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Aeolian Dust - Gift from the Gods or Curse from Hell?

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Most of the earth's land surface is blanketed by aeolian dusts and about 10 % of the land surface carries a dust cover of considerable thickness, in certain places up to 300 m and even more. The dust deposits provide information about environmental conditions at the present time and in the geological past. Dust storms are often very powerful, dangerous and disastrous for the environment causing severe problems for human civilization. Modern dust may be polluted with harmful atmospheric particulate matter causing disease and raising mortality. On the other hand, long-lasting dust deposition has provided fertile ground for the development of ancient farming civilizations such as the early Chinese advanced civilization. In addition, aeolian loess deposits in both hemispheres form the most important archives of Quaternary palaeoclimatic and palaeoenvironmental history on land as shown by the study of many physical and chemical properties, especially the magnetism of the dusts.

Under semiarid to arid conditions, dusts are converted to loess due to weathering, biological activity and secondary calcification. The magnetism of loess sediments has been studied worldwide for about 25 years, ever since it became clear that the natural remanent magnetization (NRM) of these dust deposits faithfully records the polarity of the geomagnetic field. The Matuyama/Brunhes polarity boundary was recognized in many regions worldwide and it was found that the beginning of the proper loess formation coincided roughly with the Gauss/Matuyama boundary. The beginning of general dust deposition in China, however, started much earlier, some 22 Ma ago.

Since the loess formations have accumulated in variable palaeoclimates during the Quaternary, they usually consist of an alternation of pristine loess layers which formed under cold arid conditions, and of loess altered to palaeosols under warm humid conditions. These lithological changes are also recorded in every detail by the observed rock magnetic properties. For instance, magnetic susceptibility of Chinese loess is enhanced in the palaeosols and has been used to tune the aeolian sequences to the earth's orbital frequencies thus providing a refined time frame for loess deposition. Attempts have also been made to quantify the relations between palaeoprecipitation and rock magnetism.

On a broad scale the magnetic research has been extremely successful in dating and in palaeoenvironmental reconstruction. On finer scales, however, many problems remain unsolved and need to be answered in carefully selected study programs if further progress is to be made: The NRM acquisition process, even the origin of NRM, if chemical or detrital, is still debated. This affects the accurate stratigraphic location of reversal boundaries or the determination of palaeointensities of the geomagnetic field. The natural mineral formation is closely connected to environmental change, but still the pathways and extent of diagenetic mineral and especially magnetic mineral formation which are related to pedogenesis, are largely unclear. Hence quantitative relations between climate (e.g. precipitation) and magnetism must remain vague at present.

Simple single parameter methods will probably not work to solve the questions currently facing us. Integrated mineralogical-rock magnetic studies are required. Magnetization processes have to be modelled by integrating stratigraphic information, pedological and palaeontological data and mineralogical observations about iron mobility. Second-generation studies of this kind have the potential of enhancing the value of the original "gift", but it remains to be seen if ongoing global change will lead to the "curse" of a dustier future.