Island experiencing valley and alpine glaciation while the southern and central parts of the North Island had greatly reduced vegetation cover and experienced widespread regolith erosion. These conditions were conducive to the creation of significant amounts of dust that were deposited on land (as loess) and offshore.

Loess, as defined by McCraw (1975) for New Zealand conditions, is any fine-textured deposit of aeolian origin other than sand dunes or tephra. It occurs over extensive areas of New Zealand, especially in eastern South Island and southern North Island south of about 39°N (Fig. 1). It is estimated that loess 1 m or more thick covers at least 10% of New Zealand's land surface (McCraw, 1975), and soils with a loessial component cover approximately 60% of the country (Bruce et al., 1973). Loess occurs mostly on late Pleistocene or older river terraces and marine benches. It is also present in soils developed on 'downlands' and hills, especially downwind of river floodplains. Deposits vary greatly in thickness, with maxima of about 20 m (Selby, 1976). The loess has been derived mainly from dust deflated from broad, braided, river floodplains, usually by prevailing westerly winds (Cowie, 1964a; Raeside, 1964). The dust was largely produced by cold climate processes (e.g., freeze and thaw and perhaps glacial grinding) in mountain areas (McCraw, 1975), and by river abrasion, comminution, and fluvial sorting (e.g., Palmer et al.,

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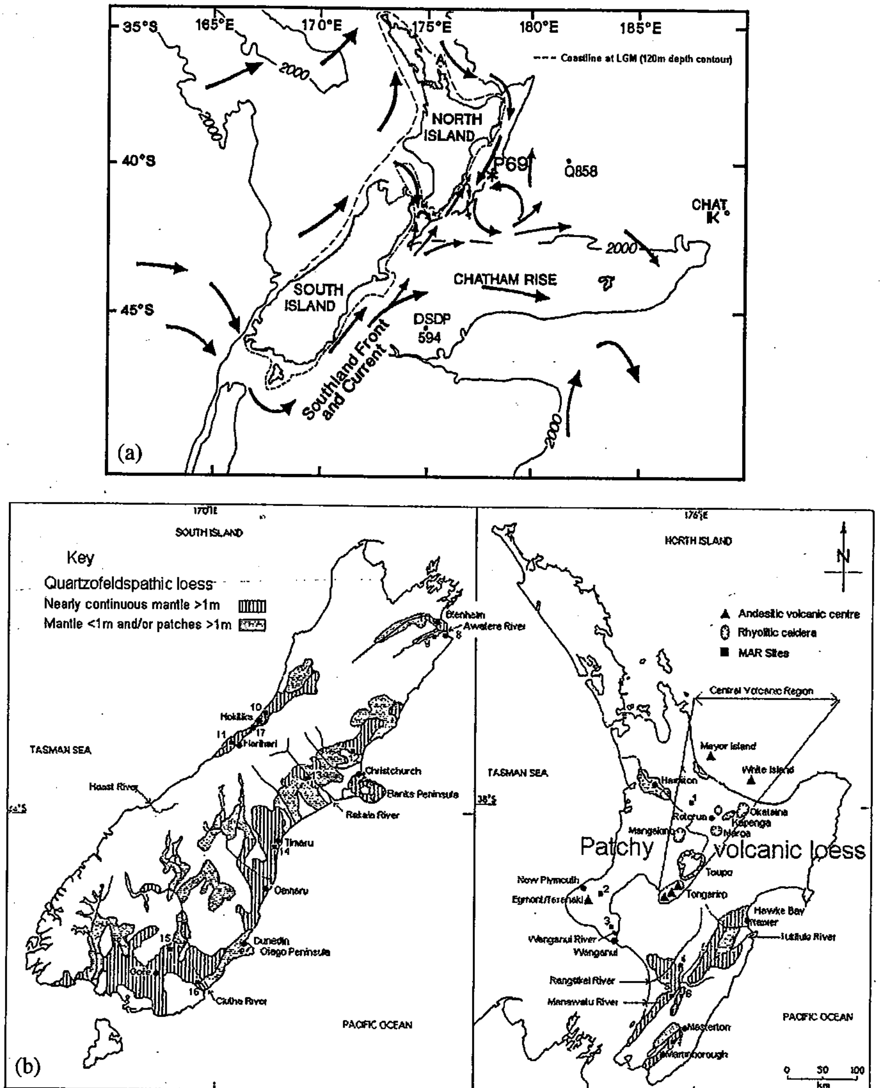
doi:10.1016/S0277-3791(03)00168-9



Key to onshore MAR sites (numbered):

1 Tapapa	6 Pahiatua	11 Saltwater Forest	16 Romahapa
2 Waitui	7 Bidwill Hill & Riverside	12 Cust	17 Blue Spur
3 Rangitatau East	8 Muritai	13 Barrhill	
4 Kimbolton	9 Marfell Downs	14 Darling	
5 Aokautere	10 The Lamplough	15 Stewarts Claim	

Fig. 1. Site maps showing. (a) LGM coastline and offshore MAR sites (P69, CHAT 1 K, Q858, DSDP 594) and (b) onshore MAR sites (numbered), distribution of loess deposits, major rivers, and volcanic centres (modified after McCraw, 1975; Nelson et al., 2000).

1989). It has been described as mountain loess by Smalley (1978).

In the North Island there are aeolian deposits formed from the reworking of tephra deposits by wind (Pullar, 1967; Pullar and Birrell, 1973; Pullar and Pollok, 1973). These are known as volcanic or tephric loess and are best developed in central North Island close to the source volcanoes (Stewart et al., 1977; Alloway et al., 1988; Benny et al., 1988). We will refer to loess that is dominantly of volcanic provenance as volcanic loess. It thickens with increasing distance from volcanic sources and it lacks the graded bedding of tephras. In addition, small amounts of dust from Australia (desert loess) have been deposited on New Zealand landscapes (Windom, 1969).

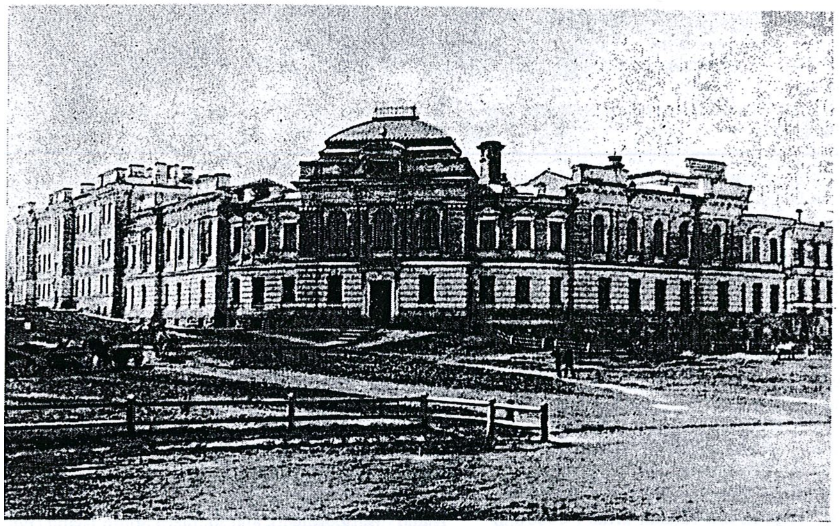
Loess profile morphology (loess facies) in New Zealand is variable in response to rainfall, drainage conditions, and parent materials. New Zealand loess is non-calcareous except in low rainfall areas (<900 mm annual rainfall) such as Banks Peninsula, near Christchurch, coastal Marlborough, near Blenheim, and eastern Hawke's Bay, e.g., Crownthorpe, near Hastings. In the drier areas (<900 mm annual rainfall) of the eastern South Island and southern and eastern North Island, layering is clearly recognizable in loess exposures that have been subject to weathering. Here pale yellowish, prismatic, compact layers which stand out in section are separated by mottled, softer, more weathered horizons representing palaeosols (Raeside, 1964). In higher rainfall areas (>900 mm annual rainfall), loess is browner, jointing is less noticeable and layers are less compact (Bruce, 1996). In the central North Island, where additions of andesitic tephra rich in ferromagnesian minerals are a significant component, palaeosols are more distinctive, having a chocolate brown colour and strongly developed blocky soil structure. These contrast with lighter yellowish brown loess that may consist of non-volcanic minerals (quartz and feldspar), with a weak structure (Pillans, 1988). The loess facies that differs most from classic loess occurs on the South Island's West Coast where annual rainfall exceeds 2500 mm. These deposits are generally <1 m thick, are light grey to grey, massive, structureless, and saturated with water for most of the year (Mew et al., 1988a, b). Some layers have humic horizons and are peaty (Hammond et al., 1991; Almond, 1996).

Loess was first recognized on Banks Peninsula, near Christchurch (Fig. 1) more than a century ago by von Haast (1878) and shortly after in the Timaru district (Hardcastle, 1889) (see Smalley and Davin, 1980), but it was some 80 yr later before serious attempts were made to describe these deposits. An extensive soil mapping programme throughout New Zealand during the 1960s and 1970s resulted in maps showing the distribution of loess deposits throughout the country at a scale of 1:1,000,000 (Bruce et al., 1973; Cowie and Milne, 1973). In addition, the Ninth INQUA Congress, held in Christchurch in 1973, was a catalyst for many regional loess studies from the southern South Island to the central North Island. Publications associated with this congress include "Quaternary Studies" (Suggate and Cresswell (1975), published by the Royal Society of New Zealand), and a special issue (volume 16) of the New Zealand Journal of Geology and Geophysics (1973).

During the 1970s and early 1980s, loess studies by scientists from the New Zealand Soil Bureau and several universities focused upon characterizing the deposits and relating their properties to those of soils. An important benchmark was the compilation of a bibliography of all publications dealing with New Zealand loess by Smalley and Davin (1980). An international loess symposium held in New Zealand in 1987 reported major advances in the knowledge of loess deposits in western and central North Island, northeastern South Island (Marlborough), and southern South Island (Eden and Furkert, 1988). At about this time and into the 1990s, studies of southern South Island loess containing microtephras (tephra datum layers not visible to the unaided eye) (McIntosh et al., 1990; Eden et al., 1992) confirmed the suggestion of Bruce (1973a) that widespread erosion (pedosphere stripping) of loess occurred close to the start of the last Glacial maximum (LGM), indicating that the stratigraphic columns for this area are incomplete. Later, Hammond (1997) found no pre-LGM loess on some older geomorphic surfaces in Hawke's Bay (Fig. 1) and attributed its absence to pre-LGM or early LGM stripping.

In 1994, an inter-INQUA conference in Hamilton also included several papers on loess which were published as conference proceedings in Quaternary International, Volumes 34–36 (1996), edited by David Lowe. By that time, the reasonably well-dated terrestrial loess record in New Zealand had been linked to the oxygen isotope record in marine cores (Pillans, 1994a, b). This showed that the New Zealand onshore and offshore records are temporarily in synchrony with global models of late Quaternary climate change and landscape stability/instability, for example, the orbitally tuned SPECMAP chronology (Martinson et al., 1987). Studies of quartzofeldspathic and volcanic loess by Horrocks (2000) in the Kauroa sequence in the Western Waikato region, found deposits dating back to around 1.7 Ma that are the oldest in New Zealand.

During the mid to late 1990s the momentum of loess research in New Zealand slackened due to the restructuring of science in the country, and to a change in the focus of Quaternary studies. Loess appears to have become less important per se, although it retained its significance in palaeoenvironmental studies, e.g., Quaternary climate change, because of its association with periods of cold climate conditions. In addition, loess often contains tephra layers or volcanic glass that can be



Горное отделение Томского института. 1905 год.

Обручев в своем кабинете в горном отделении в 1906—1911 годах.

PROVENANCE AND AGE OF LOESS ON LONG ISLAND, NY, USA

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Loess ubiquitously overlies Late Wisconsinan glacial sediments on Long Island and is a major reason Long Island's soils have been so productive. The provenance of the loess was studied using single grain $^{40}Ar/^{39}Ar$ biotite and muscovite ages from two localities along the North Shore of Long Island: Caumsett State Park and the Stony Brook University campus (Zhong, 2002). Muscovite from Caumsett State Park loess has Ar/Ar ages ranging from 200-400 Ma consistent with its source being basement rocks to the north in Connecticut. Biotite in loess from Caumsett State Park did not give reliable ages.

Muscovite Ar/Ar ages from loess on the Stony Brook University campus are similar to those at Caumsett State Park. Biotite Ar/Ar ages of loess on Stony Brook campus also have a mode between 200 and 400 Ma consistent with their source being the basement rocks to the north in Connecticut. However, there are a small number of Ar/Ar ages for biotite that are up to 1800 Ma suggesting that a small proportion of the loess has sources to the west in the mid continent.

Optically Stimulated Luminescence (OSL) ages for a 2.7 m thick loess deposit at Wildwood State Park on the North Shore of Long Island are 13,780 ± 1,100 years for the bottom of the deposit, 13, 400 ± 1,250 years for the middle and 7,730 ± 690 years for just below the soil line. These data are consistent with the hypothesis that the immediate source of Long Island loess is glacial sediment deposited in glacial Lake Connecticut in Long Island Sound basement. The deposition of loess would have started when the proglacial Lake Connecticut drained and its bottom was exposed at about 15 ka (Lewis and Stone, 1991). The deposition ceased when the sea entered the Long island Sound basin at about 12 ka (Lewis and Stone, 1991) and its bottom was no longer exposed. The *ca* 8 ka age corresponds well to the Holocene cooling episode known as the 8.2 ka event (Dean et al., 2002; Yu and Wright, 2001). At that time a drier and colder climate might have been responsible for loess deposition on Long Island.

PERIODICITIES IN LOESS-PALEOSOL SEQUENCE OF CHINA

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Periodicity in Chinese loess-paleosol sequence has long-time been investigated. However, there are many drawbacks in the previous works so that the conclusions are still controversial and the interpretation is equivocal. In this study, two typical loess-paleosol sequences (148 m and 191 m in thickness, respectively) in the Loess Plateau are sampled and total 2872 samples are measured in order to reconstruct the palaeoclimatic changes during the past three million years. On the basis of the new and sensitive proxy indicator of paleoclimate and the newly developed independent (orbitally-untuned) time scale, time series of the dust storm variations, which is highly related to the paleoenvironmental system changes, is obtained. By wavelet transfer and power spectrum analyses, the results show that there are approximately 400, 200, 100, 66, 57, 41, 31, 27 and 22 kyr cycles in the loess record. The orbital cycles are weak and are not completely presented in the new time series; there are also non-orbital cycles. Because the eccentricity frequencies of the solar irradiance of the approximately 400-kyr and 100-kyr are preserved in these sequences, the missing of 41-kyr-obliquity and 22-kyr-precession cycles in part of the time series may be explained by lower time-resolution of the loess-paleosol deposit. The presentation of the non-orbital cycles may be explained by the unstable depositional process of the dust and pedogenic process in the paleosol units, which misrepresents or obliterates imprint of the solar irradiance frequency. This conclusion may imply that it should be cautious when investigate the specific paleoenvironmental changes recorded in the loess, especially in the paleosol units.

ITALIA 2004

XXXII GEOLOGORUM CONVENTUS · FLORENTIAE · 20 04 · ITALIA · MENTE ET MALLEO

Loess Letter LL51 April 2004
Published by School of Property & Construction
Nottingham Trent Univ., Nottingham NG1 4BU, UK

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