Sydney gets a dusting, but what's in it?

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Abstract
During late September 2009, a series of spectacular dust storms moving across eastern Australia and out into the Tasman Sea. One of these dust storm events (September 23rd, 2009) was so severe that it reduced visibility in the city of Sydney to several hundred metres. Such an event offers a rare insight into the conditions that must have prevailed during the arid, glacial periods of the late Pleistocene, when significant aeolian dust deposits are thought to have formed across southern New South Wales (NSW). Deposited dust in Sydney and two inland NSW locations was analysed for particle size characteristics, morphological features and mineral suite. The dust deposited in Sydney, estimated as being around 4 t/km^2 for the event, was very fine, yet contained relatively little clay; the mineral suite was dominated by quartz, with small amounts of iron oxides, kaolinite and illite. For the deposited dust collected in inland NSW, the modal particle sizes were somewhat coarser than those of the Sydney dusts, but other attributes were similar. The transport mode for the dust deposited in Sydney appears to have been primarily particulate, unlike the assumed aggregated mode of transport for the ancient dusts deposited in southern NSW.

Key Words
Aeolian dust, parna, loess, particle size, transport distance

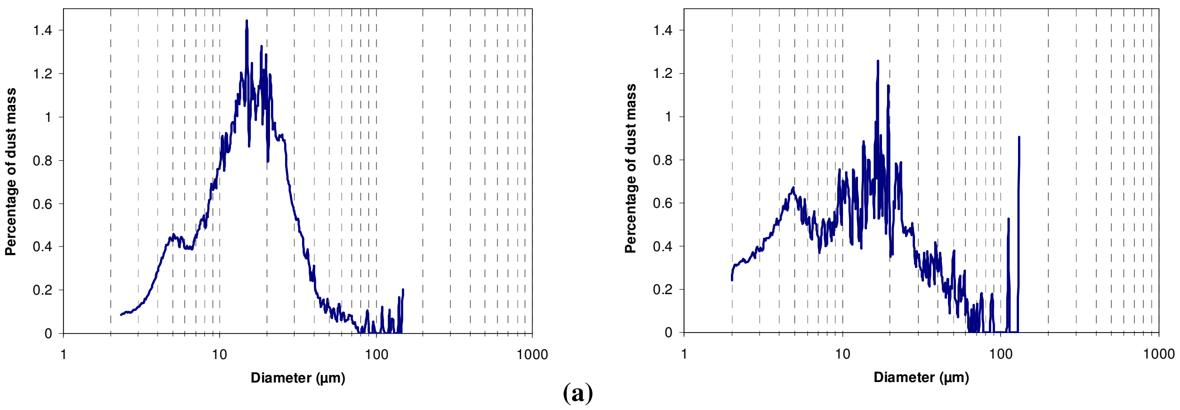
Introduction
In Australia, loess deposits have rarely been reported. Instead, most of the literature reporting aeolian deposits has discussed "parna", a red, clayey material believed to have been formed in deposits laid down during arid phases of the late Pleistocene. The source of this material is presumed to have been the semi-arid lands of northwestern Victoria and the arid lands of western NSW and eastern South Australia. A further assumption regarding this material is that it was transported as silt-sized aggregates of clay and calcium carbonate, along with some companion grains of quartz (Butler, 1956). As noted by Hesse and McTainsh (2003), however, there is scant evidence of either the age(s) or transport mode(s) of this material. During 2009, the western districts of NSW and the Lake Eyre Basin of South Australia experienced a period of prolonged dryness. In the month of September, a series of fast-moving frontal systems swept from west to east across Australia, pushing erosive winds over desiccated landscapes. On Tuesday, September 22nd and Wednesday, September 23rd, large dust plumes engulfed Canberra and Sydney, respectively. In Sydney, the dust plume arrived in the pre-dawn hours of September 23rd and had reduced visibility to several hundred metres by about 7 am. At 9 am the visibility in the city of Sydney was approximately 2 km, and by 2 pm the dust had largely cleared. As this remarkable dust storm provided a rare insight into conditions that presumably prevailed during the previous arid, glacial periods, a number of deposited dust samples were collected in Sydney during and after the event for analysis. Of particular interest was the apparent mode of transport of the dust – did it travel largely as particulates or as aggregated entities? Also, what sizes were the dust grains/aggregates, what were the main minerals in these dusts, and how do these dusts compare to the pedogenically altered dusts that comprise "parna"?

Methods
Deposited dust samples collected
A number of deposited dust samples were opportunistically sampled from car windscreens and verandah surfaces in Sydney during, or shortly after, the dust storm of Wednesday, September 23rd. Similarly, deposited dust samples were taken from previously clean, exterior surfaces of buildings near the central western NSW town of Orange and the southern NSW town of Albury, shortly after the dust storm event of September 23rd. On the morning of the dust storm, three open-topped trays containing glass beads were positioned on the rooves of multi-storey buildings on the campus of The University of Sydney to act as dust traps. These dust traps were removed the following morning and the trapped dust washed off the marbles before being slowly oven-dried.

Measurement and analyses of the deposited dust
For the opportunistically sampled dust deposits, small sub-samples were assessed for particle-size distribution using a Coulter Multisizer 3. The micromorphological features of these dusts were determined and recorded using a scanning electron microscope, while for those dust samples of sufficient mass, the mineral suite was determined qualitatively using X-ray diffraction analysis. A conservative estimate of dust deposition rate in Sydney was made by doubling the amount captured by the traps, as the period of poorest visibility occurred in the 3 hours prior to installation of the traps.

Results

The dust that fell onto Sydney on the morning of Wednesday, September 23rd, 2009 was remarkably fine. As indicated in the particle size distributions in Figure 1, the dust particles falling onto car windscreens up to 9 am, and between 9 am and 12 pm that day, have modal diameters of around 18 µm and 5 µm. Interestingly, the finer population appeared to increase in proportion as the morning wore on (cf. Figures 1a and 1b), despite the fact that windspeeds picked up during the morning and visibility gradually improved. Although the Coulter Multisizer does not effectively measure clay-sized particles, the notable presence of particles 2-5 µm in diameter, particularly in the windscreen dust deposited between 9 am and midday, suggests the concomitant presence of clay-sized material. This was confirmed when dust samples were viewed under the scanning electron microscope, with clay-sized particles found to be adhering to fine silt-sized grains of quartz. Particulate dust appeared to be more common than strongly aggregated dust.



(a) (b)

Figure 1. High-resolution particle size distributions of deposited dust samples obtained from a car windscreen at The University of Sydney at (a) 9 am and (b) 12 noon, on Wednesday, September 23rd, 2009.

The dusts sampled at Orange and Albury was distinctly coarser than the Sydney dust (modes between 20 and 30 µm), but there were still minor populations of finer (5-20 µm) particles. This difference in dominant particle size is reflection of the distance travelled from source. Mineralogically, the dusts collected in Sydney, Orange and Albury are relatively uniform, consisting primarily of quartz, with smaller contributions of iron oxides, kaolinite and illite. Calcium carbonate, a prominent component of the “parna” conceptual model, was not present in any of the dust samples. The contribution of iron oxides to the dust that engulfed Sydney is likely to have been temporally variable. In the first few hours after sunrise, the suspended dust was distinctly reddish-brown in colour, whereas by mid-morning the suspended dust was light brown in colour. Verification of this dust colour change is provided by comparison of the deposited dust samples collected after 9 am with those samples including dust from the entire event; the whole event dust samples are red-brown, whereas the post-9 am samples are light brown. Presumably this colour difference is a result of different source areas contributing sediment to the different parts of the air cell moving across NSW the preceding night.

Only a conservative estimate can be made of the dust deposition amount in Sydney on September 23rd because dust traps were not installed on building rooves until 9 am, by which time the suspended dust had thinned somewhat. Nevertheless, the three traps installed captured between 1 and 2 g dust/m^2, which equates to between 1 and 2 t dust/km^2. As the windspeed increased during the morning, it could reasonably be expected that deposition was greater before 9 am than after, so doubling the post-9 am amount (to 4 t dust/km^2) would seem to be a plausible, conservative estimate of total dust deposition. Whilst this is not a large deposit by global standards, it represents about a half of the annual dust deposition measured at a number of other Australian sites (Cattle *et al.* 2009).

Conclusion

The spectacular dust storm that engulfed Sydney on September 23rd 2009 offered a glimpse of the conditions that must have prevailed during the arid glacials of the late Pleistocene. It is thought that aeolian dust deposits of southern NSW were laid down during these arid glacial periods, but there has been conjecture over the form of the transported dust and the degree of pedogenesis of this sediment. Dust samples collected from around Sydney and from two inland NSW locations were generally very fine-grained, but not particularly well aggregated. Mineralogically, these dust samples are dominated by quartz, with small amounts of iron oxide, kaolinite and illite. Calcium carbonate does not feature prominently in any of the dust samples. Overall, the dust transported in this event does not strongly conform to the conceptual model of "parna" which took hold in Australia in the 1950s.

References

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