Loess deposits from two different times: A comparative review

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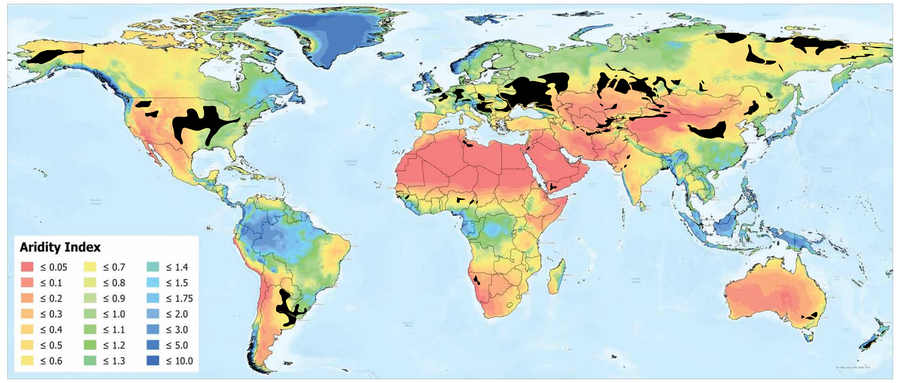
Abstract

Loess deposits are key repositories of Earth's past environment, climate, and surface processes. Here we compare the middle Cenozoic and late Paleozoic loessites to understand the climate conditions that generated abundant silt grains and strong wind systems. The latest Eocene-early Oligocene loess in the western U.S.A. and China occurred during the rise of the North America Cordillera or Tibetan Plateau and late Eocene-early Oligocene global cooling. Similarly, the Permian loessites were deposited on the supercontinent Pangea during the uplift of the Ancestral Rockies and Central Pangean Mountains and late Paleozoic ice age. Therefore, both deposits coincided with mountain uplift and climate cooling. Glaciation in the equatorial region during the late Paleozoic was the major mechanism of silt production, with some contribution from river erosion and transport as an intermediate process. The silt of the middle Cenozoic loess was also derived by recycling of sediments by fluvial processes from Cambrian to Cenozoic sedimentary strata during late Eocene and concurrent volcanic activities. However, the stepwise retreat of the Paratethys coupled with global cooling and Tibetan plateau uplift caused desertification in the western central Asia which provided the dust for the Chinese loess during the mid Eocene.

Quaternary Loess Distribution

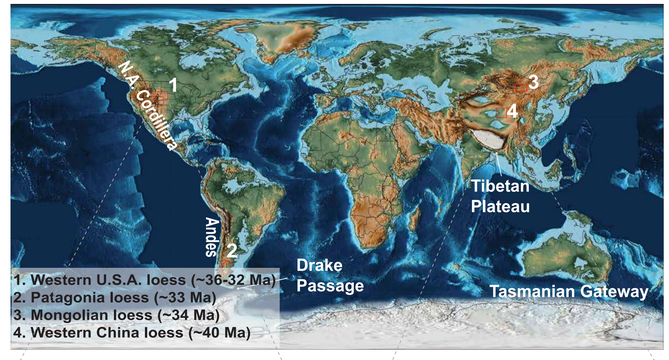


Map of quaternary loess deposits (black polygons) after Li et al. (2020). Aridity index taken from Zomer et al. (2022).

Loess (Age and location)	Major tectonic event	Effect of global cooling	Major Silt providing mechanism
Mid Cenozoic – Western USA	Rise of NA cordillera	Formed around the EOT, but some section dates back to ~32 Ma	Recycled fluvial sediments, and vocaniclastics
Mid Cenozoic – China	Uplift of Tibetan plateau	Not the driving factor, but played an important role later on	Desertification of Central Asia
Late Paleozoic – France and Western USA	Formation of Central Pangean Mountains and Ancestral Rocky Mountains	Major contributor, falls within the late Paleozoic ice age	By glacial and periglacial processes from the Central Pangean Mountains and Ancestral Rockies, reworked by rivers

- Quaternary loess deposits are closely associated with semi-arid regions globally.
- The map indicates a strong correlation between the distribution of Quaternary loess and low aridity index values (0.2-0.5).
- This spatial analysis reinforces the notion that semi-arid climates play a crucial role in the formation and distribution of Quaternary loess deposits.

Mid Cenozoic Loess



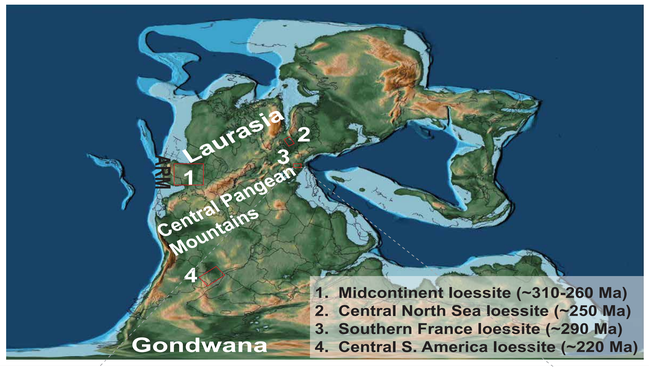
Western U.S.A. loess (~36-32 Ma) (Fan et al., 2020)

- Started just before the EOT, at around ~36 Ma.
- Renewed uplift of NA Cordillera and the global cooling have contributed to the formation of this loess.
- It was likely recycled from fluvial sediments with a great volcaniclastic input.

Western China loess (~40 Ma) (Meijer et al., 2021)

- Dust appearance started at around ~40 Ma.
- Uplift of Tibetan plateau, retreat of Paratethys and the global cooling are major contributors to the formation of this loess.

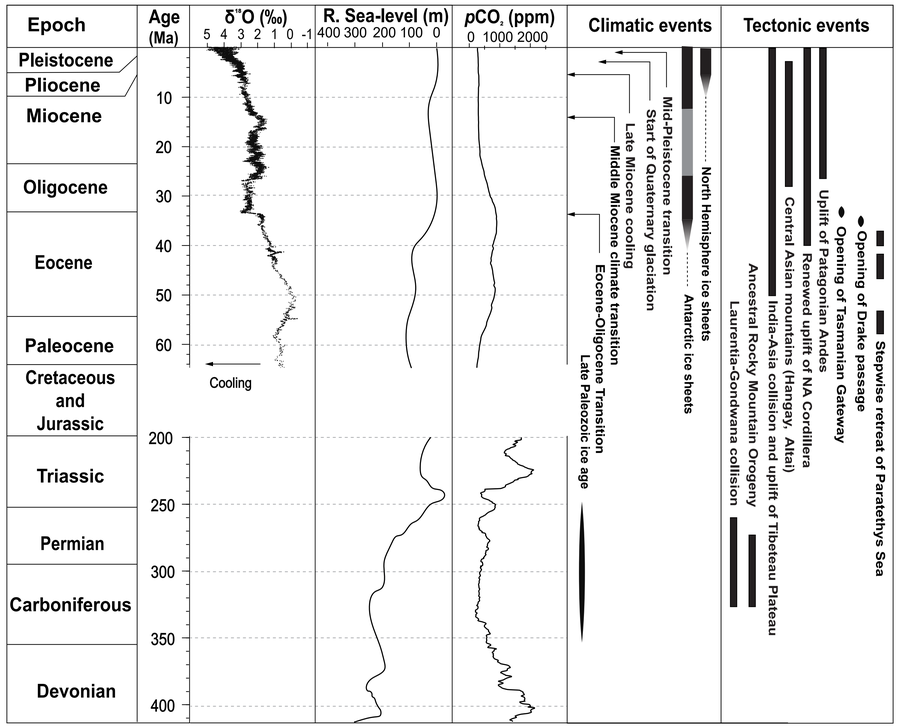
Late Paleozoic Loessite



Southern France loessite (~290 Ma) (Soreghan et al., 2008)

- Dates back to ~290 Ma, lies in the period of late Paleozoic ice age.
- The Laurentia-Gondwana collision which formed the Central Pangean Mountains, which may have caused regional drying,
- leading to loess formation.

Paleoclimate proxies and geologic events



Comparison of oxygen isotope records alongside global changes in sea level and atmospheric CO_2 concentrations. The rightmost columns denote major tectonic and climate events. The alignment of these records offers insights into the interplay between loess deposition and significant geological and climatic events throughout history.

Conclusions

Global climate changes, on a longer timescale, is controlled by land-sea distribution and tectonic uplift of mountains and plateaus, as well as atmospheric pCO_2 drop cause continental aridification and enhance silt production. The Quaternary loess, middle Cenozoic loess, and late Paleozoic loessites all occurred during a major global climate cooling period. While the late Paleozoic loessites and middle Cenozoic loess were mostly driven by climate changes induced by tectonic uplift and land-sea redistribution, the Pleistocene-Quaternary loess deposition was driven and enhanced by global climate cooling.

References

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