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Research Advances

Zircon U-Pb Ages of Quaternary Loess-Paleosol Sequences from the Luochuan Section: Implication for Sediment Provenance

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Objective

The sediment provenances of the thick Quaternary Loess-Paleosol sequences of the Chinese Loess Plateau can provide clues to the evolution of the paleoclimate and paleoenvironment in East Asia. Furthermore, based on the proposed sediment sources and transport routes, the evolution of the East Asian monsoon can be evaluated.

Methods

U-Pb geochronology of detrital zircons is one of the powerful approaches to trace sediment provenances because the multi-age populations can reveal the multi-source regions. This study provides the U-Pb ages of detrital zircons of the Quaternary loess-paleosol sequences from the Luochuan section of the Chinese Loess Plateau. Totally, eight layers were sampled. From the top to the bottom, it includes the dark loessial soil S0 (0.067±0.02 Ma), Malan loess L1 (0.12–0.08 Ma), second loess L2 (0.196–0.12 Ma), second paleosol S2 (0.246–0.196 Ma), second silt L15 (1.25–1.1 Ma), twenty-fourth loess L24 (1.6 Ma), twenty-sixth loess L29 (1.87 Ma), and bottom loess L33 (2.5 Ma) layers. They are utilized to constrain the provenances of sediments in this region after 2.58 Ma.

Results

The U-Pb dating results of detrital zircons from the eight layers (S0, L1, L2, S2, L15, L24, L29, and L33) of the Luochuan section were processed, and age populations of each layer are illustrated in Fig. 1. All of these samples show the dominant age peaks between 200 Ma and 600 Ma, but they are distinct in the older age populations. Samples from the lower layers (L24, L29, and L33) display age peaks around 1800 Ma and 2500 Ma, whereas those from the upper layers (L15, S0, L1, L2, and S2) show peaks around 900 Ma and 1800 Ma. The differences in the older age distributions between the upper and lower layers indicate that they have different provenances, which further implies that, between 1.6 Ma (L24) and 1.25 Ma (L15), the sources of the Quaternary sediments of the Chinese Loess Plateau were changed.

The lower layers (L24, L29, and L33) show the two main peaks (200–360 Ma and 420–600 Ma) between 200 Ma and 600 Ma with subordinate peaks around 1800 Ma and 2500 Ma.The age distribution patterns of the lower layers from the Luochuan section are quite similar to those of the northern China deserts that were derived from the North China Craton and display age groups of 2.3–2.6 Ga and 1.6–2.2 Ga. Therefore, we propose that before 1.6 Ma, the sediments of the Chinese Loess Plateau were dominantly derived from the eroded bedrocks in North China, and transported by the north wind.

The upper layers (S0, L1, L2, S2, and L15) exhibit the main age groups between 200 Ma and 600 Ma with subordinate groups around 900 Ma and 1800 Ma, which are similar to the geochronological characteristics of the Tibet Plateau. It suggests that sediments in these layers were derived from the Tibet Plateau by the Yellow River and from the northern part of the Qilian Mountain by the northwest wind.

Based on the results of early studies and this study, we propose that a climatic event took place around 1.6 Ma in East Asia. Before 1.6 Ma, the prevailed north wind transported the dust from the eroded bedrocks in North China to the Chinese Loess Plateau. Then, around 1.6 Ma, the Tibet Plateau began a new stage of uplift, which resulted in the increase of ice coverage, dry climate, enhancement of the wind, extensive development of mountain rivers, and intensive erosion of mountains. As such, the Yellow River, originated from the Ba Yan Carat Mountain, could transport the eroded materials from the

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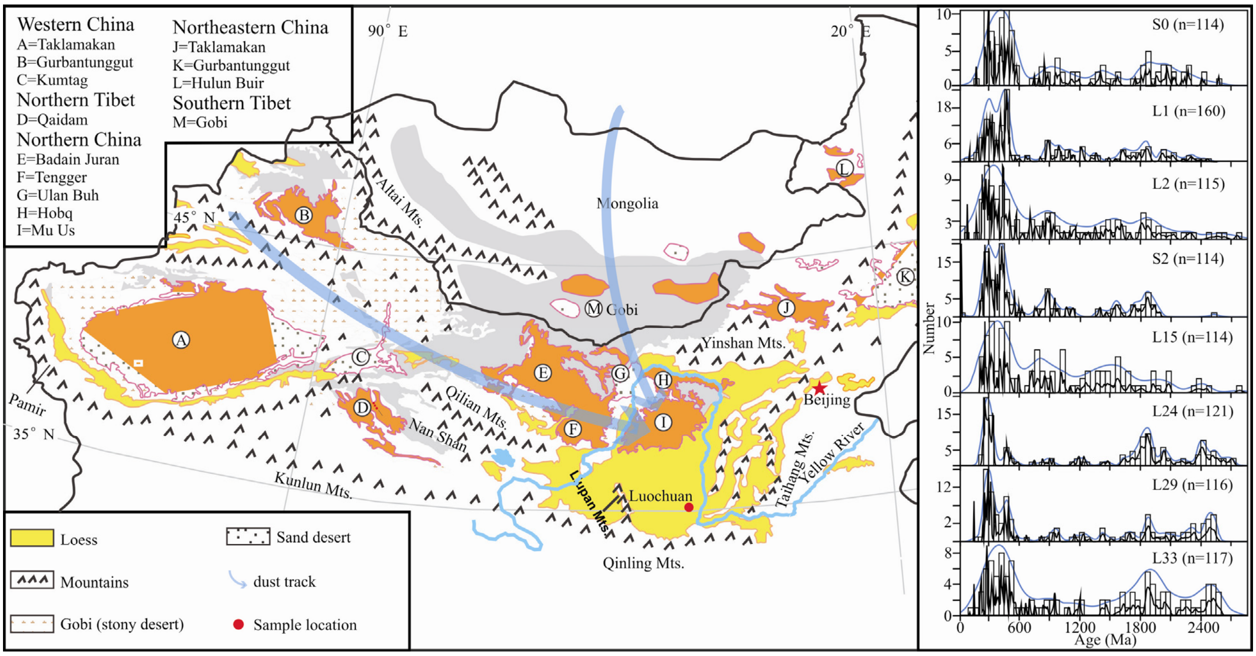

Fig. 1. Left: Distribution of the Chinese loess deposits, potential source regions, and proposed dust tracks. The northern arrow represents the transport route before 1.6 Ma, and the western arrow represents the transport path after 1.6 Ma. Right: Zircon U-Pb age distribution patterns of samples from the Luochuan section.

Tibet Plateau to the western Mu Us desert. Furthermore, the enlarged ice sheet made the Tibet Plateau become a "low-temperature center" in East Asia, which caused the northwestern deflection of the winter monsoon. As such, the Tibet Plateau at that time was one of the provenances of the Chinese Loess Plateau.

Conclusions

The U-Pb age distribution patterns of detrital zircons from the eight layers (S0, L1, L2, S2, L15, L24, L29, and L33) of the Luochuan section of the Chinese Loess Plateau shed light on the variations of sediment provenances in this region after 2.58 Ma. The upper layers (S0, L1, L2, S2, and L15) derived from the Tibet Plateau have distinguishable age peaks to the lower layers (L24, L29, and L33) derived from the northern China deserts. The change of provenances from the north China deserts to the Tibet Plateau suggests that the direction of the East Asia winter monsoonwas changed from north to northwest, which was directly driven by the uplift of the Tibet Plateau.

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