THE FIRST INDEPENDENT CHRONOLOGY FOR THE EAST ASIAN MONSOON OVER THE LAST 200,000 YEARS FROM LOESS

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Abstract

The Asian monsoon rains directly sustain 2/3 of the world’s population and related processes of both increasing aridification and catastrophic flooding in India and China have major environmental and societal impacts. The vast area of wind-blown dust (loess) deposits in China store a detailed record of the behaviour of the East Asian monsoon system through the properties of the sediments and are known as one of the most important archives of past climate. However, the interpretation of this record requires an accurate knowledge of when the loess was deposited.

This project has developed and used novel luminescence dating methods to develop the longest, most detailed age models of any loess deposits to date, providing reconstructions of climate at unparalleled detail in loess. They show that the loess record is not always continuous, contrary to popular belief, and that accurate climate records rely on identifying these breaks. Furthermore, our new age models show that the timing of peak dust accumulation at this site matches that recorded in North Pacific marine and Greenland ice core records supporting the suggestion of at least hemispheric synchronicity in past dust activity, a major component of the global climate system. This new knowledge is an important contribution to improving models of Asian and global climate, and so improving our ability to predict future climate.

Short project report

The aim of the project was 1) to develop the first radiometric chronological scale covering the last two glacial-interglacial cycles for a key East Asian (EA) monsoon archive: Chinese loess (dust) and thus 2) to investigate the relationship between this EA monsoon record and other climate archives. There were no major changes from the original research plan although the Japanese part of the project proved to be less important. Three field campaigns were undertaken (1 in Japan, 2 in China) and a total of ~500 luminescence samples were collected together with more detailed proxy record sampling. The project resulted in peer-reviewed publications related to methodological developments of luminescence dating and several new chronostratigraphies and interpretations of key loess (and lake) archives were also published (see publication list).

1) A previously unidentified dependence on test dose size was detected for the SAR pIRIR dose measurement protocol both for doses given in the laboratory and for natural doses; however, the resulting ages were found to be independent of test dose size for test doses that lie between 30-80% of the dose to be measured. First IR stimulation plateaus also indicate that for older samples with doses > ~600 Gy a first IR stimulation temperature ≥170°C should be used in the SAR pIRIR measurement protocol. This research resulted in more robust dose estimates and so ages.

2) Major gaps were identified in the loess record at the northern edge of the Chinese Loess Plateau at Jingbian. This site is considered as one of the three global stratotypes in the IUGS time scale. This project
has dated 5 sections at this site at high spatial resolution (230 samples in total) back to ~250 ka. Striking hiatuses of up to ~60 ka (approximately a full glacial cycle) have been identified. This result highlights the considerable risk of using “wiggle-matched” orbitally tuned age models for loess sections at this location. In addition, the appropriateness of the Jingbian section as a global stratotype needs re-evaluation.

3) Investigations of the last glacial period at Xifeng and comparison with other loess sites demonstrate significant pedogenic and anthropogenic disturbance of material younger than ~20 ka. In contrast to a recent study (Kang et al., 2015, Quat. Int.), the timing of peak dust mass accumulation rates at Xifeng matches the timing of peak dustiness recorded in North Pacific marine and Greenland ice cores, supporting a major pulse in atmospheric dust at that time. The Xifeng data support the assertion that there is a teleconnection between the North Atlantic and East Asian climate systems, providing critical insight into the nature of links in the last glacial climate system.

4) The research carried out in this project sets a new standard for loess chronostratigraphy and demonstrates the necessity for instrumentally dated Chinese loess records rather than those based on the correlation of proxies. Only with such independently dated EA monsoon records can the information recorded in the loess archive be accurately interpreted.