Asian summer monsoon variability during the last two millennia - "Thailand Monsoon Project"

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Statement of Significance

The Asian monsoon affects more than half of the world's population. Understanding the history of its variation is important, because the monsoon is connected to multiple aspects of the global climate system. Southeast Asia is located in a key position for studying how regional components of the Asian monsoon system interact, but long-term environmental data for this region are scarce. This study from **Lake Pa Kho** (Fig.1), Thailand, analyzes the climate record contained in the sediments/peat and includes the first record from Indochina to reconstruct a detailed climate history of the last 2000 years. The study advances our understanding of the spatial patterns of Asian summer monsoon variability and the factors that affect monsoon variation in Southeast Asia.

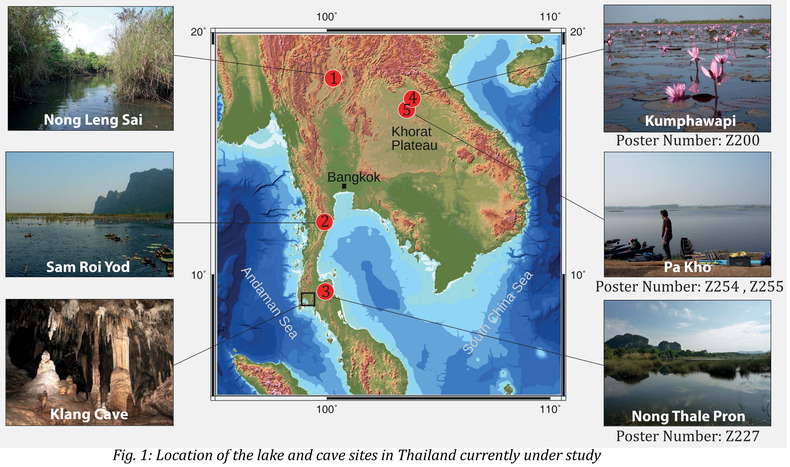

Fig. 1: Location of the lake and cave sites in Thailand currently under study

Several sediment/peat sequences were obtained in January 2009, 2010 and 2012 from Lake Pa Kho within the frame of the "Thailand Monsoon Project". The peat sequence CP3 is the focus of this presentation (Fig. 3).

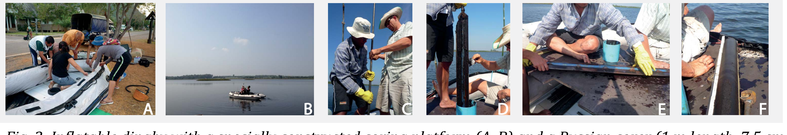

Fig. 2: Inflatable dinghy with a specially constructed coring platform (A, B) and a Russian corer (1 m length, 7.5 cm diameter) (C-F) are used to recover the lake sediment

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Regional Response (Pa Kho) to monsoon variability

The study of lake sediments/peat using a variety of different chemical, biological and physical analytical techniques allows tracing the intensity of the Asian summer monsoon back in time. Here we present a multi-proxy (TOC, C/N, $\delta^{13}C$, biogenic silica, charcoal and plant macrofossil remains) study of a 1.5 m sediment/peat sequence which is supported by 20 AMS ^{14}C ages.

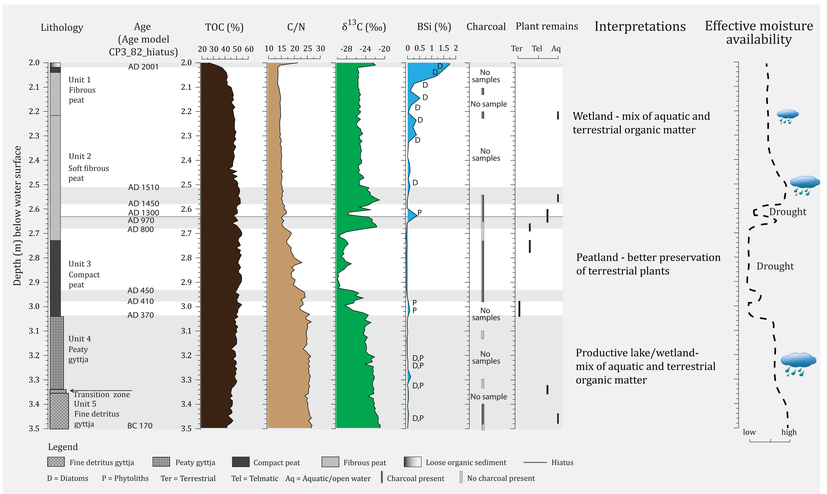

Fig. 3: Lithostratigraphy and geochemistry of Pa Kho´s sediment sequence

The sedimentary proxies show that Pa Kho was a shallow productive lake or wetland between BC 170 and AD 370. Such an environment implies higher effective moisture, likely caused by a strengthened summer monsoon. Around AD 370 the wetland transformed to a peatland, which suggests a decrease in effective moisture and a weakening of the summer monsoon. This transition occurred stepwise. The re-establishment of a wetland between AD 800 and 970 is a sign of higher moisture availability and likely reflects increased monsoon precipitation. The subsequent hiatus (AD 970-1300) might have been caused by degradation of the peat surface during an interval with lower effective moisture and a weakened summer monsoon (AD 1300-1450) (Fig. 3). The increase in aquatic plant remains, the appearance of diatoms and the isotope proxies show again a wetland environment starting around AD 1450.

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Correlation to other Asian monsoon records/ Global perspective

To infer spatial patterns of hydroclimatic variability, we compare the Pa Kho data set to selected high-resolution paleoclimatic records established for the Asian monsoon region.

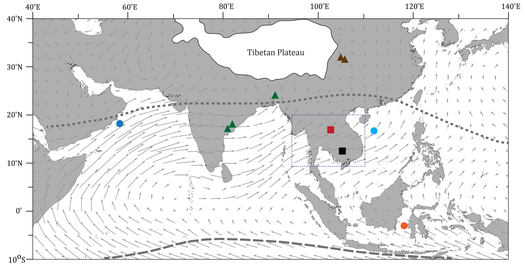

Fig. 4: Location of selected high-resolution Asian monsoon paleo-records for the last 2000 years.The mean position of ITCZ is according to Wang (2009). The July-August wind directions and wind speeds follows Wang et al. (2003)

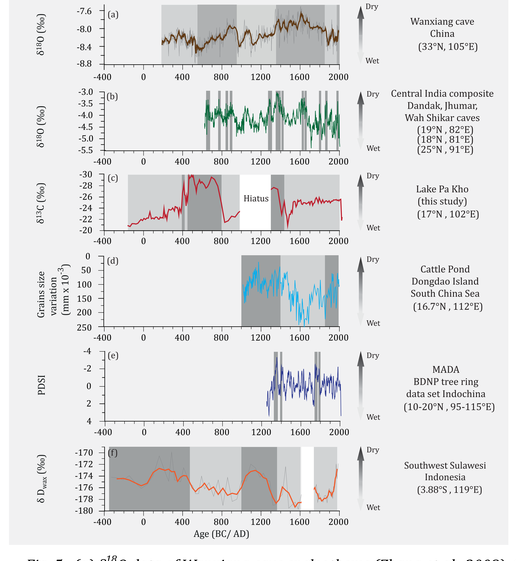

Fig. 5: (a) $\delta^{18}O$ data of Wanxiang cave speleothems (Zhang et al., 2008); (b) Composite $\delta^{18}O$ time series for central India (Berkelhammer et al. 2010; Sinha et al. 2011a, 2011b, 2007); (c) $\delta^{13}C_{org}$ data from Lake Pa Kho (this study); (d) grain size variations in sediment of Cattle Pond, Dongdao Island (Yan et.al, 2011); (e) Palmer Drought Severity Index (PDSI) derived from MADA for the region between 10-20°N and 95-115°E (Buckley et al., 2007, 2010; Cook et al., 2010); (f) δD_{wax} from marine cores 31MC and 34GGC from southwest Sulawesi (Tierney et al., 2010).

Summer monsoon variability (BC 170 – AD 1450) reconstructed for Pa Kho compares well to hydroclimatic patterns derived from speleothem proxies in China and India, and marine proxies from the Arabian Sea. The drought intervals expressed in these records compare to intervals of stronger monsoonal rainfall in Indonesia. This hydroclimatic pattern seems to have changed sometime between AD 1450-1600, when the inferred moisture history for Pa Kho was more similar to that reconstructed for the South China Sea and the Indonesian region. This would suggest that the mean position of the Intertropical Convergence Zone (ITCZ) over land generally did not reach as far north as before AD 1450.

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