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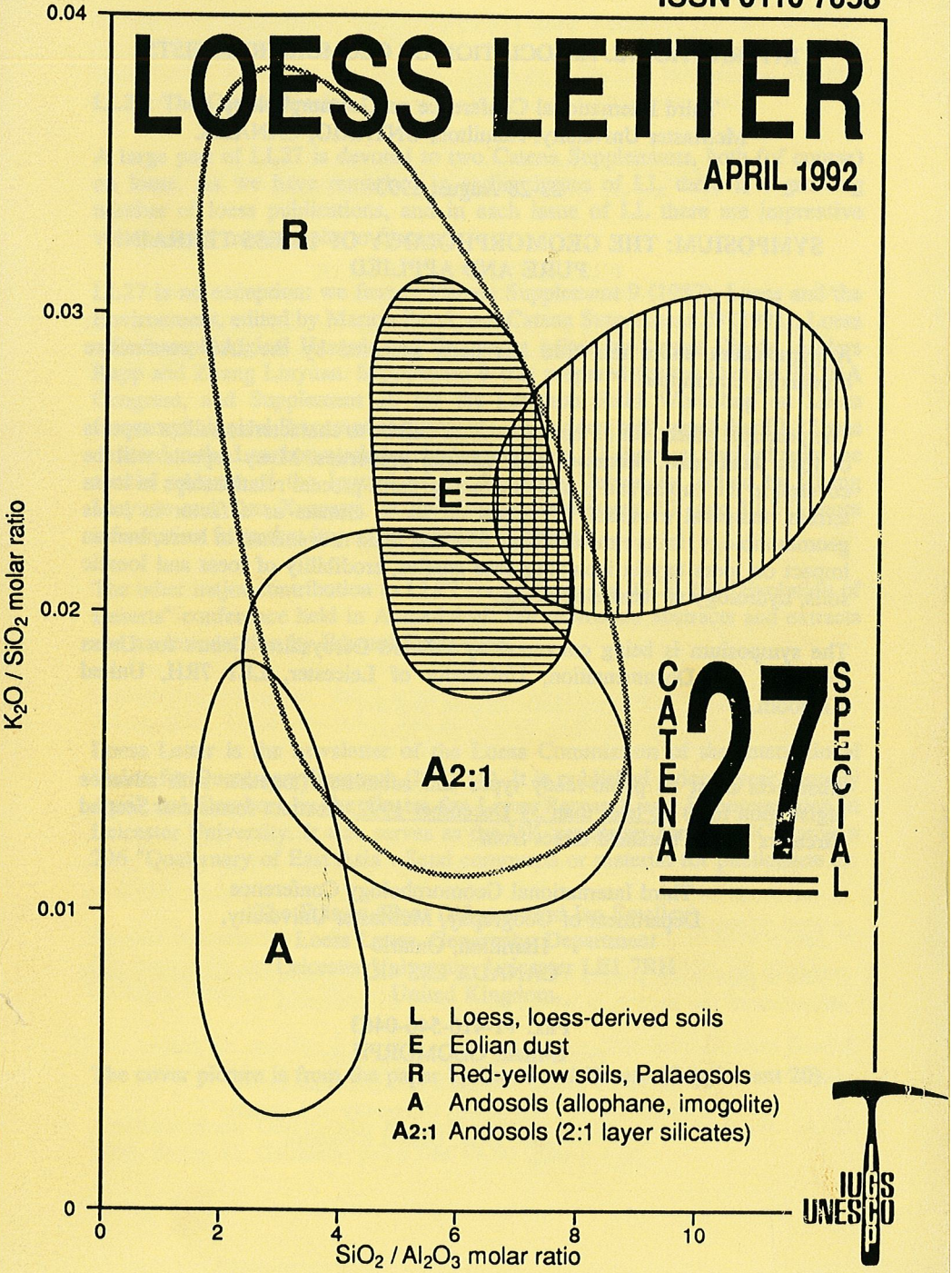
LOESS LETTER

APRIL 1992



CATENA 27 SPECIAL

IUGS UNESCO

INTERNATIONAL ASSOCIATION OF GEOMORPHOLOGISTS

Third International Conference on Geomorphology
McMaster University, Hamilton, ONTARIO, CANADA.

23-28 August 1993

SYMPOSIUM: THE GEOMORPHOLOGY OF LOESS TERRAIN: PURE AND APPLIED

A symposium under this title has been accepted by the IAG conference organising committee.

The principal objectives of the symposium will be to characterize salient aspects of loess landforms, processes and material properties. Many aspects will be covered in the papers and posters including: form-process relationships in loess terrain, temporal evolution of slopes on loess, climate as a factor in loess geomorphology, failure mechanisms in loess, mass movements in loess, human impact on loess terrain including case studies, erodibility of loess and loessic soils, hydrology of loess slopes, etc.

The symposium is being convened by Edward Derbyshire, Centre for Loess Research and Documentation, University of Leicester, LE1 7RH, United Kingdom.

Abstracts must be photo-ready types and submitted (together with advance registration fees) no later than 31 December 1992. Abstract forms and Second Circulars can be obtained direct from

Third International Geomorphology Conference
Department of Geography, McMaster University,
Hamilton, Ontario
CANADA L8S 4KI

Fax: +1-416-546-0463
E-mail: GEOMORPH

LL27: The Catena special.

A large part of LL27 is devoted to two Catena Supplements, both (of course) on loess. As we have remarked in earlier issues of LL there is a growing number of loess publications, and in each issue of LL there are impressive volumes and monographs to feature.

LL27 is no exception: we feature Catena Supplement 9 (1987), Loess and the Environment, edited by Marton Pecsi, and Catena Supplement 20 (1991), Loess - Geomorphological Hazards and Processes, edited by Setsuo Okuda, Anders Rapp and Zhang Linyuan. Supplement 9 was prepared for the Ottawa INQUA Congress, and Supplement 20 for the Lanzhou Field Workshop on Loess Geomorphological Processes and Hazards. LL readers will recall that LL22 was devoted to the Lanzhou workshop and reproduced 17 abstracts derived from the special volume of the Journal of the Lanzhou University, edited by Zhang Linyuan and Dau Xuerong. In the Catena Supplement 20 (and LL27) more information from that important meeting is given.

The other major contribution to LL27 comes from the IGCP 252 "Evolution of Deserts" conference held in Ahmedabad. We reproduce abstracts and extracts and an introduction by Edward Derbyshire.

Loess Letter is the newsletter of the Loess Commission of the International Union for Quaternary Research (INQUA). It is published twice a year (usually April and October) by the Centre for Loess Research and Documentation at Leicester University. It also serves as the UK newsletter for the IGCP project 296 "Quaternary of East Asia". Send comments or material for publication to:

The Editors (Tom Dijkstra ansd Ian Smalley)
Loess Letter, Geography Department
Leicester University, Leicester LE1 7RH
United Kingdom.

The cover picture is from the paper by Inoue and Naruse (Supplement 20).

LOESS IN THE QUATERNARY RECORD

London, January 1994

A conference jointly organised by
the International Union for Quaternary Research
and the Quaternary Research Association.

PRELIMINARY CIRCULAR

This conference is designed to provide a forum for the evaluation of loess and related silts as recorders of environments and environmental change during Quaternary time.

It will be of interest to members of several INQUA commissions (e.g. Loess, Palaeopedology, Glacial Deposits, Stratigraphy, etc.) some of which are expected to play an active role in formulating the programme.

Contributions are invited under six broad headings as follows:

- origin of silt particles,
- loess sediemntology,
- loess stratigraphy,
- dating of loess,
- weathering and pedogenesis in silts, and the
- geomechanical behaviour of silts and loess.

Invited speakers will provide keynote talks for each section.
The conference will last for three days and wil be held at Royal Holloway and Bedford New College (University of London) at Egham, United Kingdom. Over 30 papers (20 + 5 minutes) wil be presented and there will be ample poster space. Plans are already in hand to publish the collection of papers, following normal refereeing procedures.

Offers of papers and posters are now INVITED. These should be sent, with a clear indication of the section in which they are to be presented, to:

Professor Edward Derbyshire
Centre for Loess Research and Documentation
Department of Geography, University of Leicester
Leicester LE1 7RH, United Kingdom.

Attention is also drawn to the meeting being organised by the INQUA commissions on Loess and Tephrachronology to be held in New Zealand immediately following the Egham conference. Further information on this meeting can be obtained by writing to the LOESS LETTER secretariat.

THE TAKLAMAKAN DESERT AND ITS PERIPHERY

Edward Derbyshire

The name Taklamakan conjures up shades of great explorers including Sven Hedin and Aurel Stein and mental pictures of a vast and, for most of us, an unattainable region in the heart of High Asia. It is thus of particular interest that *Die Erde* has published a two volume special issue reporting the results of the 1986 Sino-German Kunlun Shan-Taklamakan Expedition. The first volume contains 200 pages of text, photographs and figures, and volume two is made up of four original and very beautiful maps in full colour.

The text is written by several scientists but the publication as a whole has been carefully edited by Dr. Dieter Jäkel of the Free University of Berlin and Dr. Zhu Zhenda, Director of the Desert Research Institute of Academia Sinica in Lanzhou, China. The text chapters are in English with introductory chapters in both the English and German languages. They cover topics such as ecology and geomorphology from Lanzhou to Hotan, glacial and periglacial features in the Kunlun Mountains, Quaternary geomorphological features of the Kunlun-Taklamakan transition, the Keriya dunes, aeolian landforms of the central Taklamakan, Tokai vegetation and ecological degradation, drift sand activity, changing climates of the Taklamakan, water resources of the Keriya River valley in the historical period, dating of groundwaters, and Quaternary dune field evolution. There are also some interesting observations on Pleistocene ice limits. The text is full of information derived not only from field work but from the remarkalble written archives of China, and includes a map of the Keriya River crossing the Taklamakan about 2000 years ago.

Anyone concerned with fluctuating desert margins will want to have a copy of this beautifully produced piece of work which is excellent value for money. Ordering details are as follows.

> Jäkel, D. and Zhu Z.D. 1991. Reports on the 1986 Sino-German Kunlun Shan-Taklimakan Expedition. *Die Erde*, Ergänzungsheft 66, 2 volumes.

Available from: Gesellschaft für Erdkunde zu Berlin, Arno_Holz-Str. 14, D-1000, Berlin 41, Germany, price DM 69.80 (plus p + p).

CATENA SUPPLEMENT 9

LOESS AND ENVIRONMENT

MÁRTON PÉCSI (Editor):

CATENA SUPPLEMENT 9 p.1–10 Braunschweig 1987

FABRIC AND OTHER PHYSICO-MECHANICAL PROPERTIES OF LOESS IN SHAANXI PROVINCE, CHINA

WANG Yongyan, LIN Zaiguan, LEI Xiangyi
& WANG Shujie Xian, Shaanxi

SUMMARY

Under the scanning electron microscope, the microfabric of loess in China may be divided into 3 fabric groups and subdivided into 6 fabric types, i.e.:

1. Supporting-mosaic fabric group

1.1 Supporting-macropore fabric and

1.2 Mosaic-micropore fabric;

2. Semicementation group

2.3 Supporting macropore semi-cementation fabric and

2.4 Mosaic-micropore semi-cementation fabric;

3. Cementation fabric group

3.5 Flocculent cementation fabric and

3.6 Coagulum cementation fabric.

Loess with different fabric has different physico-mechanical properties. The supporting-mosaic fabric group is the main group in loesses L_1 and L_2 with higher values for such main indices of physico-mechanical properties as void ratio (e), coefficient of collapsibility (δ_s) and coefficient of self-weight collapsibility (δ_{zs}), and lower values for natural bulk density (γ), preconsolidation pressure in the natural state (P_c) and preconsolidation pressure in the saturated state (P_{cw}), revealing the fact that the uppermost loess strata are intensely prone to subsidence. The loess strata in the lower parts of the profile are mostly of the cementation group with physico-mechanical properties quite different from those in the younger loess, i.e. e, δ_s, and δ_{zs} are much smaller, while P_c and P_{cw} are much higher. Such loess soils are not prone to subsidence. The semicementation fabric group is transitional between the above-mentioned two and its physico-mechanical properties are intermediate in magnitude.

Based on what has been said it is considered that the study of microfabric may provide a useful approach to correlating and evaluating the general, the physico-mechanical properties of soils in the vast loess regions of China.

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CATENA SUPPLEMENT 9 p.11–25 Braunschweig 1987

LOESS ET GEOTECHNIQUE: l'exemple des limons de Normandie

J.P. **Lautridou**, Caen
M. **Masson**, Aix-en-Provence
R. **Voiment**, Rouen

SUMMARY

Close cooperation between geomorphologists and a geotechnical team has facilitated highway location and design. Knowledge of stratigraphy, geomorphology and sedimentology has been important in predicting the location of adverse geotechnical conditions during the construction of the motorway in Normandy.

Soil moisture was found to be strongly influenced by difference within the loess sequence, clay content, soil and discontinuities. In particular it was found that the attitude of loamy layers within the loess and their truncation at an periglacial glacis, on the sides of loessic hills, contributed to the high water contents of the loams, the movement of water being blocked between recent clay soils at the surface and argillaceous loams of the Early Weichselian below. As a result of it it was possible to avoid excavations or choose alternative methods in high moisture content loess deposits and to define a method of study useful for highway location.

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1 INTRODUCTION

Les études concernant le comportement géotechnique des limons sont relativement rares en France. Pourtant les loess couvrent une surface importante de la France septentrionale particulièrement dans l'Ouest, la Normandie, le Nord, le Bassin Parisien et l'Alsace. L'épaisseur des limons d'origine éolienne dépasse parfois 8 m en Alsace, dans le Nord et en Haute-Normandie (LAUTRIDOU 1985, SOMME 1977). Cependant l'origine commune de ces silts (apports eoliens de période froide), qui est responsable d'un certain type bien connu de granulométrie (dominante de la fraction 10–50 micromètres) et de minéralogie (quartz majoritaire), recouvre des différences importantes au point de vue sédimentologique (LAUTRIDOU et al. 1982, LAUTRIDOU 1985) en raison de la diversité des provinces d'alimentation (LAUTRIDOU 1985): paléoestuaires de la Seine et plate-forme exondée de la Manche pour le Nord-Ouest, Mer du Nord et deltas de la Meuse et du Rhin pour le Nord de la France, vallée du Rhin pour l'Alsace, mais aussi de l'altitude des gisements, de leur éloignement des sources de limons (LAUTRIDOU 1985, LEBRET 1984, 1986) et des processus de loessification (redistribution ou lessi-

CATENA SUPPLEMENT 9 p.27–34 Braunschweig 1987

IN SITU SHEAR STRENGTH OF FRIABLE LOESS

A.J. **Lutenegger**, Potsdam, New York

SUMMARY

A frequent problem encountered in the study of the geotechnics of loess is the measurement of shear strength. High quality undisturbed samples are often difficult to obtain and therefore, laboratory tests may not be representative of field strengtn. In order to investigate the shear strength of loess, a study was conducted using the Borehole Shear Test (BST) to directly obtain the soil friction angle (ϕ) and cohesion (c) by performing tests in situ in prepared boreholes. This work was carried out over the past few years throughout the midwestern United States and along the Danube River in Bulgaria. The paper describes the test procedure and presents results from field tests. A discussion of the test results and the influence of other soil properties such as texture, water content, density and stress level is also presented. The results indicate that the BST is well suited to testing loess soils and may be the only economical alternative to use in cases of deep and shallow foundation designs and slope stability problems in loess.

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1 INTRODUCTION

A problem frequently encountered in the study of geotechnics of loess is the measurement of shear strength. All too often, difficulties arise in obtaining high quality undisturbed samples for laboratory triaxial or direct shear tests, which can lead to erroneous results. Because of the sensitivity of some loess soils, an alternative to conventional methods of measuring shear strength is desirable. One option is to conduct in situ tests. This paper describes results of Borehole Shear Tests conducted on friable loess deposits in the Mississippi River Basin throughout the midwestern U.S.A. and along the Danube River in Northern Bulgaria.

2 BOREHOLE SHEAR TEST

The Borehole Shear Test (BST) has been described in some detail by various authors, (e.g. WINELAND 1975, LUTENEGGER & HALLBERG 1981) and its use in testing loess soils has also been described (FOX et al. 1966, LOHNES & HANDY 1968, LUTENEGGER et al. 1984). Therefore, the details of the test will only briefly be presented here. The concept is a simple one and essentially involves performing a series of direct shear tests on the sides of borehole with the objective of obtaining the Mohr-Coulomb failure envelope

CATENA SUPPLEMENT 9 p.35–46 Braunschweig 1987

GEOCHEMICAL ENVIRONMENT OF LOESS IN CHINA

Wen Qizhong, Diao Guiyi & Yu Suhua, Guiyang

SUMMARY

About 340 samples of Malan loess (and related sediments) from 55 localities in the middle reaches of the Yellow River have been collected and six trace elements, Zn, Cu, Mn, Co, Ni, and Mo have been analyzed by methods of atomic absorption, spectrophotometry and polarography.

Application of the analytical data allowed to construct maps of trace element distribution in this area based on the content ranges and analytical error of every element with geological background of loess. From the maps of their distribution pattern it can be seen clearly that the all contents of trace elements increase progressively from northwest to southeast, showing a belt-like distribution. It is interesting that the trace element regions are consistent with the zones of granulometric composition of Malan loess (sandy loess - loess - clayey loess, from northwest to southeast). Further, the samples with lowest values lay at the transitional zone between loess and desert; the samples with highest values are located in the area of secondary loess and loess in Weihe Valley. Thus the distribution of trace elements in Malan loess is controlled by granulometric compositions and is closely related to the mineral constituents and to the difference of the bioclimatic conditions in loesses. These maps have an important significance for estimating agricultural utilization of loess and its influence on human health.

1 INTRODUCTION

In the middle reaches of the Yellow River loess is so well developed and so thick that it constitutes the famous Loess Plateau of China. In particular, the Malan loess is most widespread, covering an area of about 275,600 km^2 (LIU TUNGSHENG et al. 1964). Cultivated loessic soil is derived from parent loess. Evidence shows that the content of trace elements in the loess has influence on the fertility of the upper cultivated soil. Therefore, studies of the contents and distribution of trace elements in the Malan loess are not only helpful in the understanding of the compositional characteristics and environmental changes of loess, but are also of great significance for agriculture and human health.

As a result of progressing research on the geochemistry of loess and of the improvement of analytical techniques, we know something more on the contents and distribution characteristics of trace

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THE LITHOLOGY AND ORIGIN OF LOESS IN WESTERN CENTRAL EUROPE

W. **Tillmanns** & K. **Brunnacker**, Cologne

SUMMARY

Relationship exists between the granulation and calcium content of loess. The active valleys of the ice age can be identified as the main sources of loess in addition to local areas. The loess has undergone repeated redeposition, during which the calcium has been partly leached or converted to other forms.

1 INTRODUCTION

Systematic investigations concerning the formation of loess with respect to its lithology are still in their infancy. The following discussion, therefore, can only be regarded as providing some points of reference for new considerations of this remarkable sediment.

2 GRANULATION

Generally it can be said that there is a fundamental difference between the grain size frequency of typical loess and that of eolian sand (fig.1). The mean value for loess lies between 0.02 and 0.04 mm , whereas the smallest mean value for eolian sand is 0.1 mm . A grain size transition from one eolian sediment to the other with respect to grain sorting and source distance has not been determined. Coarser loess occurs solely at the "Eiserne Tor" (fig.1) and occasionally in the vicinity of the former Rhine-bed. But even this loess displays an atypical grain size frequency. Age differences also exist—at least with respect to the time of final deposition. Loess formation is usually regarded as finished with the onset of the Alleröd interstade, whereas eolian sand formation is regarded as finished with the beginning of the Holocene.

3 CARBONATE CONTENT

To a certain degree it can be shown that an increase in the carbonate content of loess is accompanied by finer granulation and poorer sorting (SCHÖNHALS 1952, BRUNNACKER 1980). In the Mainzer Basin (MENGDEN 1981) it was shown that the carbonate content of the loess is essentially dependent on the fine silt fraction, whilst a higher clay content generally coincides with a reduced carbonate content. In contrast, the clay fraction of carbonate rich mediterranean deluvial loess increases with increasing carbonate content (fig.2).

Generally speaking a certain relationship can be shown to exist between the carbonate content and the main source areas of the eolian dust, if it is assumed that the regions of dust source were

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THE ROLE OF LOESS-PALEOSOLS FORMATION IN THE STUDY OF THE REGULARITIES OF PEDOGENESIS

A.A. **Velichko** & T.D. **Morozova**, Moscow

SUMMARY

A great deal of facts have been collected concerning the evolution of factors of soil formation during the Pleistocene which included at least six natural-climatic macrocycles. The most studied among them is the Late Pleistocene macrocycle comprising the Mikulino Interglacial (warm semi-cycle) and the Valdai Ice Age (cold semi-cycle). Under the mesoscale natural fluctuations one understands to those of observed within a semi-cycle.

Paleosols formerly being the integral components of the landscapes apart from the characteristics of the epoch of their formation have inherited features which correspond to previous natural-climatic conditions as well as indications of the subsequent changes. That is why authors suggest to distinguish "synevent", "postevent" and "protoevent" processes revealed in loess-paleosols formations.

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1 INTRODUCTION

A great deal of facts have been collected until recently concerning the evolution of factors of soil formation and soils during the Pleistocene (tab.1).

The natural-climatic macroscale changes during the Pleistocene determined the transformational changes in the structure of the landscape mantle within a system involving a series of macrocycles.

A macrocycle includes two semi-cycles; one warm, completed interglacial and one completed, cold (glacial) epoch. Sharp differences of heat and moisture supply during semi-cycles determined different courses and intensity of soil formation, structure of zonality, (zonality, hyperzonality), brought about differences in evidences of correlation between soil formation and sedimentation.

There were at least six natural-climatic macrocycles during the Pleistocene. It is characteristic that the total duration of warm semi-cycles (of interglacial stages) had exceeded by two-to-three times the duration of cold stages (glacial). The direction however of the interglacial pedogenesis was normally changing from subtropical in the early Pleistocene to temperate interglacial in the Late Pleistocene

CATENA SUPPLEMENT 9 p.67–80 Braunschweig 1987

STRATIGRAPHY OF EUROPEAN LOESSES OF SAALIAN AGE: WAS THE INTER-SAALIAN A WARM INTERSTADIAL OR A COLD INTERGLACIAL?

H. **Maruszczak**, Lublin

SUMMARY

The older loesses of Europe, deposited in the interval from 310–300 to 140–130 ka BP, are correlated with the Saale glaciation and with oxygen-isotope 8 to 6 stages in deep-sea sediments. In numerous European sections, the older loesses contain well developed paleosols: brown forest and leched brown forest soils, forest-steppe leached chernozems, and meadow gleyed soils. In some sections (Achenheim (France), Kärlich (West Germany), Bilzingsleben (East Germany), Paks (Hungary), Nové Mesto (Czechoslovakia), Odonów, Łopatki, Nieledew, Orzechowce (Poland) and Korszów (Ukr. S.S.R.)) these soils were dated directly or indirectly by K/Ar, Th/U, or thermoluminescence method. Most of these dates show that the paleosols developed about 230–220 ka BP, corresponding with the oxygen-isotope stage 7 (either 7a or 7c, depending upon subdivision of stage 7, into three or five parts). Paleogeographic analysis indicates that during the climatic optimums when these paleosols developed, the central European lowlands and uplands lay within a southern subzone of boreal forest. If this interval is considered to be an interglacial (correlative with the Treene Warmzeit, Kärlicher Interglazial, Lublinian, and Odintsovian), then its paleopedology shows that it was quite cool. From a paleobotanic point of view, it does not seem to represent a typical interglacial, but rather a warm interstadial.

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1 INTRODUCTION

Loesses of the last glaciation (Würm → Weichselian = Vistulian age) are the most common in Europe and their chronostratigraphy is best known. It is generally assumed that the layers of these young loesses have been studied so that they can be correlated without any greater difficulties with the successive phases of the last glacial cycle.

However, in the case of older loesses, i.e. Riss → Saalian there are more difficulties, but also more possibilities of their various interpretation. They are less distributed and usually hidden under the young loesses and usually weathered. Even there where they have been best studied, their particular layers are

CATENA SUPPLEMENT 9 p.81–94 Braunschweig 1987

THERMOLUMINESCENCE STRATIGRAPHY OF THE LOESS IN THE SOUTHERN RHINEGRABEN

J. **Buraczynski**, J. **Butrym**, Lublin

SUMMARY

The study of loesses provides a number of data for regional stratigraphy. In loess sediments there have been fairly well recorded the conditions of the development of the loess cover and they can be compared with the deep-sea record. In this study we have carried through a detailed correlation of the development of loesses and soils with climatic conditions over the past 250,000 years. The stratigraphy of the Southern Rhinegraben loess was elaborated on the basis of the loess's lithostratigraphic differentiation and its thermoluminescences (TL) dating, in correlation with the main climatic cycles of the northern Atlantic Ocean (RUDDIMAN & McINTYRE 1976).

1 INTRODUCTION

Almost for one hundred years the studies on Alsace loesses were limited mainly to the Achenheim and Hangenbieten profiles (ANDREA 1884, SCHUMACHER 1900, 1914, WERNERT 1957, RASSAI 1971). Recently they concern also other Alsace and Baden profiles. In the literature there are data concerning the chronostratigraphic studies of the Alsace and Baden loess profiles. The detailed investigations were conducted on the basis of the soil typology and lithology (BLANCK & WACQUANT 1971, BURACZYNSKI 1979, 1982, FOUQUOIRE 1978, GEISSERT 1972, HEIM et al. 1982, KHODARY-EISSA 1968). The archaeological studies (THEVENIN 1973, 1976) as well as faunistical and malacological (PUISSEGUR 1978) investigations enabled the determination of ecological and climatic conditions of the loess accumulation periods and soil development. The Achenheim profile is a typical sequence, important for loess stratigraphy of Central and Western Europe.

The loess occur in two zones on the edges of the Rhinegraben. On the western side the loess area extends along the Vosges mountains as a several kilometers wide zone. On the eastern side, along Schwarzwald, it has a width of a few kilometers. Both zones join each other on the south generating one loess sheet on the Sundgau upland (fig.1). The loess appear on the uplands, terraces, sub-Vosgesian and sub-Schwarzwald hills as well. On the high terraces and uplands the loess reaches 20 to 30 m in thickness (Achenheim, Bötzingen, Niederbetschdorf). On the contrary, on the

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CATENA SUPPLEMENT 9 p.95–102 Braunschweig 1987

PALEOSOL STRATOTYPES IN THE UPPER PLEISTOCENE LOESS AT BASAHARC, HUNGARY

M. **Pécsi** and Gy. **Hahn**, Budapest

SUMMARY

In Hungary the most widespread loess formation is the young loess, which probably developed during the last glacial stages. In several sections almost complete sequences can be studied. The 20–25 cm thick young loess is represented in sections most suitable even in Eurasian comparison for subdivision. Among them some type localities with nearly identical sequences have been investigated (Basaharc, Dunaujváros, Mende, Tápiósüly etc.). In the young loess series of Basaharc type locality two stratotype paleosols occur ("Basaharc Double" = BD_1, BD_2, and "Basaharc A" complexes) representing two marker horizons in the lower and middle part of young loess in Hungary. According to the lithogenetic and paleoecological analyses and comparison of young loess profiles, we can identify these stratotype paleosols in several loess exposures. The "Basaharc Double" paleosol complex is a chernozem-like double forest-steppe soil horizon, its estimated age is ca. 40–45 ka. The "Basaharc Lower" paleosol is a remarkably well-developed chernozem-like forest steppe soil. In the BD and BA paleosols charcoal fragments of *Quercus cf. robur* and *Pinus cf. silvestris* occur.

1 INTRODUCTION

In the last decades several Hungarian loess localities (fig.1) have been studied and their lithostratigraphic sequences were collected. Two loess profiles at Mende and at Basaharc proved to be the most typical ones. The most complete sequence of the stratigraphic series known as the **young loess** is present in the Mende Brickyard (PECSI et al. 1979). The loess profile of young loess in the Basaharc Brickyard near the town Esztergom is fairly complete. Two paleosols of the Basaharc type locality; the "Basaharc Double" soil complex (BD) and the "Basaharc Lower" (BA) soil have been interpreted as **significant stratotypes** of paleosols in the Hungarian series of young loess. The BD_1, BD_2 and BA paleosols are subdivided the middle and lower part of young loess. The "Mende Upper" (MF) soil complex and the "Mende Base" (MB) paleosol complex are also important stratotypes in the young loess sequence. The MF paleosol separates the upper young loess from the middle and the MB paleosol boundaries separate the young loess from the old loess formation.

The Basaharc loess exposure was sev-

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CATENA SUPPLEMENT 9 p.103–115 Braunschweig 1987

THERMOLUMINESCENCE DATING OF LOESS

A.G. **Wintle**, Cambridge

SUMMARY

The application of the thermoluminescence dating methods to loess is far from routine, even though it is the best type of sediment for this technique. The methodology applied varies considerably and it is impossible to compare dates from different laboratories unless the laboratory procedures are given in detail.

For example the grain size selected for the TL measurement may be 2–8 μm, 50–56 μm or 90–100 μm, the minerals may be separated quartz or potassium feldspar, or unseparated grains, the spectral region observed may be near ultraviolet or blue, laboratory radiation doses may be given to increase the TL level or may be added after exposing the grains to light to remove their naturally acquired TL signal, the light source may be sunlight or a sunlamp with a totally different spectrum. Also, the annual radiation dose can be measured in several different ways, each with its own advantages and disadvantages. The influence of these factors is discussed in this paper as are the current limitations of the method.

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1 INTRODUCTION

Of all the dating methods applicable to Quaternary sediments, thermoluminescence (TL) has the greatest potential for aeolian sediments. However, the thermoluminescence signal from a sediment is extremely complex. This has led to the development of different laboratory techniques which in turn may give rise to different estimated ages. The approaches of individual TL laboratories may also differ since their directors may have different backgrounds-physics, geology or chemistry. In this paper I will try to cover some of these points and give examples of the discrepancies that have appeared in the literature. Although the method has been applied with varying degrees of success to a wide range of sediments, this review will only cover applications to loess and the reader is recommended to other review papers for further information (DREIMANIS et al. 1978, WINTLE & HUNTLEY 1982, SINGHVI & MEJDAHL 1985, BERGER 1986).

2 THERMO-LUMINESCENCE

In TL dating the effect of continuous exposure to radiation within a sediment since it was laid down is measured. The sources of the radiation are naturally occuring isotopes. In particular, the uranium and thorium decay chains and ^{40}K are responsible for about 95% of the ra-

CATENA SUPPLEMENT 9 p.117–128 Braunschweig 1987

NEW DATA ON THE SEDIMENTOLOGY AND MAGNETOSTRATIGRAPHY OF THE LOESSIC SILTS AT SAINT VALLIER, DROME, FRANCE

A. **Billard**, Meudon, E. **Derbyshire**, Leicester
J. **Shaw**, T. **Rolph**, Cardiff

SUMMARY

A new description, based on an excavation in 1985 of the silt and siltstone succession containing a rich mammalian fauna at Saint Vallier in the Rhône valley of southeastern France, provides sedimentary, pedological and magnetic data for this classic site.

The series comprises superposed silts including two indurated layers at depths of 2 m and 5.5 m, strongly cemented by calcite intergrowths within the silt skeleton, many of which have the appearance of calcrete.

In the scanning electron microscope, the silts show loess-like fabric features, with juxtaposition of clean, subangular grains, and it is concluded that the material originated as an aeolian silt (loess). However, some of the layers have suffered weathering and pedogenesis followed by truncation of the palaeosols. There is some evidence of reorganisation of the fabrics by mechanical reworking but no frost-induced fabrics have been recognised. A complex palaeoclimatic history of aeolian accumulation alternating with weathering and pedogenesis, these often followed by truncation, is recorded in the sequence. Detailed measurements of remanent magnetisation, using both declination and inclination, were made through the lowermost 4.5 m of the profile with scattered measurements above. Alternating field demagnetisation with limited additional measurements using thermal demagnetisation show that the whole of the measured profile has reversed magnetisation, and so all accumulation occurred in the Matuyama chron. No normally magnetised section has been detected, so an age greater than the Matuyama-Gauss boundary seems unlikely.

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1 INTRODUCTION

The silts and siltstone succession near Saint Vallier, about 50 km south of the city of Lyon in France (fig.1) lies some 225–230 m above the Rhône River on the Chambaran plateau which consists of a gravelly alluvium of Pliocene age

CATENA SUPPLEMENT 9 p.129–144 Braunschweig 1987

ETUDE COMPAREE DE LOESS PERIGLACIAIRES ET PERIDESERTIQUES: PREMIERS RESULTATS D'UN EXAMEN DES GRAINS DE QUARTZ AU MICROSCOPE ELECTRONIQUE A BALAYAGE

G. **Coudé-Gaussen**, Paris
S. **Balescu**, Bruxelles

SUMMARY

In this paper, we present preliminary results of a comparative SEM examination of quartz individual grains from both periglacial and peridesert varieties of loess, respectively from NW Europe and from S tunisia and Israel. A study of their shape and surface textures has been carried out in an attempt to

- specify the mechanisms of grain production;
- characterize the dynamics of aeolian transport;
- assess the post-depositional evolution of the grains within different climatic environments.

The grain shapes are predominantly sub-angular, deriving from granular desintegration of the rock. The surface textural features related to predepositional mechanical erosion are abundant. However, their ubiquitous occurrence does not imply unquestionable production process and origin. The surface chemical microfeatures are mainly related to moderate post-depositional alterations and are slightly more frequent on peridesert quartz grains. Some observations suggest a complex predepositional grain history. The microtextural similarity between the grains from both types of loess varieties must be emphasized. It shows that both belong to a same sedimentological group, termed "fine aeolianites".

Les loess périglaciaires déposés en ambiance froide au Pléistocène ont déjà suscité de nombreuses recherches au microscope électronique à balayage (MEB): elles ont principalement considéré l'origine des loess (fourniture glaciaire et/ou autres) et la signification génétique des carbonates constitutifs (thème des "incrustations"). Ces approches ont porté sur l'examen de la microstructure du matériel et sur l'étude des grains pris isolément (SMALLEY & CABRERA 1970, WARNKE 1971, CEGLA et al. 1971, SMAL-

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CATENA SUPPLEMENT 20

LOESS

Geomorphological Hazards and Processes

Setsuo Okuda, Anders Rapp & Zhang Linyuan (Editors)

CATENA SUPPLEMENT 20 p. 1–14 Cremlingen 1991

THE SOURCES OF LOESS MATERIAL AND THE FORMATION OF THE LOESS PLATEAU IN CHINA

Zhang Linyuan, Dai Xuerong, Shi Zhengtao
Lanzhou

Summary

A large proportion of the Quaternary silt deposits in China are eolian in origin. Deposits in the area north of the Qinling Mountains and in the middle and lower Yangtze River valley originated in the deserts of northwestern China. The source area for the silt deposits on the eastern edge of the Tibet Plateau and in Sichuan Province is the interior of the Tibet Plateau. The principal area of deposition, the Loess Plateau, is partially enclosed by upland. This topography favours subaerial deposition. The Loess Plateau is still developing at the present time.

1 Introduction

Typical loess is a soil rather than a sediment. It is formed of loessial material which is composed mainly of silt that has undergone soil-forming processes in semi-arid bioclimatic conditions (loessification or calcification). This is the precise scientific definition of loess. Loess should be distinguished in relation to its parent material — silt deposits or loessial material. The theory that loess is of alluvial origin has been put forward again in recent years and the cause of the very large eolian deposits on the Loess Plateau during the Quaternary questioned. In addition it has been suggested that the loess originated as a result of the cold climate that developed when High Asia was covered with a large ice sheet (KUHLE 1987). Further discussion of the origin of loess and the formation of the Loess Plateau is, therefore, necessary.

Based on field investigations over a number of years, and on analyses of particles in recent duststorms, this paper provides some initial information about the cause for the large quantity of Quaternary silt deposits in China, which were the parent material of the eolian loess, and for the formation of the Loess Plateau.

2 The distribution and sources of Quaternary silt deposits

During the Quaternary silt was deposited on more than 10% of the total area of China. Most of the deposits occurred in the middle Yellow River valley in an area that has become known as the Loess Plateau. In the arid inland areas the

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CATENA SUPPLEMENT 20 p. 15–24 Cremlingen 1991

SPATIAL AND TEMPORAL VARIATIONS IN SPLASH DETACHMENT: A FIELD STUDY

G. Govers, Leuven

Summary

During an observation period of 11 months, data on splash detachment were collected at 21 sites on the experimental field of Huldenberg using circular splash cups. Spatial variability of splash detachment is well related to variations in topsoil texture. Parameters describing topsoil structure gave less satisfying results, which is due to the fact that aggregate stability is rather low over the whole field. The relationship between splash detachment and texture is most significant for low-intensity rainfall. Considering the temporal evolution of splash amounts, the use of rainfall kinetic energy leads to an underestimation of splash detachment during high-intensity rainfall, while the use of rainfall intensity as a detachment factor leads to an overestimation of the detachment power of high-intensity rainfall. Better results are obtained when the product of rainfall kinetic energy and drop circumference is used or when rainfall detachment power is estimated as the 0.75 power of rainfall intensity.

1 Introduction

Soil detachment by raindrop impact is generally considered to be one of the primary sources of sediment production on interrill areas (e.g. MEYER et al. 1975, FOSTER 1982). The local redeposition of material detached by splash is also a major factor in the formation of a depositional surface crust on arable land on silty soils (BOIFFIN 1984). Splash detachment will therefore not only affect interrill erosion but will also have an influence on the extent of erosion by flowing water on crusting soils such as the loess soils of China as the degree of crusting affects runoff amounts. Because it is a basic erosion mechanism, temporal and spatial variations in splash detachment should be predictable as accurately as possible using soil and rainfall characteristics and, if necessary, taking into account variations in the soil surface state and vegetation cover. Although splash detachment is one of the water erosion processes that has been most intensively studied, there is still no general agreement on which rainfall and soil properties actually determine the amount of sediment produced.

Soil detachability has been related to a variety of soil characteristics, describing textural as well as structural soil properties. The literature is rather unani-

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CATENA SUPPLEMENT 20 p. 25–42 Cremlingen 1991

ACCUMULATION OF ASIAN LONG-RANGE EOLIAN DUST IN JAPAN AND KOREA FROM THE LATE PLEISTOCENE TO THE HOLOCENE

K. **Inoue**, Morioka, T. **Naruse**, Yashiro

Summary

Long-range, tropospheric eolian dust transported from the Asian continent has been deposited on the land in Japan and Korea and on the sea floor of the Sea of Japan and the North Pacific Ocean since the Late Pleistocene. Nonallophanic Andosols developed on Quaternary volcanic ash deposits but characterized by a predominance of fine grained quartz, kaolinite, 2:1 and 2:1:1 layer silicates and their intergrades appear to have been strongly influenced by the tropospheric eolian dust. Red-Yellow soils formed on Quaternary coral and Paleozoic limestones and basalts in Japan and Korea and the paleosols buried in paleodunes along the coast of the Sea of Japan are composed predominantly of weathered eolian dust deposits. The median particle diameters of wadi sediment samples in the Takla Makan desert ranged from 20 to 100 μm. The median particle diameters of loess in the Loess Plateau in China, loess-derived soils, eolian dust deposits, and pelagic sediments decrease steadily from the eastern part of China through Japan and Korea (3 to 20 μm) to Hawaii and the North Pacific Ocean (0.7 to 8 μm). Tropospheric eolian dust in Japan consists predominantly of fine grained quartz, kaolinite, and 2:1 and 2:1:1 layer silicates, and is characterized by high K_2O/SiO_2 and SiO_2/Al_2O_3 molar ratios. Oxygen isotope compositions ($\delta^{18}O$) of fine grained quartz (1 to 10 μm) from sample soils and eolian dust deposits in Japan, Korea and the Sea of Japan pelagic sediments ranged from +14 to +17‰, indicating that it is of Asian continental origin. The recent flux of Asian eolian dust is about 4 to 7 mm/1,000 years, compared to about 14 to 23 mm/1,000 years in the Late Pleistocene cold periods. Acids in acid rain and snow are partially neutralized by calcite contained in the long-range eolian dust. These results indicate that Asian long-range eolian dust should receive close attention in our efforts to understand the pedogenesis processes and the properties of various kinds of soils in Japan and Korea and also the transport and ultimate destination of acids in terrestrial and aquatic environments in East Asia.

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CATENA SUPPLEMENT 20 p. 43–55 Cremlingen 1991

DESERT DUST-STORMS AND LOESS DEPOSITS IN NORTH AFRICA AND SOUTH EUROPE

A. **Rapp** & T. **Nihlén**, Lund

Summary

Peridesert loess deposits in Tunisia show episodes of deposition during the Upper Pleistocene and into the Holocene periods according to datings by ^{14}C and TL methods. The contemporary dust plumes of African eolian dust over the Mediterranean are less frequent and smaller than the Afro-Atlantic dust plumes. But still the northward eolian dust transport and fallout plays a large role in soil genesis in the Mediterranean area. Several authors have like us, advocated the hypothesis mentioned, that much of the red-brown terra rossa soils and the yellow silts in the Mediterranean, have been derived from eolian sediments. The samples analyzed have a high silt content, with quartz as the predominant mineral of up to 60–70%. These and other criteria which we continue to study, agree with the eolian hypothesis. Sampling at high sites on or near late snow patches on hard limestone rocks are of particular importance in our studies.

1 Introduction

One of the major background documents of the UNCOD Conference was the "Desertification Map of the World" (UNCOD 1977). Fig. 1 of our article shows a simplified version of the map. We have added to the map arrows to show main tracks of dust storms, as they have appeared e.g. on satellite images (RAPP & NIHLÉN 1986). The main trajectory of eolian soil dust is formed by the so-called Afro-Atlantic dust plumes, which occur westwards from Africa towards the West Indies in the summer, and along a more southerly course in the northern winter.

Included in tab. 1 is the range of estimates of the Saharan dust production by PROSPERO & CARLSON (1972) and JAENICKE & SCHÜTZ (1977). Clearly, the Sahara desert seems to play an important role in the northern hemispheric dust cycle, providing about half of it. The addition of the Saharan source results in a range for the global source strength of 260 to 400×10^6 tons yr^{-1} (disregarding the uncertainty of non Saharan production) which agrees well with older estimates. Applying an uncertainty factor gives the possible range of 130 to 800×10^6 tons yr^{-1} (JUNGE 1979).

2 Monitoring of eolian dust

The mobilization of dust in and around the Sahara and its subsequent transport in the atmosphere far beyond the desert fringes has been going on for a long period of time. This has led to the depo-

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CATENA SUPPLEMENT 20 p. 57–73 Cremlingen 1991

RECENT AFRICAN DUST DEPOSITION IN WEST GERMANY — SEDIMENT CHARACTERISTICS AND CLIMATOLOGICAL ASPECTS

T. **Littmann**, Bochum

Summary

During the observation period from October 1987 to April 1989 nine deposition events of African mineral dust were recorded in Bochum, West Germany. This paper describes sedimentary characteristics of the fallout material and discusses critical climatological aspects of African dust deposition in Europe.

The sediments show median grain sizes of 2–26 μm and may be classified into groups of unimodal or bimodal grain size distribution. Comparing SYNOP-dust storm reports from North Africa immediately before the deposition events and results from the analysis of biological remains in the samples, it can be concluded that deposition material with unimodal grain size distribution and a dominance of either Sahelian or Saharan diatom species was derived from a single source in the Sahara or the Sahelian zone. On the other hand, bimodally distributed samples always show the presence of both Sahelian and Saharan diatom species which points to a recharge of Sahelian dust plumes over the Sahara. Mineralogical analysis, however, did not allow a regional differentiation of the material.

African dust deposition in Europe depends in both dust emission strength in North Africa and the frequency of tropical air mass influx into the mid-latitudes. Both factors may show significant annual deviations from their long-term seasonal average. High dust storm frequency in North Africa combined with a low intensity of the blocking west wind drift during the observation period could explain the relatively high frequency of deposition events in Europe.

1 Introduction

Long range transport of desert dust is a frequent and worldwide phenomenon. Airborne mineral particulate matter from the southwestern USA can reach the Atlantic coast (PYE 1987), loessic aerosols from Central Asia are deposited in Japan (INOUE & NARUSE 1987). Although there is little doubt that the Saharan and Sahelian zones of North Africa are one of the most efficient emission sources, their source strength is difficult to assess. As some $240 \cdot 10^6$ t yr^{-1} are deposited on the Atlantic Ocean (SCHÜTZ et al. 1981) and

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THE DEPOSITION OF EOLIAN SEDIMENTS IN LACUSTRINE AND FLUVIAL ENVIRONMENTS OF CENTRAL SINAI (EGYPT)

K. **Rögner**, München, W. **Smykatz-Kloss**, Karlsruhe

Summary

In the Central Sinai the Precambrian rocks of the crystalline basement are partly covered with fine-grained, marly sediments where recent drainage channels widen to larger basins. The yellowish to whitish loess-like sediments form terraces together with coarser materials which show to be true fluvial deposits. The carbonates of these loess-like silty sediments consist of calcite and dolomite. The dolomite is a suitable indicator for an **eolian** transport of the fine-grained material. The deposition of this "loess" under high relief conditions requires a calm sedimentary environment. This environment was provided by the existence of several sediment traps, e.g. by a sequence of natural dams at distinct and narrow places of the drainage channels. In most cases the formation of the dams could have been caused by rockslides or rockfalls initiating the damming up and creating the basins. The sediments indicate a periodic change between more fluvial, coarser horizons and more fine-grained, eolian horizons which have been accumulated under stillwater conditions. Additional results prove the partial drying out of the lakes. The fine-grained eolian sediments exhibit an age of only 1040+55 a BP.

Zusammenfassung

Im von kristallinen, präkambrischen Gesteinen aufgebauten Zentral-Sinai treten feinkörnige, mergelige Sedimente auf, die terrassenbildend den rezenten Abflußgerinnen folgen. Die Carbonate dieser lößartigen siltigen Ablagerungen bestehen neben Calcit auch aus Dolomit. Letzterer ist bei derartig jungen Sedimenten ein Hinweis auf äolische Herkunft der feinkörnigen Terrassensedimente. Die Ablagerung feinkörniger Sedimente in einem Gebirgsrelief erfordert ruhige Sedimentationsbedingungen, welche durch die Existenz verschiedener Sedimentfallen vorgegeben waren. Das Abdämmen dieser Becken kann durch verschiedene Mechanismen erklärt werden. Meistens dürften es natürliche Dämme gewesen sein, die auf Felsstürze zurückgehen. Der Sedimentaufbau zeigt häufig einen Wechsel von stärker fluvial geprägten (gröberen) und lößähnlichen (feineren) Lagen, welche unter Stillwasser-Bedingungen abgelagert wurden. Weitere Ergebnisse zeigen, daß die Sedimentationsbecken zumindest teilweise ausgetrocknet waren. Das Alter dieser äolischen Sedimente ist 1040+55 a BP.

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DEFORMATION MECHANISM OF COLLAPSIBLE LOESS IN CONSIDERATION OF THE MICROSTRUCTURE INSTABILITY

T.D. **Miao** & Z.G. **Wang**, Lanzhou

Summary

A common but serious problem in the loess region is the water-induced collapsing of soil foundations which civil engineers and soil conservation workers are much concerned with. Based on the data of the electron scanning of loess microstructure and the soil tests, the paper presents a hypothesis: the collapsing deformation of loess comes from the damage of the microstructure stability. In accordance with this, a constitutive relation for collapsible loess is developed by means of micromechanics and damage theory, where the Collapsing model of the microstructure is set up by the mathematical theory of catastrophe. This constitutive theory well describes the deformation behaviour of loess and offers a reasonable explanation of the collapse mechanism.

1 Composition and microstructure of loess

Civil engineers used to differentiate two kinds of loess: collapsible and noncollapsible (FENG & ZHENG 1982). Here we talk about loess only with the meaning of the collapsible one.

Loess is a special kind of clay soil with a three-phase system consisting of solid grains, water and air. The most solid component is the powder grains. The grains with diameter greater than 0.01 mm called "skeleton framing" take 70 percent to 75 percent of the total grain amount. Another 10 percent to 15 percent with diameter less than 0.002 mm which make the skeleton grains jointed together are called "cementing". The remainders, being of diameters between 0.002 mm and 0.01 mm, are called "stuffing", filled in the gaps framed by the larger grains. It is shown by electron scanning that loess has a porous microstructure (see photo 1). There are three kinds of voids. One is the pipe shaped void made by biological activities, which is visible to the naked eye. Another is the chink void formed by grains spacing in a jagged, interlocking pattern. The size of the chink void is smaller than that of the surrounding grains. The third one is the framed void formed by loosely accumulation of the skeleton grains. The size of these voids is much bigger than that of the forming grains. The last two kinds constitute the main part of the voids. The loess porosity is very high, usually up to 50 percent.

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TOPOGRAPHY OF SHIRASU IGNIMBRITE IN JAPAN AND ITS SIMILARITY TO THE LOESS LANDFORMS IN CHINA

S. **Yokoyama**, Kumamoto, Y. **Matsukura**, Ibaraki & T. **Suzuki**, Tokyo

Summary

The topographic characteristics of the Shirasu ignimbrite in Japan and their similarity to those of the loess landforms in China are summarized and the geotechnical properties of the Shirasu and the loess, that are responsible for this similarity, are examined.

1 Introduction

"Shirasu" are loosely-consolidated white sediments (white sand in Japanese), distributed extensively in southern Kyushu, Japan. The topography of southern Kyushu is characterized by an extensive area of plateaus formed of Shirasu, which is called Shirasu plateau. The plateaus and other topographic features formed of the Shirasu are very similar to those of the loess in the Loess Plateau in China. In this paper, the topographic characteristics of the Shirasu and their similarity to those of the loess in China are summarized and the geotechnical properties of the Shirasu and the loess responsible for the similarities are examined.

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Various kinds of white sediments of different origins, ages and sources are collectively called Shirasu. However, the Shirasu in southern Kyushu is composed mostly of the unwelded portion of the large Ito pyroclastic-flow deposit associated with the Aira caldera, which occurred about 22,000 years ago. For convenience, therefore, the term "Shirasu" is used in this paper to designate the unwelded portion only of the Ito pyroclastic-flow deposit, and the term "loess" relates to the loess in the Loess Plateau in China.

2 Shirasu ignimbrite

The distribution of the Ito pyroclastic flow deposit is shown in fig. 1. The most distant deposit has been found in a valley bottom about 90 km north of Aira caldera. Thickness of the deposit exceeds several tens of meters in many areas. The maximum thickness attains about 160 m in an area about 15 km north of the Aira caldera. In some areas, such as north and east of the Aira caldera, a welded zone of up to 50 meters in thickness has been formed in the lower part of the deposit (YOKOYAMA 1974). The total volume of the deposit has been estimated to be about 250 km^3 (ARAMAKI 1984). The unwelded portion (Shirasu) is a loosely-consolidated mixture of rhy-

CATENA SUPPLEMENT 20 p. 119–145 Cremlingen 1991

LANDSLIDES IN THE GANSU LOESS OF CHINA

E. **Derbyshire**, Leicester
Wang Jingtai, Jin Zexian, Lanzhou
A. **Billard**, Meudon, Y. **Egels**, Paris
M. **Kasser**, Paris, D.K.C. **Jones**, London
T. **Muxart**, Meudon
L. **Owen**, London

Summary

The European Community, in partnership with the Gansu Academy of Sciences, set up in 1987 a programme to map, monitor, analyse, and model the landslides of Gansu Province, China. The project integrates the work of a number of Chinese and European institutions. The Gansu Geological Hazards Research Institute is in charge of field and air-photo mapping at scales of 1:100,000, 1:35,000 and 1:10,000, statigraphical logging, climatological data, geotechnical testing, and research into historical literary sources. The European consultants are contributing work on medium and small scale landslide mapping (by IGN utilising stereoscopic SPOT imagery and finescale terrestrial photogrammetry of individual slides), geomorphological and geotechnical mapping (University of London), detailed sedimentology and shallow seismic survey (University of Leicester), clay mineralogy and thin section work (CNRS), groundwater regime and water tracing (CNRS and Leicester), and past and present land utilisation (CNRS). Mathematical modelling of individual slides near Lanzhou city, as well as the major 1983 slide at Sale Shan (mountain) in southern Gansu, will eventually provide a classification of slides based on failure mode as a guide to prediction. Key geotechnical properties in the Lanzhou loess do not vary simply as a function of depth, and there is no simple relationship between loess thickness and size and speed of failure. Major variables appear to be the morphology, and the nature and degree of weathering of the underlying bedrock. South of Lanzhou city, for example, first results suggest a correlation of large slides with relatively thin loess (less than 30 m), and shallow slides, falls and powder flows with thick loess. Both monsoonal- and earthquake-triggered slides appear to approximate to the flowslide and mudslide types.

Some first results, including maps, profiles, sedimentology, stratigraphy, geotechnics, meteorology and infiltration rates are presented as a basis for the

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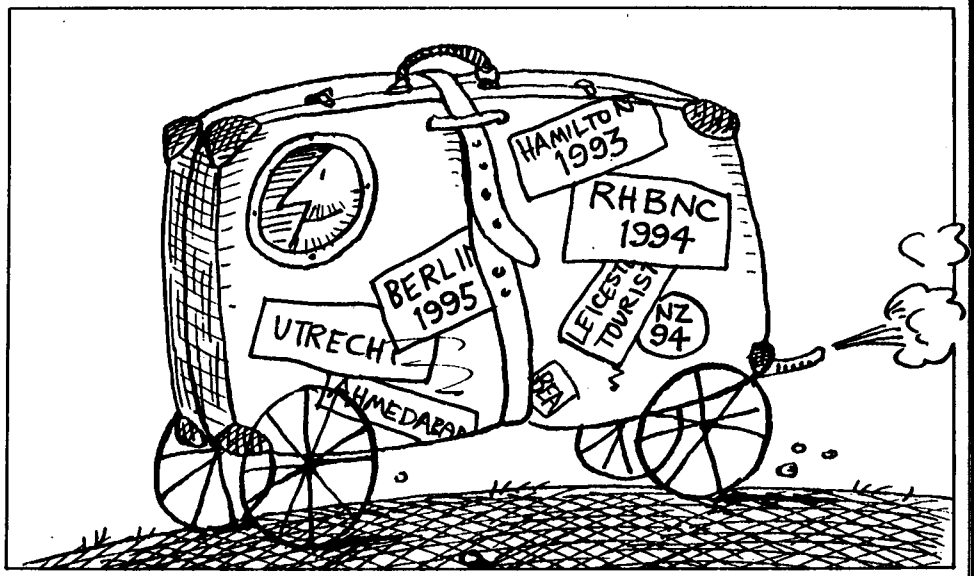
Setsuo Okuda, Anders Rapp & Zhang Linyuan (Editors): LOESS

LOESS AND DESERTS

Readers of LL will be interested to know that a recent conference on the Evolution of Deserts (IGCP 252: organised by the Physical Research Laboratory at Ahmdabad, India) contained a number of papers concerned with desert dust and loess, as well as the dating, geochronology, stratigraphy and atmospheric circulation conditions associated with their deposition. Of the 136 summaries in the Abstract volume, 19 are selected for inclusion here. Of these, 16 were presented verbally in Ahmdabad. This international symposium was followed by a field excursion to the Thar Desert: apparently there are aeolian silt deposits on its leeward (NE) side but shortage of time did not allow a visit. Nevertheless, this was an admirably conceived and run international conference and Dr. A.K. Singhvi and his colleagues at Ahmdabad must be congratulated on the conference itself and on the well produced Abstracts volume and field handbook (SINGHVI, A.K. and KAR, A. (eds) 1992. *Thar Desert in Rajasthan: Land, Man and Environment*. Geological Survey of India, 191 pp.).



ESR Dating of Desert Deposits

MOTOJI IKEYA
Department of Earth and Space Sciences, Faculty of Science,
Osaka University, Toyonaka, Osaka, 560, Japan.

Electron spin resonance (ESR) is a microwave absorption spectroscopy which can be used for dating based on the dosimetry of accumulated natural radiation. A cartoon which has been frequently used by the author to illustrate the principles of ESR dating is given below.

The First International Symposium on ESR Dating was held in the Akiyoshi-Yama-guchi limestone area in Japan in 1985 (Ikeya and Miki, 1985). The second and third International Symposium on ESR Dosimetry and Applications were held in Munchen (1988) and Washington (1991) respectively. The increasing importance of ESR in geochronology was formally recognized. when the title of the Specialist Seminar on TL dating was changed to Specialist Seminar on TL and ESR dating. Today, the ESR forms an important method in Quaternary Geochronology.

ESR dating of carbonate stalactite from the limestone cave, in Akiyoshi was followed by dating of carbonate fossils like shells and corals, paleontological and paleo-anthropological bones and teeth, silica from geological faults and volcanic materials, and desert evaporites. The details of the principle and method of ESR dating are described in several reviews and books. Some of the work done in our laboratories is listed below.

Deserts, in respect of the ESR technique has been used to date (1) $NaHCO_3$ and NaCl : ESR dating of saline lake deposits was made using drilled cores at death valley (Ikeya and Kai, 1988); (2) Gypsum or $CaSO_4.2H_2O$: ESR dating of marine gypsum (Nambi, 1982), gypsum speleothem (Ikeda et al, 1991) including gypsum from deserts have been dated. Basic studies relating to the origin of the ESR signals in such evaporites were also conducted on synthetic samples; (3) Other mineral deposits : e.g. Calcretes should also be amenable to ESR dating to exploit this new technique for desert research.

We have also investigated the possibility of producing a low cost ESR spectrometer using permanent magnets. This would make ESR dating accessible to many more geologists and archaeologist for routine applications.

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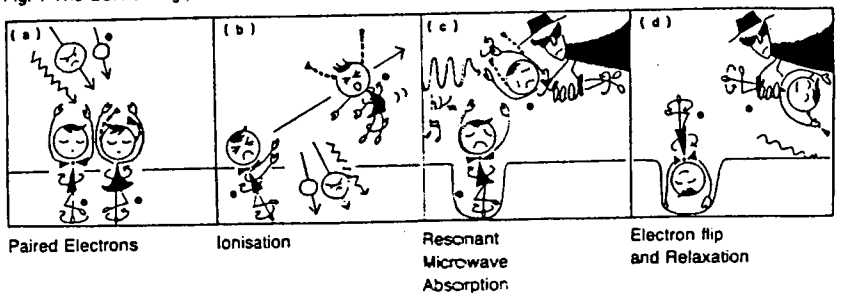
Fig. 1 The ESR dating process



Loess Chronology and Luminescence dating

LUDWIG ZOLLER
Forschungsstelle Archaometrie der Heidelberger Akademie der Wissenschaften, MPI Kernphysik, Postfach 103980, D-6900 Heidelberg.

Sensu-stricto, loess consists of aeolian dust which has undergone diagenesis in specific ecological environments. It is the widest-spread Quaternary formation on a continent. Although today minor loess sedimentation is still active in some steppe areas of the world (Inner Asia, Patagonia), thick loess layers were mainly a result of worldwide cooling and aridification. It occurs in the continental mid-latitudes which remained unglaciated during the past glaciation (Primarily Eurasia and North America, but also in South America and Australia). S_0- called desert-loess with slightly different grainsize distribution has been described from the margins of tropical/subtropical deserts such as the Sahara. Both types, normal loess and desert loess, are stratified by intercalated paleosols indicating paleoclimatic changes. Thus. loess-paleosol sequences are excellent records enabling us to study the paleoclimate and paleoecology of a site. The most complete sequences have been discovered in the Chinese loess plateau where they have reached an overall thickness of more than 300 m. By means of paleomagnetic research (polarity, susceptibility) correlations with the oxygen isotope chronology of deep sea sediments back to 2.5 Ma have been established. Loess of similar age (2.5 Ma) has also been found in Europe but the sedimentary record is not as complete as in China.

Up to now the studied loess-paleosol sequences in China have clearly reflected the major paleoclimatic cycles as predicted by Milankovich's theory. Paleoclimatic fluctuations or oscillations of shorter periods are also recorded in the middle and upper Pleistocene loess sections in regions with more frequent changes of humidity and mean seasonal or annual temperatures. Very well-stratified loess-paleosol sequences from the last interglacial-glacial cycle have been studied e.g. in Belgium, Northern France and Germany and also in Israel. There is a great need for reliable absolute dating of these sections in order to evaluate the paleoclimatic and paleoenvironmental development in continental areas and to resolve events and to correlate them with marine records. Luminescence dating methods promise great potential for dating sediments of at least the last glacial-interglacial cycle.

Thermally stimulated luminescence (TL) dating has been applied to sediments since the mid-sixties in the Soviet Union and elsewhere, but only since the end of the seventies the understanding of physical backgrounds and dosimetric problems have enabled its widespread application in the dating of windlain sediments. Nevertheless, large uncertainties still exist about appropriate techniques relating to sample processing and the "upper age limit". The talk will focus on some of the main problems such as optical bleaching, sensitivity change, stability of the signal and upper age limit. Also discussed will be dating results from European loess sections and their constraints on the regional variability of paleoclimates.

Mentioned briefly will be the newly emerging optical dating methods (laser stimulated or infrared stimulated luminescence) and their potential for dating windlain as well as other sediments.

Recent Advances in Thermoluminescence Dating of Old Eolian and Lacustrine Sediments Using Detrital Feldspar Coarse Grains

SANDA BALESCU AND MICHEL LAMOTHE
Universite du Quebec a Montreal,
Departement des Sciences de la Terra, CP 8888; SUCC. A.
Montreal (Quebec), H3C3P8, Canada

The dating of dune and lacustrine sand deposits in deserts, is of great significance in establishing the chronology of arid and humid periods of the Late Quaternary times. This chronology, however, remains uncertain beyond the range of the C-14 dating method (i.e. 30 ka).

The objective of this paper is to demonstrate that dune and lacustrine sand deposits older than 39 ka are indeed directly datable by the thermoluminescence (TL) method, using detrital feldspar coarse grains. This feldspar TL dating method has been initially tested and improved on (1) fossiliferous beach sand of known age (i.e. biostratigraphy, ESR and amino-acid dates) and (2) associated littoral dune sand, deposited along the North Sea and the mediterranean basin. It has recently been extended to littoral lacustrine sand deposits from Eastern Canada.

In this paper, we present the results of these TL investigations. Our feldspar TL dates, extending up to 300 ka, will be compared with independent TL ages obtained on (1) quartz coarse grains and (2) polymineralic fine grains.

This promising TL dating technique, applied to dune and lacustrine sand, should therefore provide challenging perspective for a better understanding of the time-space evolution of deserts over the last 300 ka.

Stratigraphy and Luminescence Geochronology of Aeolian Sediments in Northeastern Thar

K.S.RAGHAV[1], N.K.PAL[1], S.PAREEK[1]
V.S.KISHAN KUMAR[2] AND A.K.SINGHVI[2]
1. Geological Survey of India, Jaipur 302 001.
2. Physical Research Laboratory, Ahmedabad, India.

In the Eastern Thar, extensive sedimentological clay mineralogical and Scanning Electron Microscopic studies suggest three phases of aeolian accumulation that are preceded by playa/lacustrine sediments of the earliest phase (Raghav, 1991).

The aeolian sediments of the *earliest phase* are oxidized and are widely distributed in the N-E Thar. The dunes and sand sheets often show evidences of reworking by a later phase aeolian and fluvial cycles. The aeolian sediments of the *second phase* are moderately oxidized and show evidences of erosion. The transverse, longitudinal and parabolic dunes belong to this cycle and are seen in South Haryana, Delhi and Agra. The aeolian sediments of the youngest phase can be sub-divided into two categories based on sedimentological characteristics, dune forms and their spatial distribution. The first category of dunes comprises of longitudinal, transverse, parabolic and barchan dunes that are under process of accumulation, erosion and stabilization depending on the local geology and micro-climate. The second category comprises barchans, linear, star, shrub and coppice dunes. The dunes of the youngest phase are seen at Bikaner, and Churu region and occur on the top of destabilised older dunes generally bordering the course of present day river, lakes etc.

In order to understand the evolutionary chronology of these phases of aeolian accumulation. Luminescence search of aeolian sands from the region was attempted. The regeneration TL ages at aeolian phase has yielded a limit of ~1 ka. Evidence of an intense aeolian accumulation phase is seen at *Ca* 13-17 ka. Two samples at the base of the second aeolian phase have provided TL ages of *Ca* 50 ka and 100 ka.

. These results are in excellent conformity with other TL ages in the Thar (this symposium). Most important inference of this study is the reconfirmation of intense aeolian phase at ~14-15 ka (Chawla et al. 1991). The TL dates of ca 50 and 100 ka for the base of second phase, imply that the antiquity of the earliest aeolian activity should extend to 100 ka. This is also supported by TL dates from deep dune cuts at Didwana being 150 ka. Thus it is unambiguously inferred that aeolian sedimentation

in the region dates back to the early part of Late pleistocene. The presence of fossil sands dating to 15 or 50 ka in the regions which have at present only a marginal/negligible aeolian activity also leads to an inference that at present the spatial extent of the Thar is in a contracted phase.

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A 0.55 Ma Climatic Record at the Transition Region between Loess and Desert

LIU TUNGSHENG
Institute of Geology, Chinese Academy of Sciences,
Beijing 100029, China.

It has long been accepted that the loess in north-central China is transported by winds from inland deserts in northwest China and that the coherent variability of loess soil alternations to the advance and retreat of the deserts is controlled largely by global hydrological regimes during glacial-interglacial cycles. Recently, a 50 m thick loess section at Yulin, the northern margin of the Loess Plateau, is observed. At present this area is covered by semi-stabilized sand dunes with an average annual precipitation of about 400 mm. This section has the major loess-soil units comparable to the sequence from S_0 to S_5 in the classic loess sections and thus a basal age of about 0.55 Ma BP is inferred. In the loess section, eight paleo-sand dunes with grain size similar to the modern dunes and six paleosols with almost complete carbonate leaching are recognized. Spectral analysis of the magnetic susceptibility time series of the loess section and correlation of the susceptibility record to the Daoji grain size profile and the SPECMAP oxygen isotope shall lead to the conclusion that desertification, loess deposition and soil development in this area, representing large-amplitude climatic fluctuations, are forced by global climatic changes and have responded to orbital variations of the Earth, especially to 100 and 41 ka periodic cycles.

Last 20,000 Years of Climatic Change and Desertification in South Asia

D.P.AGRAWAL
Physical Research Laboratory, Ahmedabad 380009, India.

Recent evidence, especially from the Continental Asia, shows that there are marked latitudinal differences in global climatic changes. From India, we now have new evidence from Kashmir, Rajasthan and the Arabian Sea which shows that in the North (35°-40°N latitude) warming had started c. 20 ka (in Kashmir, Ladakh and Nepal) when in higher latitudes it was still the Last Glacial Maximum (LGM). At *ca.* 18 ka, the pollen spectra from Butapathri (Kashmir) bogs show an emergence of thermiphilous plants like *Alnus, Juglans, Carpinus* at the cost of conifers. A palaeosol on the loess profile of Kashmir is datable to *ca.* 18 ka which again shows climatic amelioration. Organic matter from this palaeosol gives $\delta^{13}C$ values of about -24‰ indicating that it was derived from C_3 type of vegetation. Presence of an Upper Palaeolithic culture at this time, in Kashmir, again confirms a period of climatic amelioration. Higher lake levels, from several other sites around c. 18 ka show the same trend. From Ladakh, climatic amelioration is inferred from the higher percentage of Junipers around 20 ka. Similarly in Nepal, an improvement in climate is indicated.

In Rajasthan, *ca.* 18 ka is a period of aridity. Maximum sand building activity is TL dated by Chawla et al. (1991) to *ca.* 14 ka which just precedes the strengthening of the monsoon at *ca.* 13 ka. Evidence of upwelling at *ca.* 13 ka in the Arabian Sea has been reported by Anderson et al. (1991) and the French group has shown a similar evidence of monsoon strengthening at *ca.* 13 ka based on pollen evidence from an African lake.

In Rajasthan, multiple analyses seem to show a concordant picture, based on palaeo-salinity measurements and pollen analysis. Both had indicated before *ca.* 13 ka there was considerable aridity and desiccation which did not allow any pollen to be preserved. The lakes had turned into evaporites (halites, gypsum), though Chawla et al. (1991) opine that sand building activity peaked at *ca.* 14 ka and not earlier. This was perhaps because the winds became strong only around *ca.* 14 ka, therefore despite aridity no major sand mobilization was possible before this date. The data needs to be checked from other sites.

It is, however, obvious that no major human settlements were possible in Rajasthan before *ca.* 6 ka when both annual and summer precipitation increased. The ephemeral streams became perennial. Man-environment relationship is more complex in Rajasthan than it appears to be. Neotectonic movements changed the courses of the rivers and the Sutlej joined the Indus and the palaeo-Yamuna joined

Climate of High Altitude Tropics During Last Glacial Maximum : A Puzzle

S.K.GUPTA AND P.SHARMA
Physical Research Laboratory, Ahmedabad 380009, India.

During the last few years considerable amount of new palaeoclimatic data from the tropical/sub-tropical regions of the globe has become available. We have been particularly intrigued by the data pertaining to the period of approximately 4 ka centred around LGM, about 18 ka ago. We notice that in contrast to the global picture, many of these regions show evidence of a warming event in an otherwise glacial climate at this time. We summarise the evidence and identify a mechanism for this warming event.

Oceanic evidence

Sarkar et al (1990) reported a negative spike of about 1‰ in the $\delta^{18}O$ record of a sediment core SK-20-185 from the Eastern Arabian Sea (10°N, 71°50'E) during a period of 4 ka centered around LGM. Kennett and Shackleton (1975) have also reported a negative spike of similar magnitude from two cores K-97 (26°N, 94°W) and K-139 (21°N, 95°W) in the Gulf of Mexico again at the time of LGM.

Continental evidence

(a) Dunde Ice Cap, Tibet :

Thompson et al (1989, 1990) measured several parameters namely dust content, soluble aerosol concentration, oxygen isotope ratios and ice crystal sizes on three long ice cores spanning a proxy climatic record of more than 40 ka from the Dunde ice cap (37°06'N, 96°24'E; 5325 m elevation) in the northern part of Tibetan Plateau. A pronounced warming event peaking at about 20 ka, indicated by less negative $\delta^{18}O$, decreased dust deposition and increased anion concentrations is discernible from their data.

(b) Kashmir, India

Bhattacharyya (1989) observed a prominent warming event indicated by the increased abundance of *Juniperus* pollen from the palynological record of the alpine Tsokar lake in Ladakh (32°21'N, 78°E; 4572 m elevation) during the 21-18 ka.

At Butapathri (36°06'N, 74°43'E) a distinct climatic amelioration at 18 ka B.P. was marked by partial dominance of broad leaved thermophilous elements such as *Ulmus, Alnus* and *Juglans* (Dodia et al, 1984). Further, climatic amelioration at 18±

1.5 ka is indicated by the presence of palaeosols in the loess sequences (Kusumgar et al 1986) at Dilpur (33°56'N, 74°57'E), Puthka (34°14'N, 74°21'E), Burzahom (34°10'N, 74°53'E) and Tilsar (33°52'N, 74°47'E). Krishnamurthy et al (1982) found that the palaeosol at Burzahom had an organic fraction with $\delta^{13}C$ = -25‰ which is indicative of C_3 type of plants that thrive under climatically optimum conditions. This is in contrast to the $\delta^{13}C$ = -16‰ in the layers below, which is indicative of the dominance of C_4 type of plants characteristic of arid climate. At Burzahom variations of both magnetic susceptibility (χ) and its frequency dependent component (χ_{fd}) indicated pedogenesis at 18 ka (Kusumgar et al., 1986).

Lake Level data

The Bonneville lake system (38 - 42°N, 112°-114°W, 1300 m elevation) has been shown to have two distinct lake cycles of high lake levels, 150-70 ka and 26-12 ka with a clear peak around 18 ka (Benson and Thompson, 1987a). Reconstruction of the lake level data for the lake Lahontan system (38°-42°N, 117°-120°W, 1200 m elevation) for the last 40 ka reveals that by 20 ka the lake level had risen from 1210 m to about 1265 m where it remained for 3.5 ka (Benson and Thompson, 1987b).

In Western Iran, lake Zeribar fed by snowmelt from high in Zagros had a high water level at 18 ka (Wasylikova, 1967).

Lake Mobutu Sese Seko at Zaire/Ugandan border rose from a low to high water level (Patterson et al, 1979) at 18 ka BP. The lake Manyara (04°S, 36°E), shows diatom evidence for more dilute water and raised lake level at 18 ka BP. (Holdship, 1976). Lake Abhe situated at the downstream end of the perennial Awash river, which drops from a height of 2,500 m on the Ethiopian Plateau hence recording climatic fluctuations in the Ethiopian highlands, shows a small rise in water level between 21 and 19 ka, eventually becoming dry at about 17 ka (Gasse, 1977).

Quantitative estimates of temperature and precipitation using a multivariate analysis of pollen time series from the peat deposits in Burundi (3°28'S, 29°34'E; 2240 m elevation) for the past 40 ka indicate a significant warming event of about 2°-3°C between the radiocarbon dated layers of 18.9 ka and 21.5 ka (Bonnefille, 1990).

Not all the above cited evidence has been interpreted by the respective authors in terms of warming event at LGM but we show that a few of them can, however, be interpreted to indicate anomalous warming of the tropics at high altitude at LGM.

This warming obviously needs a heat source which the changes in the earth-sun geometry (the primary cause of Quaternary glacial fluctuations) cannot provide. Among the various internal sources, changes in volcanic activity appear to be a promising candidate, because a reduction in the concentration of volcanic aerosol over a thousand year period around the time of LGM can conceivably heat up the high altitude tropical regions of the earth due to increased transparency of the

atmosphere and relatively (with respect to mid latitudes and polar regions) high amount of solar radiation received in this belt. Support for this hypothesis is provided by the volcanicity index series given by Bryson (Fig.1 in Bryson, 1989) where it is clearly seen that the volcanicity index significantly drops around the LGM. In the paper we make an attempt to assess the effectiveness of this mechanism for explaining the observed palaeoclimatic data.

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Natural Isotope Tracers of Aerosols

PIERRE E. BISCAYE
Lamont-Doherty Geological Observatory of Columbia University
Palisades, New York 10964, USA.

The distribution of desert regions on the Earth's surface is manifest in a number of ways, but in the atmosphere is seen as a greatly increased frequency of haze and/or dust. This dust constitutes the solid portion of the aerosol which can be carried around the earth by the prevailing winds. Once deposited, the aerosol represents a distant fossil record of the deflation of the source area, and of the wind patterns that carried it from source to sink.

Some places in the deep oceans are sinks where the rate of accumulation of aerosol particles is comparable to, and even greater than that of non-aeolian particles. Even there disentangling the aeolian signal is no simple task, and its distinction in continental lake sediments is even harder, due to the greater proximity of non- aeolian sources.

Loess deposits can be extremely thick, old and datable records of aerosol deposition, but the bulk of them are of the order of tens to hundreds (rather than thousands) of kilometers from their sources, and exhibit thinning away from their source areas such that neither their provenance nor the trajectories of the paleowinds that carried them are much in question. Loesses may also contain a long distance aerosol component, and may act as aerosol sources of subsequent long-range dust transport.

Continental ice caps are a relatively rare repository of aeolian dust, but they have the advantage that the particles deposited on and in them over time constitute a pure aeolian signal. Cores drilled in the continental ice caps of Antarctica and Greenland and in the smaller ice cap of the Chinese Tibetan Plateau have revealed a particulate aerosol record over tens- to hundreds of thousands of years long, in which the dust flux is variable as a function of time, and variations of which are synchronous with climate variations recorded in loess deposits and in deep-sea sediments.

Several kinds of tracers, both biological and geological, have been used to identify and trace aerosols and aerosol deposits to their points of origin. Biotracers point back to more-or-less distinctive conditions of climate that produced the environment in which the tracer grew. Geological tracers such as aerosol mineralogy can also sometimes indicate particular climate-related characteristics of the source area, but, on a global scale, these characteristics tend to be very broadly latitude dependent, and not be highly specific, e.g., kaolinite from one continent looks the same as

kaolinite from another. This is also true of the quartz in aerosols that has been used to indicate desert provenance, although some variant features have helped to make the quartz more origin-specific, such as the red *wustenquarz* of the Equatorial Atlantic, or quartz grain shapes and surface textures, or quartz grain size frequency distributions as indicative of source characteristics and/or of wind transport strength and proximity.

The addition of natural isotope ratios provides not simply another method in the analytical bag of tricks, but one that exhibits a much broader dynamic range on the earth's surface, and one with the potential for a more site-specific indicator of provenance. The isotope systems we have used with some success are the Rb-Sr and Sm- Nd systems which provide, in different lithologies at the earth's surface, variable ratios of respectively, Sr-87/Sr-86 and Nd-143/Nd- 144, which are, to a great degree, retained in the soils and other weathering products derived from the parent rocks. Because the lithologic geochemistry of the radioactive parent isotopes Rb-87 and Sm-147 is different in different rock types, the analysis of both isotope ratios on an aerosol increases by an even greater degree the possible site specificity of its provenance. Site specificity may be further enhanced by using the isotope system data to calculate a model geologic age of the aerosol, which is related. but not identical to the geologic ages of the rocks from which the aerosol was ultimately derived, thus emphasizing the differences in geochronology, rather than in lithology, of possible source areas.

Examples will be given of the use of these two isotope systems in identifying the aerosol component in deep-sea sediments, soils and in dusts from a continental ice cap.

Soil Formation Processes and Aeolian Activity In the North Eastern Margin of the Thar Desert During the Later Quaternary Period

M.A.COURTY
U.A. 723, C.N.R.S., Univ. Paris-Sud, Bat. 504,
91405 Orsay Cedex, France

This paper discusses the diversity of environmental conditions which controlled the formation of aeolian deposits during the Late Quaternary period in the North Eastern margin of the Thar desert. A classification of the various types of wind-borne sediments which occur in this region is presented based on microscopic investigations of their sedimentary and pedological characteristics. A large range of pedo-sedimentary microfacies are observed which can be subdivided into three main groups.

The first type consists of weakly pedogenized, loose very fine sands characterized by good textural and mineralogical maturity. This facies generally occurs over large regions. It typifies periods of intense aeolian activity under a drier climate than today, when wind effects were predominant over alluvial activity.

The second type consists of weakly pedogenized, loose fine sands characterized by poor mineralogical and textural maturities. These sands form massive accumulation along the banks of Himalayan rivers which were active in the studied region during the Late Quaternary period. Their formation is directly related to the dynamics of alluvial phases which maintained a high amount of source materials available for short distance wind transport. No stabilization of the flood plain could occur due to the constant shifting of the river channels. The comparison of these aeolian sands with contemporary sediments which were formed in marginal regions from the main river channels indicates that semi-arid or arid conditions may have prevailed during their accumulation.

The third group consists of moderately to well pedogenized silty sand to sandy silt which can be defined as coarse loessic sediments. Their pedological characteristics indicate that they have been formed under semi-arid conditions similar to the present ones, when the alluvial landscape remained exposed to the combined effects of large scale flooding and seasonal wind activity. This facies is characterized at a micro-regional scale by an important lateral variability in the textural and mineralogical attributes which reflect progressive changes from the source sediments due to constant recycling of the dust by wind and water.

Aeolian sediments formed in the studied region during the Late Quaternary period can have thus been accumulated under a large diversity of environmental and climatic conditions. They should not be any longer considered to be representative of arid phases.

Study on Transport and Characterization of Desert Aerosols

P.V.N. NAIR, P.V. JOSHI, Y.S. MAYYA AND K.S.V. NAMBI
Environmental Assessment Division, B.A.R.C., Bombay 400 085

Transport of radioactive and chemical pollutants in the form of aerosols in desert regions is of great significance in the Indian context. There is a need for extensive data on diffusion climatology governing dispersion, transport and deposition of particulate pollutants generated within the arid regions of western India or across the border, as well as on the characteristics of aerosols typical of the area. A programme of study consisting of measurements and modelling is proposed here with a view to a better understanding of the atmospheric environment of desert regions.

Annual global natural generation of airborne mineral dust has been estimated to be about 25% of the total aerosol production. Anthropogenic sources will contribute not only to local variations, but to changes at large distances under adverse weather conditions, as the average tropospheric lifetime of aerosols is reported to be of the order of a week. The study consisting of estimation of 1) meteorological features such as temperature and wind structure, changes in atmospheric boundary layer and intensity of turbulence which govern aerosol behaviour in the atmosphere in the desert regions and 2) physical and chemical characteristics of particulates will be very useful in assessing their environmental impact.

One aspect of desert aerosols that has not been properly understood is the kinetics of interaction of mineral dust with particulates of different origin and characteristics, introduced into the atmosphere by anthropogenic processes. While the mineral dust is predominantly in the coarse mode, pollutant particles may be finer in size and it is necessary to study the aggregation process and the consequent degree of mixing of the airborne particles. The desert region of western India provides a natural laboratory for their investigation by way of field experiments. It is necessary to carry out detailed analysis of not only the size and chemical composition of aerosols at selected locations but their spatial and temporal variations as well. Airborne radioactivity is an important tool, to be utilised as a tracer, for the work.

An experimental programme is outlined and a tentative procedure for modelling aerosol behaviour is presented. Suitable computational technique to be developed for the model and procedure for validation under specific site and weather conditions are briefly discussed.

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Environmental Assessment Division, B.A.R.C., Bombay 400 085

Transport of radioactive and chemical pollutants in the form of aerosols in desert regions is of great significance in the Indian context. There is a need for extensive data on diffusion climatology governing dispersion, transport and deposition of particulate pollutants generated within the arid regions of western India or across the border, as well as on the characteristics of aerosols typical of the area. A programme of study consisting of measurements and modelling is proposed here with a view to a better understanding of the atmospheric environment of desert regions.

Annual global natural generation of airborne mineral dust has been estimated to be about 25% of the total aerosol production. Anthropogenic sources will contribute not only to local variations, but to changes at large distances under adverse weather conditions, as the average tropospheric lifetime of aerosols is reported to be of the order of a week. The study consisting of estimation of 1) meteorological features such as temperature and wind structure, changes in atmospheric boundary layer and intensity of turbulence which govern aerosol behaviour in the atmosphere in the desert regions and 2) physical and chemical characteristics of particulates will be very useful in assessing their environmental impact.

One aspect of desert aerosols that has not been properly understood is the kinetics of interaction of mineral dust with particulates of different origin and characteristics, introduced into the atmosphere by anthropogenic processes. While the mineral dust is predominantly in the coarse mode, pollutant particles may be finer in size and it is necessary to study the aggregation process and the consequent degree of mixing of the airborne particles. The desert region of western India provides a natural laboratory for their investigation by way of field experiments. It is necessary to carry out detailed analysis of not only the size and chemical composition of aerosols at selected locations but their spatial and temporal variations as well. Airborne radioactivity is an important tool, to be utilised as a tracer, for the work.

An experimental programme is outlined and a tentative procedure for modelling aerosol behaviour is presented. Suitable computational technique to be developed for the model and procedure for validation under specific site and weather conditions are briefly discussed.

Geochronology of Paleo-monsoon Variation in the Last 130 ka in the Loess Plateau, China

LU YANCHOU, AN ZHISHENG, ZHANG JINGSHAO,
XIE JUN AND MU HANQI
Institute of Geology, State Seismological Bureau.
Beijing 100029, P.R.China

Many sections in the Loess Plateau preserve the well developed younger loess which can be divided into following sub-units in decreasing order. The recent Loess Holocene black loams (or Helutu) (S_0), the Malan Loess (L_1) including the upper layer (L_{1-1}), middle layer (L_{1-2}) characterized by strongly weathered or soil complex, and lower layer (L_{1-3}), and the first buried reddish brown paleosol (S_1). The geological and biological evidences of this loess- paleosol sequence and the historic records of dust-storm and dustfall, as well, indicate that the duet deposits transported by the northerly wind of winter monsoons and also suffered to some extent from pedogenesis caused by weakened summer monsoons, and that the paleosol accreted by the rather slow dust accumulation was closely related to strengthened summer monsoons. Alternating occurrence of loess (L_0, L_1 and L_{1-3}) and paleosol (S_0, L_{1-2} and S_1) in the sections implies the changes of cold-dry climate with relatively weakened summer monsoons and warm-humid climate with vigorous summer monsoons.

Based upon statistics of the fine grain TL dates for each subunit at seven typical sections from different geomorphic part in the Loess Plateau, a preliminary geochronology of this loess-paleosol sequence, in turn of the paleomonsoon climate variation, in the last about 130 ka was suggested.

Desert Aerosols and their Role in Atmospheric Radiative Transfer

B.H. SUBBARAYA AND A. JAYARAMAN
Physical Research Laboratory. Ahmedabad 380 009, India

Aerosol has for a long time now been recognised as an important minor constituent in the atmosphere with a potential for perturbation of the atmospheric radiation balance and impact on climate. There are both natural and manmade aerosols in the atmosphere. Manmade aerosols arise out of combustion (industrial and transportation activities) and are important mostly in localised regions of heavy urban pollution. Natural sources by far dominate the global atmospheric aerosol abundance and the sources include sea-salt spray, volcanic emissions, forest fires and wind blown dust. The wind blown dust is specially important in desert and arid regions, e.g. Sahara and Thar desert regions. The upper tropospheric and stratospheric aerosols which are more important from the climatic point of view are mostly due to gas to particle conversion, the sulphate aerosols from volcanic emissions providing the major contribution. The series of volcanic eruptions in recent times such as the Mt. St. Helens and the El Chichon and more recently the Pinatubo eruption in Philippines have made the role of volcanic aerosols in the atmospheric radiation balance and climate, a subject of topical research (e.g. Hofmann, 1988).

The earlier work in India in the field of Aerosols and Radiation studies has been mostly based on the Turbidity measurements from a chain of stations being maintained by the India Meteorological Department for several decades and the surface measurement of total suspended particulate matter by several groups including BARC and NEERI. One of the most significant results from the IMD turbidity measurements has been on the climatic impact of aerosols in the Rajasthan desert area (Das, 1962; Bryson, 1963). In this region the dust can produce a thick haze which can extend up to altitudes of about 10 km and the aerosols produce a net radiation divergence that results in adiabatic cooling. Severe dust storms in this area during summer months (pre-monsoon periods), popularly called "Andhi" are associated with a repeated recycling of the dust laden air in the lower regions of the atmosphere (Mukherjee and Basu, 1982). The Indian Institute of Tropical Meteorology, Pune has an ongoing programme of aerosol sample collection by an Anderson sampler and laboratory analysis of the collected samples for size distribution and chemical composition (Khemani et al., 1982). One of the major results from their study has been an identification that in most parts of the Indian region the aerosols are basic in nature and therefore these regions are not prone to the acid rain problem. During Monex - 1979, NASA research aircraft was flown over Saudi Arabia, Arabian sea and the Indian ocean during the summer monsoon period. Persistent haze layers extending up to 6 km were found over the entire region of South-West and South-

Central Asia during this experiment. These haze layers have a significant impact on the radiative transfer in the atmosphere and can have an effect on the regional climate and dynamics. The Monex experiment also revealed the highest aerosol concentrations in this region. A few measurements of the vertical profile of aerosol concentrations were also made in the lower troposphere during this programme.

Aerosol and Radiation studies in India received a significant boost with the formulation of the Indian Middle Atmospheric Programme in 1982. A programme of groundbased multi-wavelength/radiometric observations from a chain of stations (Prabha Nair et al., 1988) and a programme of measurement of the vertical distribution of the aerosol optical depth and size distribution up to altitudes of about 30 km using rocket and balloonborne suntracking and scanning multichannel radiometers (Acharya et al., 1985) were initiated. A number of rocket and balloonborne measurements were made from Thumba and Hyderabad respectively during IMAP (1982-85) and IMAP-C (1986- 89) periods. These measurements have yielded some very significant and new results on the characteristics of the aerosols in the troposphere and stratosphere over the tropics (Subbaraya and Jayaraman, 1982; Jayaraman and Subbaraya, 1987; 1988). Some of the main results are: the aerosol size distribution function is altitude dependent and there exists a layer of aerosols characterised by a relatively larger number of bigger particles in the altitude region 20 to 25 km. These are mostly sulphate aerosols formed due to gas to particle conversion mechanism from various sulphur bearing gases, such as COS, DMS, SO_2 emitted from the biosphere and volcanoes. Volcanic eruptions are found to perturb the aerosol characteristics especially at altitudes above about 10 km. However, the impact on the aerosol characteristics depends mainly on the geographic location and the magnitude of the eruption. After major volcanic eruptions, the stratospheric aerosol layer becomes a source of bigger particles to the tropospheric regions below, due to global transport. Above about 25 km the condensation nuclei type of particles are also believed to coagulate during transport and become the source of bigger particles over the high latitude regions. The eruption of Mt. Pinatubo in Philippines on June 16, 1991, believed to be the largest in this century, has given the atmospheric scientists an additional chance to verify some of the aerosol impacts based model studies. PRL has conducted a balloon experiment from Hyderabad in October 199[illegible] to study the stratospheric impact of the eruption.

The IMAP multi-wavelength radiometer network consists of the coastal stations, Trivandrum (8.5°N), Waltair (17.7°N) and the continental sites at Mysore (12.3°N) and Delhi (28.6°N) as well as at Jodhpur (26.3°N) which is in an arid region. Some of these stations have become operational only recently. But the limited results available so far already show very interesting special features like over Trivandrum and Jodhpur (Prabha Nair et al., 1988; Seshadri et al., 1988). While optical depths measured over the coastal station, Trivandrum, show large short term (even day-to-day) variability, the derived size distribution function does not show any short term changes. It exhibits a clear seasonal variation with a marked difference from a

uni-modal pattern in winter months to a bi-modal pattern in the summer months due to the production and transport of marine aerosols. The steep rise in the aerosol optical depth over Jodhpur in the winter months shows the importance of wind blown dust over this region.

Recognizing the special role of desert aerosols and wind blown dust over oceanic surface, a new programme is being initiated which makes use of satellite remote sensed data to study the aerosol optical depths. A theoretical programme to estimate the contribution of multiple scattering and account for it as a simple correction term in the single scattered upward emerging radiation intensities for evaluating the aerosol optical depths from satellite remote sensed data has been successfully evolved (Jayaraman and Koepke, 1991). It is proposed to use this technique in conjunction with data from ground truth measurements of the aerosol characteristics over the Arabian sea and Indian ocean regions as well as data from Indian satellites such as INSAT to study the aerosol characteristics over regions in and around the Indian subcontinent.

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Climatic Change in Arid Areas of China During the Past 10 ka

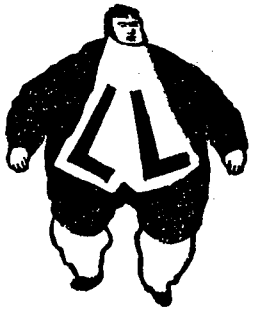
JINJUN JI
Institute of Atmospheric Physics,
Academia Sinica, Beijing, 100080, China

Based on the analysis of proxy data of sediments of salt lakes, loess deposits and glaciers in arid areas of North-western China, climatic changes in the above areas during the Holocene, generally, can be divided into three periods:

(1) 11 to 9 (or 8.5) ka B.P. : A warming period, glaciers in western mountains retreated, accumulation rate of loess decreased and lake levels in some regions rose.

(2) 9 (or 8.5) to 3.5 ka B.P. : A warm period, i.e. climatic optimum, most arid regions became wetter, sand dunes fixed and domain of desert reduced, glacial activities were not found. During this period, there were climatic fluctuations. Short relatively cold events occurred.

(3) 3.5 ka B.P. to present : Glaciers advanced, deserts extended and accumulation of loess accelerated, it became colder and drier, approaching the present climate. The relation between moisture condition, lake level and climatic change in above areas is a complicated problem which depends on the geographic factors.



Silt and the Evolution of the Deserts of Central and East Asia

EDWARD DERBYSHIRE
Centre for Loess Research, University of Leicester, U.K.
and
Geological Hazards Research Institute, Gansu Academy of Sciences, China.

The drylands of central and east Asia are among the youngest deserts and dry steppes on earth. They are also highly sensitive to climatically-driven environmental change, as can be shown on several time scales.

The record of alternation of climates from desert and semi-desert (dune sand and sandy loess) to steppe (loess) and shrub-woodland (well developed palaeosols) is well documented for the past 1.1 Ma in the semi-arid/sub-humid (sand/loess) transition of the middle reaches of the Yellow River. Evidence from pollen, mammalian fossils and archaeological remains suggest that the desert margin had fluctuated over a distance of 500km in the past 135ka. Over a broad region from the Hexi Corridor to Shaanxi there is evidence in the grain size, carbonate content and Fe_2O_3/FeO ratios of the loess and sand units of a progressive secular desiccation from the Middle Pleistocene onwards and within this trend, clear signs of periodic desert advance coincident with the colder phases within the Upper Pleistocene.

A similar environmental history is provided by the thick lacustrine basin fills in the deserts of western China, although these remain to be researched in detail. Progressive desiccation of Dabusan Lake since at least 35ka is clearly indicated by halite beds. However, the Qaidam Basin's lacustrine clay-silt sediment record may go back into the Tertiary: it is rich in Ostracoda and Gastropoda as well as diatoms and pollen, but detailed climatostratigraphy awaits high quality, semi-continuous core samples. Nevertheless, there is evidence of humid-arid shifts in the climate of the Qaidam since at least 790ka.

Remote sensing and field survey have detected abandoned shorelines high above the present saline lakes in both the Turpan and Qaidam depressions. Some are high enough to prove exoreic drainage in some areas, presumably at some time during the Pleistocene. The age and formative environments of these huge lakes, and their relation to phases of desert shift and loess accumulation, are unknown: it seems likely, however, that a very detailed history recording the initiation of and variations in desert conditions across this huge region will be found in its most complete form in the desert basin lacustrine fills.

The Wind Dynamics at Present and During the Quaternary: Case Study in Desert and Pre-desert Regions of Tunisia (North Africa)

CHAHBANI BELLACHHEB
Arids Regions Institute, Medenine, Tunisia

Wind is an important agent of erosion in the desert and pre-desert regions.

Habitually the study of the wind in a limited region is based on the analysis of the wind data frequency. We demonstrate in the first part of this paper that the best method to study the wind is based on the analysis of the **Potential Erosion** (or potential movement) and the dynamics of the wind (role of the relief on the wind flow).

This method is used to study the wind potential erosion and its dynamics in the Desert and Pre-desert regions of Tunisia (North Africa).

Using the results of that study, we explain in the second part of this paper: **why the Desert does not advance to the Pre-desert regions** (the final potential movement of the different winds, in basin of the Great Oriental Erg, is oriented to the sectors: SSW, SW, W). In the same part we explain also that the wind erosion activity increases in some located areas, (piedmonts, plains, depressions, narrow valley) because of the confluence of many eolian corridors, or because of narrowness of certain corridors which convey strong wind currents.

The increase of desertification process which is commonly considered as a result of human activities, is in fact conditioned by the wind dynamics and potential erosion.

The results of this new approach of the wind erosion activity (potential erosion) and dynamics (corridor dynamics) are used to understand and explain the genesis of some Quaternary eolian deposits in Desert and pre-desert regions of Tunisia (third part of this paper).

The main conclusion of this genesis stucy is that during the Quaternary, the wind dynamics was similar to the present wind dynamics. The potential erosion in the pre-desert increases during the Arid (dry) periods. Thus different generations of Loess coming from the desert were accumulated in the mountains and plains of the pre-desert regions. That means the domination of wind from the Desert (SSW to W) which are responsible for these loess accumulations. During the Humid periods (pluvial) the winds from the NNE to E had an important eorsion activity, alongside the coast where they built different generations of maritime sand dunes.

This domination of the two opposite directions of wind is due to the presence of the anticyclone and cyclone in the Mediterranean Sea and in the Sahara (Desert) of North Africa.

The Arrival, Residence Time and Departure Style of Loess Material in Certain Quaternary (sandy) Deserts

E.DERBYSHIRE AND I.J.SMALLEY
Centre for Loess Research and Documentation, Leicester University, Leicester LE1 7RH, U.K.

The well-authenticated association of some hot deserts with aeolian dusts including loess is in many ways misleading. Given that loess is essentially a material which should be associated with the cold phases of the Quaternary, the question arises "can we reconcile these hot and cold connections?" In the case of the deserts and loess bordering High Asia it is possible to describe a sequence of geomorphological events which connect a cold origin for loess particles, in the mountains of High Asia, with a storage period in the nearby deserts, and a culminating aeolian transport phase which emplaces the final loess deposit. Thus, for China, much material is transported to the east by the Yellow River and may be deposited in desert regions. It may stay in desert regions long enough for the particles to become considerably weathered. Some scanning electron microscope (SEM) studies on the Lanzhou loess suggest the co- existence of weathered and unweathered particles: the inference is that the latter particles have not been subjected to a desert stage. The desert appears to play an important role in the formation of loess deposits in Central Asia and north China.

Where there is no cold source for loess particles there tends to be no or very small loess deposits. The desert phase in the formation of the Asian loess deposits may be an important modifier of loess particle supply to the eventual deposits. a factor which may need to be taken into account when the chronostratigraphy of these deposits is being considered. Geomorphology may influence stratigraphy.

The particle source regions in High Asia deliver material to all the major rivers: thus it is that North India is covered with fertile proto-loess, and the Yangtse River carries material which eventually forms the deposits near Nanjing. The Indus and the Thar desert have a loess connection, but there is a stronger one between the Syr-Darya and Amu-Darya rivers and the Kara-Kum and Kyzyl Kuk deserts and the loess deposits to the north and west of High Asia. The well known Alekseev-Dodonov map shows areas of high land, of loess, and of sand. All major loess outcrops can be understood as desert-lee accumulations when transport directions of present and past networks are overlain by lower atmosphere wind circulation patterns. Current palaeoclimatic research seeking to establish changes in palaeowinds from the earliest Quaternary should lead to a refinement of this general model.

Aeolian Processes on Mars and Venus

RONALD GREELEY
Department of Geology, Arizona State University
Tempe, AZ 85287-1404, U.S.A.

Any planet or satellite that has a dynamic atmosphere, a solid surface, and a supply of loose particles on the surface may experience aeolian activity. Solar system exploration has shown that (in addition to Earth) Mars, Venus, Triton (satellite of Neptune) and possibly Titan (satellite of Saturn) meet these requirements. Although information on the satellites is very limited, abundant data exist to show that windblown sand and dust are important on Mars; in addition, the Magellan spacecraft, currently in orbit around Venus (obtaining radar images of the surface), has revealed the presence of numerous aeolian features. Thus, there is the opportunity to assess aeolian processes on three major planets (Earth, Mars, and Venus), each having markedly different environments. The principal parameter for aeolian processes is atmospheric density and the resulting surface pressure. These range from 6.5 mb for the carbon dioxide atmosphere on Mars, through the 1 bar nitrogen-oxygen atmosphere of Earth, to the 90 bars carbon dioxide atmosphere on Venus. Threshold velocities required to entrain particles scale inversely with surface pressure, with very low speeds required for Venus, and high speeds required on Mars for particle movement. However, the optimum size particle (particle size moved by lowest speed winds) is about 100 μm on all the three planets. These results are based on wind tunnel experiments simulating aeolian conditions on Earth, Mars and Venus.

Among the most common wind-related features seen on extraterrestrial surfaces are "wind streaks". These are surface patterns of erosion and deposition that are typically associated with topographic obstacles to the wind, such as small hills. Thousands of wind streaks have been identified and mapped on both Mars and Venus. Their orientations are currently being analyzed to derive models of near-surface atmospheric circulation. Preliminary results show that on both Mars and Venus, some categories of streaks define a Hadley cell circulation.

Both erosional and depositional features have been identified on Mars and Venus, in addition to wind streaks. These include sand dune fields, mantles of windblown deposits, and yardangs (wind eroded hills). Analysis of aeolian features in these planetary environments is providing insight into the nature of aeolian processes in general and is contributing to the understanding of the evolution of planetary surfaces.

Saharan Dust

A. BUCHER
Observatoire du Pic du Midi et de Toulouse, B.P.41
F.65204 Bagneres de Bigorre Cedex, France

Europe and in particular France receive, like the South Atlantic, Northern Africa and the Middle East, many Saharan dust falls but in smaller quantities. The year 1991 has had 3 major episodes which will be briefly described as well as the 818 dust arrivals, mud rains and coloured snow which have occurred between the years 1577 and 1989.

Meteorological Conditions Concerning Europe

It is frequent that a deep depression on the near Atlantic produces fast winds at altitude from South-West to South between Northern Africa and France. A cold front combined with this depression moves from Morocco to Libya producing dust and sand clouds on the Northern fringe of the Sahara (A. Bucher, J. Dessens; in press). These clouds carried by a strong wind, go towards Europe where they deposit the dust. These dust arrivals take place several times on an average in a year. They are of different importance which means that they can sometimes be difficult to discover. Indeed, if the dust falls in small quantities, it will not be noticed and this can also happen if, when it falls in large quantities, strong precipitation dilutes it.

Traces on the Ground

Over the mountains, where the dust falls as coloured snow, it is easiest to find the dust because its colour contrasts strongly with the white snow. If covered by other snow falls it will be possible to retrace it by digging. And at last, in spring, the layer cover will melt and the coloured snow could be seen.

Quantity of Dust

The Quantities of dust found have never been more than 6 grams/m^2, at least since 1972, which is the date when the research started. In the past, very important falls occurred, like in 1846 in Valence, France, where the layer was so thick that is blocked roof-gutters.

Study of Recent Cases

Between March 6th and 9th 1991, important arrivals of dust and mud rains occurred in Italy, France and England (studied by Dr. J. Dessens and self). With the

help of a network of observers created to understand this phenomenon, it has been possible to obtain 57 pieces of information coming from various places. Very often, these Saharan arrivals took place during several days. spread over 30 French departments, the County of Berkshire in England, Sicily and Rome. In this case as well, it was due to the movement of a cold front from Western Sahara to Libya. On the 24th and 25th of March of the same year, mud rains and red snow fell in France. A more recent episode happened on the 11th of October this year, when mud rains covered the majority of the French departments. In the Western part of the Pyrenees, they were so strong that they could cause short circuiting of pylons in the electrical distribution network, leading to black outs. It is quite rare that such a big area is affected. To date (28th October 1991) not all the information is available and one cannot say anymore about it.

Origin

Usually, dusts come from the Algero-Moroccan frontier, Mauritania and Central Sahara as well. Their journey is either direct by crossing the Mediterranean, as in the case most of the time, or indirectly, in which case dust clouds, diverted by the presence of an anticyclone, go towards the Atlantic Ocean then come back to Europe from the West.

Recent and Ancient Phenomena

In ancient times, mud rains were considered as blood rains which have strongly impressed, which is why it is now possible to learn about them. C.G. Ehrenberg is, amongst others, the author of two compilations concerning these phenomena, published in 1849 and 1871. One can only be stricken when looking at his work to see the quantity of information he gave, and that one can still find the places concerned today. The map of Nalivkin (1969) who studied in depth the dust storm of the 18th to 23rd February 1903, will be shown.

Looking at all the sources available, giving indications of these ancient falls, we had 715 cases by 1983 (A. Bucher, 1986). Pursuing this study until 1989, 103 new cases have been added to these 715, which gives a total of 818. It is from the year -300 to 100 that we can find a sudden increase in these events which is intriguing and for which we cannot give any answers at the moment. The period from 1500 to 1989 is rich in events as well, and within that, especially the period from 1750 to 1920. Progressively, as we come closer to the present time, the number of cases increases. This increase does not mean automatically that the Sahara exports more dust, but one is permitted to think that the density of the population, the growing scientific interest and the network I have created for this purpose means that few arrivals are not brought to our attention.

We are confronted here with an important phenomenon, at least at the geological scale and for the study of which international cooperation seems essential.

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The Radiocarbon Dating of Inorganic and Organic Carbon Components of Arid Zone Sediments

M.J. HEAD
Radiocarbon Dating Research Unit,
Research School of Pacific Studies,
Australian National University, Canberra, Australia.

The development of useful radiocarbon chronologies for landforms in arid and semi-arid environments has often been fraught with difficulty. Potentially datable materials have often been collected, but problems associated with the presence of multiple events and intrusive components having different C-14 ages have caused these materials to be placed in the "too difficult" category.

Another constraint on the dating of the more plentiful arid zone carbon containing materials has been the amount of carbon needed for an adequate sample. Typically, 2 to 5 grams of carbon has been needed for the C-14 measurement techniques such as gas proportional counting and liquid scintillation spectrometry. The advent of small sample gas proportional counting, the Quantulus liquid scintillation spectrometer, and accelerator mass spectrometry has meant that samples ranging from 40 µg to 250 mg carbon can now be dated. This has meant that physical and chemical analysis and pre-treatment of carbon fractions within samples can now be carried out so that sample fractions representative of events to be dated can be recognised and separated for dating.

This presentation discusses the problems associated with the dating of calcretes, desert varnish and clayey sediments, and strategies that have recently been developed to enable useful chronological data to be obtained from these materials.

黄土通讯

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IUGS UNESCO

INQUA LOESS COMMISSION

President:
AN Zhi-sheng
Xian Lab for Loess
P.O.Box 17
Xian
P.R.CHINA
Fax: (86) 29-752-566

Vice-President:
Nicolas FEDOROFF
Lab. de Science des Sols
INAPG
78850 Thiverval
FRANCE
Fax: (33) 1-305-49454

Secretary:
Ian SMALLEY
Centre for Loess Research
Leicester University
Leicester LE1 7RH
U.K.
Fax: (44) 533-522200