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Research Advances

North Atlantic Abrupt Climate Signals during the Last Glacial Period in Central Asia: Evidences from Aeolian Loess Sediments

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Objective

Climate fluctuations over suborbital or millennial timescale display significant instability during the last glacial period, which are often superimposed upon the orbital periodicity. They triggered some abrupt climate events, such as the Dansgarrd/Oeschger (D-O) events recorded in the Greenland ice cores and the Heinrich (H) events recorded in the North Atlantic marine sediments. Abrupt climate events during the last glacial period have been a hot issue in the circle of Quaternary paleoclimate. There has been a large effort to determine whether these climate events were global scenarios or were just confined to the North Atlantic, with attempting to reveal the mechanisms hidden in these events.

Westerlies circulation can transmit climate signals from North Atlantic and Greenland to East Asia, while Central Asia as an important climatic hub is subject to the westerlies and responds sensitively to global climate change. Thick aeolian loess sediments are distributed in the pediments and terraces in Central Asia, providing us an ideal archive to test orbital and millennial timescale climatic changes in westerlies-dominated areas. However, such millennial events have a noticeable lack of loess records from the westerlies-dominated Central Asia due to the limited robust geochronology and unclear paleoclimatic proxies. Recently, we found a 30.7-m thick loess outcrop XEBLK section in the Ili basin located in NE Central Asia. This study aims to establish a reliable geochronological framework in this section, and attempts to identify the abrupt climatic signals from aeolian loess sequences.

Methods

Quartz optically stimulated luminescence (OSL) and grain size measurements were employed to establish chronological framework and reconstruct the paleoclimatic history. Grain size of loess deposits can serve as an index of past variations in both aeolian dynamics and patterns of atmospheric development. Coarsening of median grain size were associated with strong westerlies circulation in Central Asia. Therefore, we attempt to recognize the North Atlantic abrupt climatic signals from the median grain size. In order to validate the role of the Westerlies as an environmental bridge between the North Atlantic and East Asia as proposed by previous researchers, we compared grain sizes with temperature variations from Greenland ice cores and Westerlies index (WI) from Lake Qinghai lacustrine sediments,

Preparation and measurement of OSL samples were performed at Qinghai Institute of Salt Lakes, CAS. Medium -grained (38–63μm) quartz OSL were determined using an automated Risø TL/OSL DA-20 reader. The single aliquot regenerative-dose (SAR) protocol was used for the equivalent dose (De) determination. U, T and K concentrations were obtained using neutron activation analysis (NAA) method. Grain sizes were measured using a Malvern Mastersizer 2000 laser grain-size analyzer at the Institute of Earth Environment, CAS, and replicate analyses indicate that the mean grain size has an analytical error of <2%.

Results

The OSL dating results (Fig. 1a and b) show that XEBLK loess developed since the last 30ka about late Marine Isotope Stage 3 (MIS3). No obvious hiatus or

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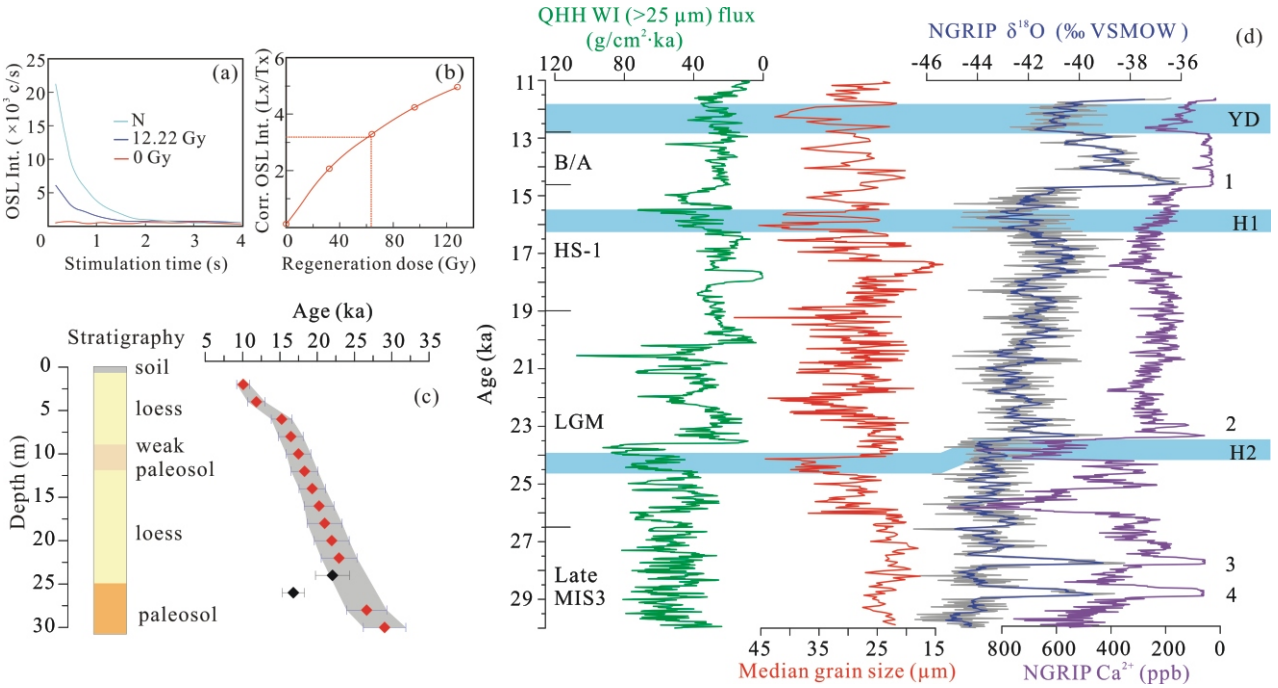

Fig. 1. (a) OSL decay curve of sample XEBLK-12; (b) the dose response curve showing De determination; (c) OSL ages and stratigraphy of XEBLK section; (d) comparison of Central/East Asia and North Atlantic climate records (blue bars denote the Heinrich-like events; black numbers (1 – 4) denote well aligned D-O events).

unconformity was found in this section at the present OSL sampling resolution (Fig. 1c), which allowed to construct a depth-age model using interpolation between selected data points (Fig. 1c).

We regarded the coarsening and fining of median grain size as stronger and weaker westerlies circulation in Central Asia, respectively. It is found that the coarsening or fining generally match the North Atlantic Heinrich events (YD, H1 and H2) or D-O events (1 − 4) in Greenland ice-core records well (Fig. 1d), although the amplitudes and frequencies are different to some extent. The variations in median grain size of the XEBLK section are the same as the tendency reflected in the WI of the Qinghai Lake sediments during, for example, 11 to 16 ka, 18 to 22 ka and 24 to 26 ka. And both respond to slight change of Greenland temperature, especially for the event at ~17.5 ka although their ages are asynchronous because of dating errors. Anyway, these similar changes indicate the existence of the millennial-scale climate events in the XEBLK section at the Westerlies-dominated region in Central Asia. The similarity of median grain size and WI curves also suggests the eastward extent of the rapid climate signals from Central Asia to East Asia, and Westerlies plays a critical role on transmitting the North Atlantic signals to East Asia.

Conclusions

We used the grain size of the XEBLK loess section to reconstruct the westerlies climatic history and variability. Based on OSL dating results, the XEBLK loess was developed primarily since the late MIS3. This research reveals that the millennial-scale abrupt climatic events also existed in the loess sediments in Central Asia although their amplitudes and frequency are different to some extent. Westerlies play a critical role on transmitting the signals from the North Atlantic to Central/East Asia. However, further work is needed to confirm these findings and discuss the driving mechanism of climatic change during the last glaciation.

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