An INQUA Newsletter for Students of Loess Material, Loess Deposits, Loess Ground, Loess Soils & Loess as a 'Climate Register'. Founded in 1979 at the New Zealand Soil Bureau.
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LL64. Closing the Gap. LL64 is aimed at the ‘Closing the gap- North Carpathian loess traverse in the Eurasian loess belt’ meeting. This is the International Workshop; 6th Loess Seminar in Wroclaw 16-21 May 2011; INQUA Project 1005.

For more information and the registration form, download the 2nd circular at www.pages-igbp.org/calendar/2011/Loess6thSeminar_2nd_circular.pdf.

Abstract deadline is 31 March 2011; send abstracts to loess2011@gmail.com. Abstracts: not more than two pages, Arial 10 point, single-spaced, A4 page- no references included.

LL65. Look out for LL65- a new departure. LL65 does not focus on loess (although it is mentioned). LL65 is a History of INQUA. Every organisation needs a History: LL65 is a contribution from the Loess
Focus Group to the History of INQUA; published April 2011, in time to be circulated at the 'Closing the Gap' meeting.

Walery Lozinski & Periglacial: 1910–2010. A centenary for the periglacial idea. At the 11th International Geological Congress in Stockholm in 1910 Lozinski gave a paper on his new ‘periglacial’ concept - this is a moment to celebrate so with LL64 we commemorate Lozinski & Periglacial.

J.K. Charlesworth said that loess was by far the most important periglacial deposit - we have a claim on ‘periglacial’.

The ‘Closing the Gap’ field trip travels the ground where periglacial concepts evolved. Also in 1910, at the Stockholm Congress, P.A. Tutkovskii gave a paper on loess - another significant moment in the development of our particular world. As we head into Ukraine we should remember Tutkovskii and his important contributions to loess science.

LL66. LL66 is due to be published in October 2011. A lot has changed since the first issue appeared in 1979. What is to be the future of LL? How will loess news be communicated? - shall it be hard copy newsletter, or website, or Facebook page, or Twitter, or Quora...? If we stay with a hard copy newsletter, what form should it take? The Editorial Commission thinks that we should operate more efficiently in the Eworld. If a robot machine exploring Mars can have a Facebook page then so can members of the Loess Focus Group.

New approaches to European loess: a stratigraphic and methodical review of the past decade

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Abstract: This review paper intends to summarize the state of the art in loess research at the first international “Loessfest’99” conference and to outline progress in loess research during the past decade. The focus is on loess as a terrestrial archive of climatic and environmental change during the Quaternary. The review highlights remarkable new results from regional investigations into European loess, as well as the emergence of new methods and refinements of established techniques, focusing on stratigraphy, dating and palaeoenvironment. It is concluded that loess research during the past decade not only has developed rapidly to take an outstanding place in Quaternary sciences, but also promises exciting perspectives for the next decade, in particular when combined approaches are applied to benefit from the now comprehensive pool of established and new methods.

Keywords: Loess • Europe • dating • palaeoenvironment methods

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1. Introduction

The international “Loessfest 2009” in Novi Sad, Serbia, was a renewal of the international “Loessfest ’99” held in Heidelberg and Bonn, Germany, in March, 2009, which placed itself in the tradition of the International Symposium “Wind blown sediments in the Quaternary record” held at the University of London in January, 1994. The present contribution examines new developments during the past decade since “Loessfest’99”, thereby disregarding research in geotechnical or applied aspects. This review will rather focus on loess as a terrestrial archive of climatic and environmental change. Of course, this review is inevitably influenced by personal viewpoints of the author and may thus, be somewhat one-sided in the focus on European loess. Newly emerging approaches to the study of loess, however, transcend regional boundaries, even if applications within this paper are on a local or regional scale. In order to outline progress in this field, the state of the art methodologies and thinking from “Loessfest’99” will be summarized first. From this, progress in loess research will then be examined under regional and methodological aspects. Although the author is primarily involved in chronostatigraphy of loess, the present review will encompass the broad scientific nature of recent loess research, including aspects of which the “loess community” may not be fully aware of.

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The State of the Art at "Loessfest’99"

tomes of the “Loessfest’99” were published in two
two volumes, Earth Science Reviews vol. 54, 2001
ed by E. Derbshire [1], and Quarterly International vol. 76/77, 2001, guest editor E. Derbshire [2].
Becoming these volumes, many papers appeared
numerous peer-reviewed journals during the following
The end of the 1990s saw the triumphal process-
the consistent Chinese loess stratigraphy in dif-
It was compellingly correlated to the marine
the loess stratigraphy and did not stay constrained to the
once loess plateau was but increasingly adopted also
other parts of Asia. Furthermore, the outcome of Chi-
loess stratigraphy started to enter Europe – despite
fragmentary local stratigraphies – and to combine with
dd’the stratigraphic scheme [3].
progress in Quaternary dating methods had led to
innumerable applications in loess and loess-like sediments.
r refers in particular to direct luminescence dating
the optical dating taking priority over themun.
geological dating, indirect magnetic (environmental mag-
ism, paleomagnetism) and chemical dating (amino
3 geochronology). Together with increased and new
applications of dating methods, however, their new emerg-
problems challenged further research and careful in-
stantiation of apparent dating results.

eological proxies, in particular molluscs, have had
ong tradition in loess research but were now ob-
used to innovative data processing and interpretations.
len analysis from loess-palaeosol sequences, normally
ected to yield stratigraphically meaningful results,
ed a very helpful tool for palaeoenvironment recon-
action and climatic stratigraphy, at least in suited re-
such as the Ukraine. Isotopic proxies from loess – ra-
active isotopes such as 39Ar, 37Be as well as stable isotopes
ling 13C – emerged during the 1990s but systematic
lications remained rather confined to individual key

w sedimentological methods (mainly laser gran size
alysis) and related provenance studies emerged. Grain
distribution indices based on high resolution granu-
metry promised to serve not only as a lithostratigraphic,
also as a chronostratigraphic tool, by correlation with
aneous dated high resolution records such as ice cores
I deep sea drilling.

olved in the last glacial cycle in loess,
ld be proposed. As a revolutionary approach, even
inventors of “Heinrich Layers” and D/O-cycles in high
olution loess sequences were suggested, thus elevat-
high resolution loess sequences to a unique terrestrial

3. The past decade

Progress in loess research during the first decade of the present millennium can be evaluated through the division of the research into regional and methodological aspects as follows:

3.1. Regional

First of all, it may be emphasised that Chinese loess stratigraphy is now more or less accepted as a “standard” stratigraphy of the continental Quaternary. This does not argue against regional stratigraphies of glaciations and interglaciations, or stadials and interstadials of a given glaciation. Glacial stratigraphies are, how-
ever, intermittent and cannot comprise the entire Quaternary. The dating of glacial advances and retreats is still a major challenge for Quaternary sciences, and, thus, for correlation with marine isotope and loess stratigraphies. So far, the Chinese standard loess stratigraphy is

In short: it is evident that the success of a scientific discipline is witnessed by its application. But “no” because of:

- Ongoing refinement of methods,
- Development and testing of new methodologies.
- The question cannot be answered unambiguously because continuous regional application, refinement and development of advanced methods characterizes loess research:

- 185 years after von Leonhard introduced the term “Loess” in geosciences literature [1],
- 48 years after foundation of INQUA Sub-
Commission on European Loess Stratigraphy and 40 years after its upgrading to a full Loess Commission,
- 6 years after restructuring INQUA commissions and start of SACCOM (Commission on Stratigraphy and Chronology).

The vitality of loess research should, however, not pri-
mainly be illustrated by organisational aspects but rather
its scientific and methodological development. Some
lights of the past decade will therefore be mentioned briefly.

![Figure 1. Suggested correlation of loess-palaeosol sequences from the Danube Basin in Hungary, Serbia, Romania and Bulgaria with the Chinese loess stratigraphy and the SPECTRUM curve (from 10).](image-url)

Ongoing regional research attempts to adopt the Chinese stratigraphic scheme to the entire Eurasian loess belt. Nevertheless, some pending problems (e.g., [6] vs. [7]) persist because of different chronostratigraphic models. En-

forced research in the Carpathian Basin has by now revealed plateau loess ranging back >1,000 ka with a con-
sistent age model [8]. Missing regional links between China and Europe must not be concealed in this context.
but a correlation of Middle and Upper Pleistocene loess-paleosol sequences in the Pannonian Basin and the Lower Danube Lowland (Romania, Bulgaria) based on magnetic susceptibility records, with the Chinese loess stratigraphy and the SPECMAP δ¹⁸O record appears reasonable (Figure 1). It is striking that in the Pannonian Basin the last 3 interglacials were drier than previous ones, as is demonstrated for the Betajnica section in Serbia [9] (Figure 2).

Figure 2. Humidity trends from Middle and Upper Pleistocene interglacials in the Betajnica section, Serbia, and suggested correlation with the EPICA ice core and the Tenaghi Phillipon pollen record (Greece) from [9].

Within Europe, despite its considerable climatic gradients, interregional correlation of Middle and Upper Pleistocene loess-paleosol sequences (based on magnetic susceptibility) and of the global ice volume curve (based on marine oxygen isotopes) reveals similar patterns [10]. This can be best demonstrated for MIS 7 (Figure 3). A further typical pattern becomes evident from paleosol S5 comprising MIS interglacial stages 13 and 15 [11]. In the sections studied S5 is more well developed than younger paleosols, even if the chronology of the Stary Kaydaki section (Ukraine) is still under debate.

Within the principally continental Pannonian Basin interstadial soils of the last glacial cycle are much more difficult to detect by field evidence than further to the West and to the North (Central and Western Europe) [11]. Again, magnetic susceptibility turns out to be a valuable tool for a refined stratigraphy beyond field inspection, as was shown for the Surduk section (Serbia) including the weak interstadial “Surduk soil” [12]. At the same time for this section a rather detailed luminescence chronology of the last glacial-interglacial cycle is now available (Figure 4), allowing for higher resolution palaeoenvironmen-

Figure 3. Characteristic pattern of magnetic susceptibility from MIS 7 pedocomplex (S5) through Central and Eastern Europe (from [10], adopted).
Loess and dust on Earth and Mars: particle generation by impact mechanisms

Received 24 November 2009; accepted 13 January 2010

Abstract
Impact between windblown quartz grains as a source of desert dust is consistent with laboratory abrasion experiments and has received some field confirmation in the Negev. The suggestion is that an important source of desert dust is derived from impact of impact on Mars. The internal stress range in terrestrial sand grains may vary, depending on the nature of the source rock, and this may influence particle production by impact processes.

Keywords: Loess • dust • particle impact • stresses in sand particles • andesite weathering • Mars

1. Introduction
Despite decades of investigation in the field and in the laboratory the origin of the material for dust and silt deposits on Earth remains unclear. Much of the literature deals with the redeposition of existing fine particles (large and small dust) on land and at sea, with the emphasis on the climatic conditions at the source or at the site of deposition, but the generation of the particles themselves is generally left unstated.

Where an origin is specified two options are favoured: the breakdown of crystalline rocks which include crystals of suitable dimensions, and the weathering of larger fragments. In the context of loess studies, however, doubts less because particle size is an integral part of the subject matter, a number of studies have focussed on particle generation. Loess emanating from glaciated areas, whether through latitude or altitude, has been widely seen as the product of glacial grinding, although this simple view is now being modified (1), where the source is thought to be a hot desert opinion are still divided between those who favour weathering, especially by salt and frost, those who promote abrasion by running water or wind, and those who believe that the fine particles were brought into the desert regions from zones of particle formation (2). The abrasion group includes proponents of fracture of suitable grains by impact of impact (3); a mechanism proposed by Smalley & Vita-Finzi (5) but developed by Whalley et al. [4].

Some support for the impact mechanism has recently come from field studies on Earth and laboratory experiments designed to illuminate the colour of the Martian regolith. In an analysis of what they termed primary loess in the Negev desert, Couvi et al. [5] showed that the only proximal source was desert sand in the Negev which was composed of coarse quartz grains, and concluded that large dust had been generated by aeolian abrasion. At about the same time laboratory experiments appeared to show that the reddening of the Martian regolith was due to prolonged abrasion (6). This discussion paper reassesses the impact model in the light of the new data and shows how it might be extended to Mars by broadening the range of suitable source grains to include feldspars derived from basalt, and perhaps anesite.

Couvi et al. [5] have shown that loess in the Negev, Israel is derived from near-surface sand deposits. They found an interesting bi-modality in the Negev loess; particle modes at around 50 µm and 3-5 µm, a classic occurrence of 'large' dust and 'small' dust. They proposed that the larger particles came from the proximal sand deposits, perhaps furnished by a chipping mechanism like that proposed by Smalley & Vita-Finzi [3] and the smaller particles from distant Saharan sources. The discuss back into discussing the idea of fine particles for dust clouds and dust deposits being made by impact processes, wind-borne, relatively small impacters transferring enough energy to produce new particles. This paper continues this discussion and considers some possible production mechanisms for loess and dust particles on Earth and Mars (discussed in outline by Smalley & Krinsley (7)).

Stuut et al. [8] produced a very simple, but sensible, classification of aeolian fine particulates which are carried in suspension. They divided dust into large dust and small dust. In a terrestrial situation the large dust consists mostly of quartz particles in the 10-50 µm size range which may go on to form loess deposits. This material travels in suspension, but for relatively short distances (<100 km). For a large loess deposit to form a very effluent production source for this large dust material is required. Terrestrial small dust is largely produced from a dry lake bed (e.g. the Bodele depression in North Africa) and tends to consist of clay mineral aggregate particles with sizes around 0.5-3 µm (b) from sand seas, accumulations of desert sand, which can deliver fine quartz dust via impact processes. This small dust can travel enormous distances in high suspension; this is the dust which fell on Charles Darwin and the Beagle and is believed to make an important contribution to the soils of the great rain forests in northern South America. There is a very well-marked bi-modality in terrestrial mineral dusts and this led Stuut et al. [9] to propose their simple classification. The classification does need to be developed slightly; satellite observations have shown clearly that although dry lake basins are major contributors, African dust there is an important dust output from sand seas. It seems likely that sand seas deliver quartz chips while lake basins deliver clay mineral aggregates (CMA). There is some understanding of the nature of mineral dust on Earth; this is largely lacking for Mars.

The formation of small CMA mineral dust in North Africa has been considered by Evans et al. [9] and they have shown, by a simple Monte Carlo simulation, how the bottom structure of a particle lake sediments develops and how this has a critical influence on the size of the eventual dust particle. This may account for much of the desert dust but there will be a proportion which can be formed by sand grain impact, yielding a small-size fracture product, and it is this impact production of small particles which is considered in this paper. If it can be shown that this is a realistic way of producing an appreciable amount of fine particulate material on Earth, it is reasonable to extend the argument to the production of Martian dust.

2. Lithological controls on terrestrial dust
It could be that there is a very simple lithological control on terrestrial dust. The major continental crustal rock is granite; the ideal granite consists of primary feldspar crystals and a eutectic-type structure of fine quartz and feldspar. On weathering the feldspars are turned into clay minerals and the high feldspar contents of granites is reflected in the abundance of mudstones in the sedimentary record. Some of the clay mineral particles wash
formed into fracture energy on impact. It is the square of the wind velocity which is a key variable, a wind of 100 km hr$^{-1}$ delivers 25 times the impact energy of a wind of 20 km hr$^{-1}$. So very high wind speeds will favour vastly enhanced particle production. It may be that very high wind speeds on Mars can generate high energy impacts. They could also move larger impactors, and although the mass factor is not so effective as the wind velocity factor the larger particles will deliver more impact energy.

5. Abrasion experiments

Kuenen [18] did some interesting experiments on particle impacts in wind streams. He produced a totally negative result: i.e. sand grain impactors did not produce significant numbers of silt sized debris particles, and thus sand grain impact could not contribute to loess deposit formation. His experimental error was to use perfect quartz particles as his impactors; these tended to lack internal defects and be very resistant to breakage (see discussion [19]). When Whalley et al. [4] repeated the experiments with more realistic material, i.e. quartz from granite containing internal stresses, silt sized quartz particles were produced.

Wright [16] has developed the experimental approach to particle production and has produced interesting suites of particle product. She introduced the Bromhead ring shear machine to model glacial grinding and made some comparisons between model glacial grinding and model wind impact particle production. She found that impact mechanisms compared well, in terms of efficiency, with glacial grinding processes.

6. Sand seas making dust

The sand in sand seas is distinctive [20] and relatively easily lifted by the wind to perform the role of small-particle-producing impactor. There have been careful studies of the nature and rate of dust production from natural dune sands [21], and we hope to progress slightly along this route. The actual production of small dust from a sand sea could include a contribution from impact chopping. Stutt et al. [8] identified sand seas as sources of dust but no actual dust producing mechanism was specified. The actual particle production mechanism is probably an extension of the original Small & Vita-Finzi [3] chopping mechanism. The SVF chopping mechanism was originally devised as a possible way of producing silt sized (e.g. ~30 μm) particles in sandy deserts, and it was presented as an unlikely scenario [although Crouvi et al. [5] seem to find it acceptable]; Small & Vita-Finzi were suggesting that sandy deserts were not effective generating regions for loess sized particles. With modification their basic chopping mechanism could deliver quartz fragments which are an order of magnitude smaller (e.g. ~3 μm). They only considered the removal of protuberances but it is possible to see how direct impact might generate small dust particles (Figure 1).

Figure 1. A simple scheme for the production of very small impact particles from quartz sand particles in a sand sea. The combination of internal stresses (a legacy of the high-low quartz crystal transition) and a wind driven impact stress causes the formation of a small particle, a very small amount of new surface is produced. The compositional change of the stresses is just right to produce a small dust product.

A sand sea is made up ideally of vast amounts of quartz sand which consists traditionally of well-rounded particles. Current observations from space show that sand seas are producing contemporary small dust. The sand particle has long been a rounded semi-perfect particle, but they continue to produce small dust. It could be that a combination of impact stresses and internal stresses can produce very small chips. The internal stress in sand sea particles is produced by the eutectic quartz forming mechanisms in the original granite [22]; these stresses are retained in the sand particles. There is an effective sub-surface tensile stress; this is released by the impact opportunity and a small chip is produced. Only a relatively small amount of energy is available (impact + stored) and therefore only a small amount of new surface is produced; the chip is small.
8. Commentary

A large sand sea should produce small quartz dust. The material is right, sand sized granitic quartz, and the desert winds produce abundant chipping activity. The terrestrial energy requirements suggest that it is unlikely that sand seas produce significant amounts of large dust; different pressures of energy are required for large dust and loess deposition—although Črůvová et al. [5] have detected loess sized material emanating from the Negev desert. Large dust does emerge from large sandy deserts but (as Smalley & Kristély [2] noted long ago) this is usually transient material, it goes into the sandy desert as large dust and emerges as large dust; the desert acts as a holding area; recently careful science has shown that the Chinese loess is not made in the northern deserts, but may be stored there for a while [27, 28]. The loess dust is made in the mountains, in ‘High Asia’ and transmits through the deserts on its way to the great deposits.

On Earth small dust mostly is made in dry lake beds, and consists of clay mineral aggregates OMAs, or in sand seas where the product is fine quartz dust produced by impact chipping, as shown in Figure 1. This novel mechanism probably accounts for most of the quartz dust. It can be confirmed by already known mechanisms [3, 9]; observations from satellites suggests strongly that these are the two main sources.

On Mars, however, there are no straightforward small dust production scenarios. There has been a vast amount of research on Martian dust from the various investigating machines which have reached Mars, but there is little actual data on the particle size analysis or mineralogy of the observed dust clouds. Approaching the problem of dust nature from the point of view of particle production presents many difficulties. No sand seas appear to be available, and there is a lack of dried up lake beds (although there may be some) so the mechanisms which link crust to particle are difficult to discern. The ‘andesitic scenario’ offers a possible route, there is nothing too exotic in the various requirements, but it must contain a high content of speculation. This is an intriguing problem because it has many layers; it is difficult to design a mechanism for the production of the intermediate particles, it is difficult to envisage initial weathering of the crustal rock, it is hard to sustain a picture of the attenuated Martian atmosphere moving impact rock fragments and producing substantial dust.

References

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Lokalizacja stanowisk prezentowanych w trakcie IV Seminarium Lessowego. Location of the sections presented during 4-th Loess Seminar.
A man from Bendery: L.S. Berg as geographer and loess scholar

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Abstract

Lev Semenovich Berg was born in Bendery, in Moldova. He had great success as an ichthyologist and geographer; he also proposed, in 1916, an interesting theory of loess formation. As a biologist he was persecuted by Lysenko and the Soviet state in the time of pseudo-science in the 1930s and 1940s. Despite his being persecuted, the loess theory became, in effect, the official Soviet theory of loess formation. This theory had to be compatible with his ‘landscape’ theory which did not find favour in Marxist-Leninist geography. Berg’s loess theory was very much a geographical theory, as opposed to the geological theory of aeolian deposition, which was accepted outside the Soviet Union. Berg was hugely successful in many fields, but his contributions to loess science tend to be neglected. His ‘soil’ theory of loess formation has been widely disparaged but still has some influence in Russia. The concept of loessification may still be relevant to the later stages of deposit formation; the slow transition from metastable to collapse may be best described as loessification.

Keywords: Lev Semenovich Berg, theories of loess formation, landscape theory, loessification

Introduction

Lev Semenovich Berg (1876–1950) was born in Bendery, in present-day Moldova (Fig. 1). Bendery is a town which is also known as Bender, and as Tighina. It is currently located in a country known as Moldova, which was essentially the Soviet Republic of Moldavia, but even that is not strictly true. It is located in a small, widely-recognised country which was once called Transnistria, but is now known as Transnistria. Most of Transnistria is on the east bank of the Dniester river, but a small part – which includes the town of Bendery – is on the west bank. When Berg was born in Bendery, it was part of Russia, part of Bessarabia. It was part of Romania from 1918 to 1940, when it became part of the Soviet Union. This is the eastern part of central Europe; the Philips Atlas places Bendery nicely in Middle Europe. However, the 1999 edition calls it Tighina.

Berg was born in the Jewish Pale of Settlement, as the son of Simon Gregorovich Berg, to gain her diploma in genetics (equivalent to an M.Sc.) and began post-graduate studies in genetics at Leningrad University’s Genetics Department. In 1939 she became a ‘candidate of sciences’ (approximately equivalent to a Ph.D.), having written a dissertation on ‘Differences between wild and laboratory populations of Drosophila melanogaster: a hypothesis of genetic correlations.’

From his days as a student in Moscow until his death in 1950, Berg displayed great scholarly prowess and he excelled in many fields. Embedded in his scholarly life was a continuing interest in loess, and this is the main topic of the present contribution.

Background

Berg (Fig. 3) remains famous as an ichthyologist (see Bernstein & Bemis, 1997) and a geographer; his scholarly output was immense. He published 217 works on ichthyology, 30 works on general zoology and biology, 20 works on palaeontology, 32 works on zoogeography, 320 articles and monographs on geography, geology and ethnography, as well as 290 biographies, obituaries, and popular articles. Within this huge output of, among others, the 320 papers on geography are several very significant pieces on loess and loess formation; and not insignificant pieces, large book-length studies essentially on the problem of loess formation. Berg offered a counterview to the aeolian theory of deposition favoured by Obручев and Richthofer. The aeolian origin of loess has been accepted since Von Richthofer’s (Fig. 4) 1878 observation and interpretation of the loess in China.
Had Berg's output been a bit less overwhelming, his loess studies would have been more easily recognised as major contributions, but their signal got somewhat lost in the overall scholarly noise. They deserve credit, however, for several reasons: (1) they offer a counter-view to the prevailing idea of aeolian deposition of loess material; (2) they run in parallel with Berg's development of the 'Landscape Science' approach to physical geography, and there may be mutual illumination; and (3) they may be correct; possibly not correct on the large scale but correct when all the separate stages in loess deposition formation are identified. A very perceptive article by Makeev (2009) has given a Russian insight into current views of loess formation and appears to add some Berg-type loessification to a basic aeolian scenario.

It is possible that, in propounding and defending his theory of loess formation, Berg was also propounding and defending his landscape-science ideas. In his entry in 'The Great Soviet Encyclopaedia' his loess ideas are mentioned (in translation), as in the context of his geographical endeavours: "Berg elaborated the study of landscapes and developed the teaching of V.V. Dokuchaev..."

Landscape science

The Russian idea of 'Landscape science' is a current topic of discussion (see Shaw & Oldfield, 2007, 2008a,b) and the present contribution might be considered as a peripheral contribution to that debate. Berg (1915) invented landscape science just one year before he proposed his theory of loess formation. Landscape science owed a lot to the ideas of Dokuchaev (Fig. 5), and so did the loess-formation theory. As Shaw & Oldfield (2008b) point out, Berg is nowadays recognised in geography as the founder of what is usually termed 'Russian landscape science' (landschaftsvennologie), a conception of geography based on the assumption that the earth's terrestrial surface is naturally divided into integrated, biophysical units or landscapes which can easily be recognised in the field. Berg defined a landscape as: "that combination of grouping of objects and phenomena in which the peculiarities of relief, climate, water, soil, vegetation and fauna, and to a certain degree human activity, blend into a single harmonious whole, typically repeated over the extent of the given zones of the Earth." (Berg, 1947, p 16)

In Berg's view, the study of such natural units formed the core of geography as a scientific discipline. The study of landscapes as zones, or of zones as landscapes, reached its apogee in the seminal book 'Landscape-Geographical Zones of the USSR', which was written in response to an invitation by N.I. Vavilov and published by Vavilov's institute. Dokuchaev propounded a zonal approach to soils: great climatic zones would provide the conditions for the formation of various types of soils. Dokuchaev's two main proposals were the role of climatic zones, and the development of soils by horizonation. Berg, following Dokuchaev, and thinking of loess as a soil, might reasonably suggest development in situ by soil-forming processes, to form loess landscapes.

Loess studies

The ongoing studies by Berg regarding the origin of loess deposits culminated in studies published in 1916, 1932 and 1947 (also published in English in a 1964 work).

The 1916 loess study

In 1916, Berg published a major work, a 67-page article in an important journal, setting out the basic idea of loessification, i.e. the transition of not-loess to loess ground. The theory became known as the 'soil' theory, or the 'in-situ' theory, or the 'pedological' theory, or the 'elluvial' theory. 'Pedological' was the term coined by Pyatakov (1946) as in: "There can be no doubt that the most important factor in the development of our knowledge concerning loess was the fruitful idea of L.S. Berg as presented in a series of articles and collected under the title of "the pedological theory of loess formation". For a wider discussion of the Berg theory, and its relation to the aeolian approach to loess-deposition formation, the reader is referred to Smalley (1971, 1978), Smalley & Rogers (1997), Smalley et al. (2001, 2005a,b), and Różycki (1991).

The 1916 publication formed the basis of the loess section in the book 'Climate and Life' (Berg, 1922). When the 2nd edition of 'Climate and Life' was published in 1947, the loess section was updated, and this was eventually included in the 'Collected Works' published in 1960. This 1960 loess section was translated into English by A. Gourevitch and published by the Israel Program for Scientific Transla-
tions as ‘Loess as a product of weathering and soil formation’ (Berg, 1964). This translation is now seen as the acceptable, default version of the Berg loess theory; in fact many scholars refer to it as though it were a nineteen-sixties work, rather than a revised version of a 1916 article. The theory did not change and evolve from 1916 to 1964, but a series of publications (Berg, 1926, 1927, 1929, 1932), as Pyaskovskii noted, keeps it visible.

‘Pedological theory’ was the term favoured by Pyaskovskii, as in his 1946 statement that supported the theory, maintaining that loess was formed in the subsoil layer of the steppe and was inherent in its ‘soil profile’. He attacked great importance to organisms which assisted carbonate solutions in their downward penetration.

The 1932 loess study

Berg (1932) is a major exposure of the theory in English, in a visible geophysics journal. Its appearance demonstrates that Berg was serious about his loess work and wished it to have maximum exposure. An observation on particle size deserves some comment: “The wind, according to its velocity, can carry either coarser or finer particles, but why should it give a preference to particles of 0.01 to 0.05 mm in diameter, has never yet been explained by any follower of the aeolian theory” (Berg, 1932, p. 134; Smalley, 1975, p. 65).

Two fairly obvious explanations were apparently overlooked by Berg: (1) certain geochemical processes produce material in the designated size range; in fact it appears that crushing low quartz (a major loess constituent) produces particles with a mode size of around 30 μm, so this is the material available for loess deposition; and (2) certain sizes are favoured by the wind as it picks up natural particles; a compromise between weight forces and cohesive forces means that a particle at about 80 μm is most likely to be picked up. The combination of these two factors results in Berg’s well sorted deposit. This is important because Berg’s pedological theory always had problems with producing the required large amounts of quartz silt by chemical processes.

The 1947 loess study

The second edition of ‘Climate and Life’ was published in 1947, and this contained what we should regard as the definitive version of the Berg theory of loess formation. The text was ready in October 1940 but the ‘Great Patriotic War’ intervened and publication was delayed until 1947. The text went to the printers in April 1946. As mentioned above, the loess section of this work was included in a 1960 work and published in 1964 in an English translation, with Berg as the author, 14 years after he died.

We extract here some parts from the text that give a feeling for Berg’s approach to the problem of loess formation, and a description of the mechanism which he was proposing:

“The difference between loess and its parent rock is like the distinction between soil and rock; the transformation of the latter into the former requires a soil-forming process; in the same manner, the transformation of a rock into a loess requires a loess-forming process. The process, though variable in each instance, is everywhere the same in its principle; it is a ‘lessification’, and from this standpoint we are justified in assuming a single family of loessic rocks. Whether we speak of loess or loess-like rocks, they are all the result of the same cause.

No other agency, except processes of weathering in situ and of soil-formation is capable of conferring a loess-like aspect to such material as morainic loam or moronic sandy-loam. It is almost impossible to conceive how else a loess-like sandy loam might have developed” (Berg, 1964, p. 14).

“The peculiar texture and constitution of loess... are the result of particular processes of weathering and soil-formation, taking place in a dry climate. What, then, are the precise physicochemical processes which give the loess its loamy character?

According to Geitröfus, those soils wherein the adsorptive complex is saturated with calcium—and it is precisely the soils of the steppe and the desert zone that have the greatest amounts of adsorbed calcium—produce with water such systems as are coarsely dispersed; even the more clayey varieties of these soils do not contain at all, or contain in very small amounts, particles of colloidal size, i.e. of less than approximately 0.25 μm” (Berg, 1964, p. 14).

“In order that any given rock, e.g. granite or fluvioglacial deposits, might become loess-like in an environment of steppe climate, the following conditions are required:

1. The rock must include a considerable amount of alumino-silicates;
2. It must contain carbonates of alkali earths;
3. It must be more or less fine-grained and permeable” (Berg, 1964, p. 35).

Contrasting approaches

Both scientific and political considerations led to contrasting approaches towards Berg and his pedological theory. This culminated in 1939, when Lysenko and his allies conspired to prevent Berg from being elected to the Academy of Sciences as an academician (so that Lysenko could be elected instead; see Medvedev, 1969). Berg became attacked as a biologist whose most important book was written at the urging of N.I. Vavilov, who was the main target of the politically inspired charlatan group. In the same year, however, Gerasimov and Markov (see Różnycki, 1991, p. 30) promoted the in-situ theory of loess formation as a Russian theory with his subsequent career and they gained the approval of Stalin. The approval of Stalin gave validity to any theory, including several of the most lunatic of the Lysenko notions. The pedological theory became effectively the official loess theory of the Soviet Union, but there was an ongoing discussion between supporters of various theories and advocates of the rival aeolian approach. Różnycki (1991) has detailed some of the controversies:

“In Eastern Europe heated discussions concerning the origin of loess continued. Gerasimov and Markov, outstanding disciples of Berg, defended the views of their master, although they made certain concessions with respect to the possibility of a restricted shelter of the aeolian process in the formation of loess.”

“Pyasakovski (1946) supported the pedogenic theory, maintaining that loess was formed in the subsoil layer of the steppe and was inherent in its soil profile. He attached great importance to organisms assisting carbonate solutions in their downward penetration.”

“The situation became peculiar, because the continuous repetition of the same arguments by either side and rejection of the opponents’ reasons inevitably ended in the discussion dying out. Each of the two groups acted independently, ignoring other opinions, and then whether a definite solution was found or a compromise was found” (Różnycki, 1991, p. 30).

Różnycki’s description of Gerasimov and Markov being ‘disciples’ of Berg may be a little misleading. They may have simply been using the pedological theory to promote their own interests. Gerasimov went on to become the director of the Geographical Institute of the Academy of Sciences, in other words the most important and influential geographer in the USSR. It seems unlikely that a disciple of Berg (who had been so comprehensively attacked) would attain the highest geographical post in the Soviet Union. Gerasimov exploited the Russian roots of Berg’s theory; the link to Dokuchaiev made a powerful appeal in those xenophobic times. It may be that Berg, having been attacked so that Lysenko could be elected to the Academy, had served his purpose and could be left alone. He had become a damaged biologist but he was a successful geographer, as his subsequent career pointed out. Thus he was able to play the discussion on problems of loess formation continued at a high level; there was no suppression of discussion or so it would appear.

Final remarks

The Russian Geographical Society website states (2009) that Berg is strongly related to: Bender, Moldova; Saint Petersburg; geographer; climatologist; biologist; Soviet Geographical Society; The outstanding people of Prinzestrovia; Vasily Dokuchaev Transnistrian Republican Bank; macroevolution; Moscow State University; Holocene; Transnistria; salmo; fossil; Central Asia; fish; Soviet Union; biological classification; Balkans; Issyk-Kul; Saint Petersburg State University; USSR State Prize; lamprey; ichthyology.

This is an impressive list of linkages, to which should be added: loess; loessification; landscape science. The publications by Shaw & Oldfield (2007, 2008a, b) clearly demonstrate the key role played by Berg in the development of landscape science and the importance of land-
Loess material has to be formed; once formed, it is usually transported across the landscape by rivers, and from floodplain deposits aeolian action moves the material to form the open-structured deposits that might, in geological terms, be considered loess. But there are post-depositional events which largely fall within the purview of soil science, and these are important in the development of loess systems (see Makeev, 2009). After the aeolian deposition event, fragipans form, coarsens form, and — most importantly — the open metastable structure can be converted into an open-collapsible structure. The overall primary mineral structure does not change but clay minerals can be concentrated at the particle contacts, and this enhances collapsibility. 'Enhances' is probably a better word than 'causes' with respect to collapsibility, but it does appear that there is a significant post-depositional change in properties. We are now in the world of soil science (with important effects in soil mechanics).

Conclusions

It is now exactly sixty years ago since the death of L.S. Berg. It is timely therefore that the present contribution is dedicated to a scarcely known activity of L.S. Berg, one of the greatest Soviet geographers, whose 125th birthday was celebrated in 2001. L.S. Berg's impact on geography and biology is indelible, but in fact, as we can see now, he was also an outstanding cultural anthropologist. His biggest contribution in this discipline was his book 'Bessarabia. Country - people - economy', edited in Petro-

Appendix: Most significant events in the life of Berg (1876–1950)

1876: Born in Bendery, Bessarabia, Russia on March 14th.
1894: Admitted to the Physics and Mathematics Faculty of Science, Moscow University.
1898: First-degree diploma in zoology and geography, Moscow University; he was a scholarship to attend university.
1899-1900: Inspector of fisheries, Aral Sea region.
1904-1913: Working as zoologist; director of ichthyology at the Zoological Museum of the St. Petersburg Academy of Science.
1908: Publication of a major manuscript, 'The Aral Sea', for which he was awarded the Gold Medal of the Russian Geographical Society.
1909: Awarded Doctor of Science in geography.
1913-1918: Professor of Ichthyology at the Moscow Agricultural Institute.
1919: Birth of daughter Raina, who became a considerable scholar in the field of genetics.
1913: Berg divorces from first wife.
1915: Konstantinovsky medal, Russian Geographic Society.
1915: Publication of 'Landscape Science'.
1916: Appointed as Professor of Physical Geography at the Petrograd University in Saint Petersburg.
1916: Important publication on loess: a long and clear statement of Berg's 'indivisible pedological theory of loess formation, requiring densification.'
1916: Publication of four volumes on the 'Study of fishes of Russia'. The fourth volume was issued in 1949 as 'The study of fishes of the Soviet Union and adjacent countries' and won him the Stalin Prize (1951).
1918: Berg convinced the Bolsheviks to set up a geological institute in Petrograd.
1918–1930: Head of the Lake Department, State Hydrological Institute.
1922: Publication of 'Nonmonogenetic', the Berg view of evolution.
1922: Publication of 'Climate and Life' which contains a large section on loess, based on the 1916 article.
1922-1934: Head of the Applied Ichthyology section, State Institute of Experimental Agronomy.
1923: Second marriage.
1926: First usage in the title of a publication of the term 'soil theory' in the context of loess formation.
1928-1946: Corresponding Member of the USSR Academy of Sciences.
1930-1934: Associate of the Geomorphological Institute of the USSR.
1932: Major English article on loess (reproduced in part in Smalley, 1975).
1934: Honoured Scientist of the Russian Socialist Federated Soviet Republic (RSSR).
1934-1950: Head of the Fish and Fishery section of the Zoological Academy of Sciences.
1939: Proposed for election as Academician (in the biology section) but denied by Lysenko and his associates (see Medvedev, 1969 for Lysenko background).
1940-1950: President of the All-Union Geographical Society of the USSR.
1946: Elected Academician of the USSR Academy of Sciences (in the geography section).
1947: 1952: Publication of 'Geographical Zones of the USSR'.
1948-1949: Publication of 'Freshwater fishes of the USSR and contiguous countries'.
1950: Publication of 'Natural Regions of the USSR' in English.
1950: Berg dies in Leningrad on December, 24th.
1951: Oshumovsky Stalin prize.
1960 Publication of an edition of Collected Works; 'Climate and life' (in volume 3) contains the loess section which was translated as Berg (1964), and which was referred to by Makeev (2009).

1964 Publication of 'Loess as a product of weathering and soil formation' by the Israel Program for Scientific Translations (IPST) in Jerusalem; this is a translation of work essentially completed in 1960.

References
Berg, L.S., 1960. Collected works (with 'Climate and life' as volume 3), containing a major section on loess.

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