

U-series dating of Quaternary climatic and archaeological indicators

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SUMMARY

Since the development of mass spectrometric techniques for U-series dating some 20 years ago, fundamental breakthroughs have been made in Quaternary climatic and archaeological studies. In this presentation I will summarise research highlights in U-series dating of palaeoclimatic and archaeological indicators achieved at the University of Queensland over the past five years. These include speleothem records from Australia and China covering the Last Interglacial, the Last Deglaciation and the Holocene periods, coral records in the South China Sea and other sites and *Homo erectus* and *Homo sapiens* sites in China.

Key words: U-series dating, speleothem, coral, Quaternary, palaeoclimatology, archaeometry.

1. INTRODUCTION

The development of mass spectrometric U-series dating techniques over the last 20 years has revolutionised Quaternary geochronology and contributed to a much improved understanding of Quaternary processes. Examples of important outcomes derived from such studies include accurate calibration of ^{14}C time-scale beyond the range of dendrochronology, precise timing and characterisation of climatic events, trends and cycles on different time scales, and numerous discoveries in human origins and evolution.

UQ's Radiogenic Isotope Laboratory is among the first couple of laboratories in Australia that established mass spectrometric U-series dating techniques. Over the past five years, numerous research initiatives and projects have been developed in collaboration with colleagues in Australia, New Zealand and China, and some 1200 coral, speleothem and fossil tooth samples dated. A few important research highlights covering the fields of palaeoclimatology and archaeometry will be reported here.

2. U-SERIES DATING OF PALAEOCLIMATIC INDICATORS

Among materials suitable for U-series dating, corals and speleothems are the two most important types that are ideal for dating and that bear important climatic information. We have undertaken U-series dating of speleothems from Tasmania, Queensland, New Zealand, and China, and corals from South China Sea, Great Barrier Reef, Moreton Bay, Western Australia and Pacific islands for a range of research projects. Following is a summary of some research highlights:

- **Speleothem records for the Last Glacial - Holocene transition**

The phase relations of climate change between the Northern and Southern Hemispheres (NH & SH) during the last

deglaciation - Holocene transition are important for understanding of the Earth's climatic system. However, our ability to address the question of whether or not climatic events in the SH are synchronous with those in the NH has been hindered by the lack of well-dated, high resolution, climatic archives. Increasing evidence shows that climatic changes in the SH lead those in the NH by 1000 to 2500 years, but few of such records are based on precise and accurate dates. Our U-series-dated speleothem records from South China and Northern Australia show that oxygen isotopic excursions in a Chinese speleothem between 20 and 10 ka are well correlated in timing with climatic oscillations in the Greenland ice core records [1], whereas the speleothems from Northern Queensland (Chillagoe) display features somehow similar to those seen in the Antarctic ice cores. The results suggest that climatic events were not synchronous between the two hemispheres and deglacial climatic changes were possibly driven by events in the high-latitude and polar regions.

- **Speleothem records for the Last Interglacial**

The precise timing and duration of the last and previous interglacials are important for understanding mechanisms that triggered deglaciation, and for obtaining insights into the course of the Holocene as we potentially approach the next ice age. Our high-precision U-series dating of a stalagmite from Newdegate Cave in Tasmania show that fastest stalagmite growth occurred between 129.2 ± 1.6 and 122.1 ± 2.0 ka (~ 61.5 mm/ka) [2], coinciding with a time of prolific coral growth from Western Australia (128-122 ka) [3]. Such correlation shows that in southern Australia onset of full interglacial sea level and initiation of highest precipitation on land were synchronous. The timing of the commencement of full interglacial conditions is also supported by initiation of a stalagmite's growth in Genghis Khan cave, and its C-O isotopic records in a subtle way. Our data, together with other published records from the Northern Hemisphere (see [4] and references therein) suggest that the onset of full interglacial conditions is globally synchronous, consistent with Milankovitch insolation forcing of global climate.

- **Speleothem records for the Holocene period**

We have dated speleothem C-O isotopic records from caves in China, Tasmania and Queensland. All these records imply a generally warmer and wetter early-mid Holocene followed by a generally cooler and drier mid-late Holocene, despite difference in their detailed patterns and trends. It is interesting to note that the 8200 yr climatic event was manifested in both Tasmanian [5] and Chinese records. The C-O isotopic trends in the Chinese speleothem records appear to follow the trends of East Asian monsoon index and summer insolation in the region. The northern Queensland record probably reflects changes in the intensity of Austral summer monsoon rainfall that may be related to the East Asian monsoon system.

- **Coral records in the South China Sea**

South China Sea (SCS) (4-22 °N) is climatically important for it is part of the Western Pacific Warm Pool and the moisture source region of the East Asian summer monsoon rainfall. We have carried out detailed investigations of coral reefs on

Leizhou Peninsula and Sanya Bay of Hainan Island and Yongshu and Meiji Reefs. Significant results will be presented by Yu and Zhao (this volume), including (1) evidence for Holocene multiple sea-level highstands and decadal sea-level fluctuations [6], (2) Sr/Ca and $\delta^{18}\text{O}$ -based sea-surface temperature and salinity records since mid-Holocene [7, 8], (3) evidence for coral cold bleaching in the Mid-Holocene [9], and (4) U-series dating of recent coral mortality and storm/Tsunami history [10].

3. U-SERIES DATING OF ARCHAEOLOGICAL INDICATORS

Fossil assemblages including hominid finds in caves are often associated with speleothems that bear important climatic archives and can be precisely and accurately dated, providing a valuable opportunity for understanding vertebrate (and hominid) evolution history and distinguishing climate- and human-forced impacts on the environment and ecosystems over the past 500 ka BP. In this talk, I will present research highlights on TIMS U-series dating of important hominid sites in China, including Nanjing Man site in Tangshan Cave near Nanjing, east China, Peking Man site at Zhoukoudian near Beijing, north China, and Liujiang and Bailiandong hominid sites in caves near Liuzhou, southwest China [11-13]. Our robust results, which are based on stratigraphically defined speleothems, show that previous chronology established for hominid evolution history in China was significantly compressed, due to inaccurate dating techniques or materials being used. For instance, these results indicate that Nanjing Man fossils were at least older than 600 ka BP, the youngest *H. erectus* at Zhoukoudian was older than 400 ka BP, the transition from late *H. erectus* to archaic *H. sapiens* occurred at Zhoukoudian between 300 and 400 ka ago, and the representative modern *H. sapiens* in southwest China was at least older than 68 ka BP, or more likely to be 111-139 ka old, approaching the ages of the earliest representatives from the Levant and Africa.

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