Interpretation of sedimentary subpopulations extracted from grain size distributions of loess deposits in the Sea of Azov, Russia

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Abstract

Loess-palaeosol sequences (LPS) in Eastern Europe, especially those in the Azov region, are among the most sensitive terrestrial archives for identification of past aeolian dynamics and Quaternary palaeoclimatic reconstruction. Grain size analyses of loess sediments are used to interpret these transport mechanisms and palaeoclimatic changes based on granulometric parameters and statistical decomposition methods. Here, we present the results of unmixing grain size distributions from a loess-palaeosol section at the Sea of Azov, Russia, by jointly applying the standard deviation method and end-member modelling. The results indicate that the two methods can produce similar grain size decompositions but that end-member modelling has advantages in terms of quantitative and objective characteristics. In addition, three main loess subpopulations or end-members (EMs) with mode sizes of 8 μm, 18 μm and 32 μm, which represent distinct aerodynamic environments, are identified from the grain size distribution in the Azov region. Thereinto, EM1 with a mode size of 8 μm is the integrated result of combining atmospheric circulation with other environmental processes. EM2 with a mode size of 18 μm is inferred to represent continuous background dust under non-dust storm conditions. EM3 with a mode size of 32 μm is a fraction transported in short-term, low-altitude suspension clouds during dust storm outbreaks. Of the three EMs, EM1 and EM2 have multiple origins due to their complex formations, whereas EM3 is primarily derived from the alluvial plains of different rivers flowing into the Sea of Azov.

Stratigraphy and methods

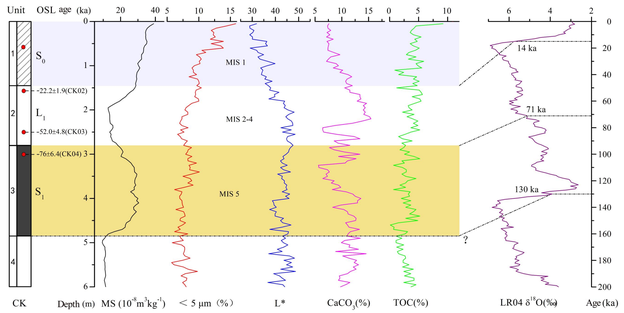


Fig. 3. Stratigraphic subdivision of the CK section on a basis of combination between optical dates and multi-proxies and correlation with benthic oxygen record.

Methods used in this study

- Magnetic susceptibility (MS)
- Grain size analysis (GS)
- End-member modelling analysis (EMM)
- Standard deviation analysis (STD)

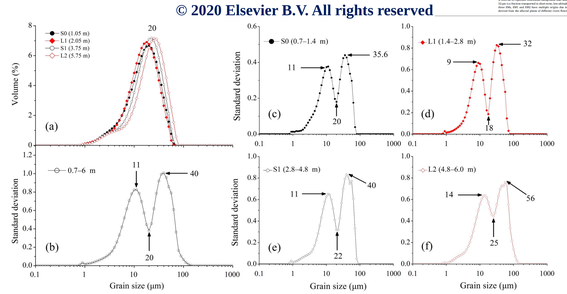
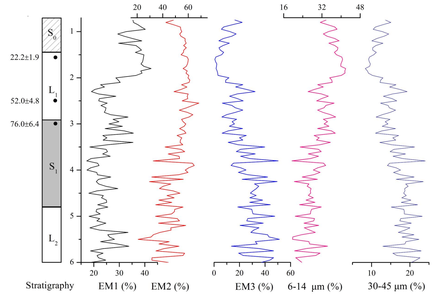


Fig. 7. Results of using the STD method.



- Two pronounced populations, at grain sizes of 6-14 μm (fine silt) and 30-45 μm (coarse silt), are observed in the plot of the whole section (Fig. 7).
- EM1 exhibits high-frequency and large-amplitude fluctuations, EM2 and EM3 change inversely.
- Proportions of 6-14 μm and 30-45 μm display fairly similar to those of EM2 and EM3.
- These three subpopulations are related to potential sediment origins, possible sediment transport processes and different conditions of deposition or re-deposition.

Fig. 8. Variations of three end-members and sensitive grain-size proportions (6-14 μm and 30-45 μm).

Study area

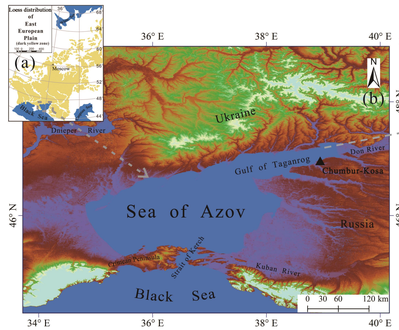


Fig. 1. map showing the location of the Sea of Azov in the East European Plain.

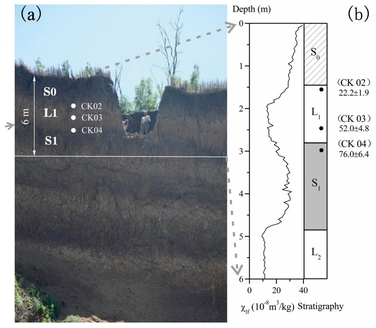


Fig. 2. Photograph of the Chumbur-Kosa section and the stratigraphy with OSL ages (ka) and MS.

- The Sea of Azov (45° ~47° N, 35° ~39° E) is an internal sea with an area of 37,600 km². It is situated in the southern area of the East European Plain and bordered by the Crimean Peninsula to the west and the East European Plain to the north and east.
- Main rivers flowing into the sea are the Don and Kuban, accounting for more than 90% of total inflow.

- The Chumbur-Kosa (CK) section (46° 57′48″ N, 38° 56′47″ E) is situated on the southern bank of the Taganrog Gulf, comprising a sedimentary thickness up to ~16 m.
- A total of 120 bulk samples were collected at intervals of 5 cm from the top of the section down to 6 m.

Results

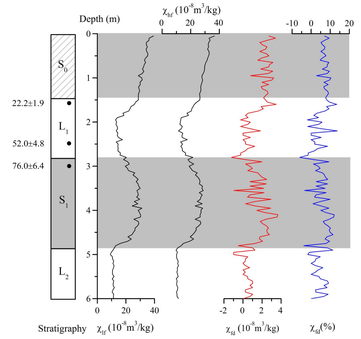


Fig. 4. Variations in MS of the CK section.

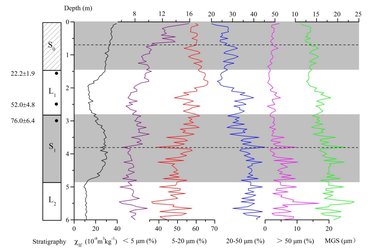


Fig. 5. Variations in GS of the CK section.

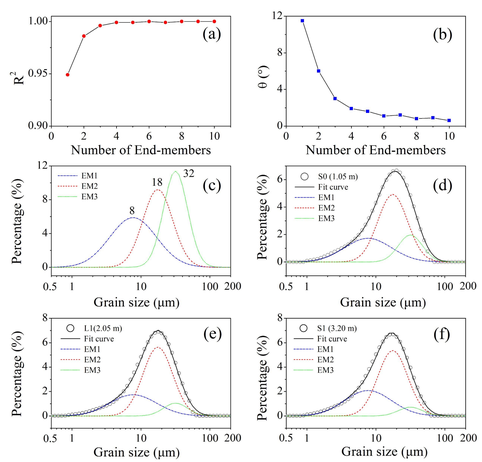


Fig. 6. Results of using the EMM method.

- The MS variations exhibite distinct characteristics with higher MS values occurring in palaeosols and lower MS values in loess (Fig. 4).
- Contents of fine and coarse silts range from 36.07 to 66.26% and 19.80 to 45.37%, respectively. Clay and sand fractions are minor components (Fig. 5).
- There are three subpopulations EM1, EM2 and EM3 with modal sizes of ~8 μm, 18 μm and 32 μm in CK section. (Fig. 6).

Conclusions

- Three grain size EMs are identified in the CK section, EM1, EM2 and EM3.
- EM1 (8 μm) is the integrated result of combining atmospheric circulation with other environmental processes.
- EM2 (18 μm) represents continuous background dust under non-dust storm conditions.
- EM3 (32 μm) is indicative of coarse silt fractions that are transported in short-term, low-altitude suspension clouds during dust storm outbreaks.
- EM1 and EM2 have multiple origins due to their complex formations, while EM3 originate mainly from the alluvial plains of different rivers around the Sea of Azov.

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