DISCOVERING THE EARTH'S SEASONAL RHYTHM

In order to reconstruct the monsoonal precipitation pattern through time it is critical to identify and characterize high fidelity archives (both marine and continental) of rainfall patterns. Dr. Prosenjit Ghosh of Divecha Centre for Climate Change has attempted to unravel the variability of Indian monsoon through geological time by applying the tool of Stable and Clumped Isotope Geochemistry on archives which forms or grows incrementally at seasonal timescales.

The group harnesses sedimentary fossil records found over the Indian landmass as archives of seasonal climatic signature through geological time, as the Indian plate moved from its original geographic position in the southern hemisphere during the Cretaceous time to its present coordinate in the northern hemisphere. These archives range from mollusc shells from estuaries to rice grains from archaeological sites.

Stable isotope research group at IISc designs proxies for determination of precipitation, temperature and relative humidity by conducting field and laboratory experiments at controlled condition.

Recent research activities of the group have shown that Global warming during Cretaceous modulated the intensity and frequency of extreme climate events. This was demonstrated by analysing well-preserved shell growth bands in fossil mollusc of Cretaceous age (145 million years) for their stable isotope and clumped isotopic signature. The study highlighted the intense precipitation events coinciding with the high pCO_2 (~1000 ppmV) level during Cretaceous. The isotopic pattern in the shell growth bands revealed that the majority of rainfall during the period when India was located at 30°S latitude was confined to the winter season (Ghosh et al., 2018), consistent with the pattern that we witness in the modern settings of western Australia. The record of seasonal temperature and rainfall during the Cretaceous might provide important clue to project the future state of climate if the global warming trend continues unattended.

One of the other investigations dealt with the Mawmluh cave deposits of Meghalaya in form of carbonates (stalagmites) and provided evidence about paleo-monsoonal variability during the last glacial age. High resolution geochemical and stable isotope data combined with palaeo-thermometry based on glycerol dialkyl glycerol tetraethers (GDGT) content showed a unique climatic transformation from limited rainfall during Last Glacial Maximum (LGM) to intense rainfall during the warm early Holocene time i.e., 22 to 6 thousand years ago (Huguet et al., 2018) The records also documented a time lag of 6 thousand years between warming at the termination of the glaciation and strengthening of the summer monsoonal rainfall; shown in the Figure below.

While the paleoclimate data are of immense importance to model the future climate system and its variability, it is equally pertinent to understand present day precipitation pattern in terms of global moisture and heat transport that is largely controlled by the ocean. The group undertook multiple

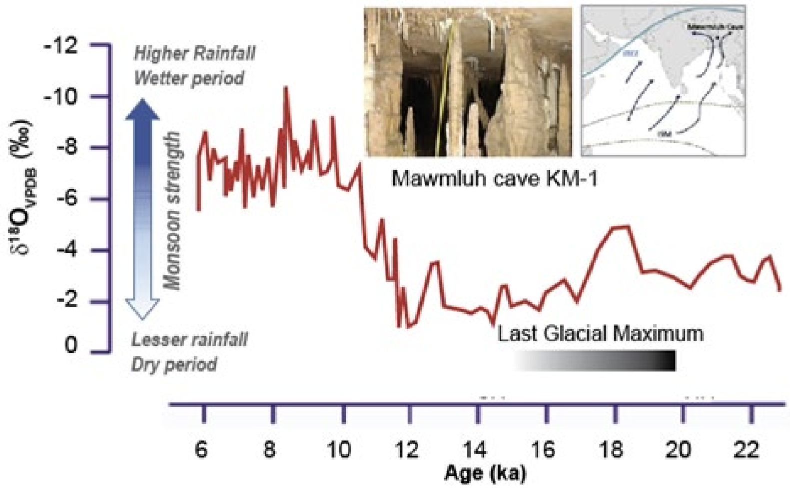

Photo from the KM-1 stalagmite inside the Mawmluh cave system. location of Mawmluh cave Light blue line indicates the position of the Intertropical Convergence Zone (ITCZ) during the summer monsoon period. The $\delta^{18}O$ in speleothems registered monsoon strength during glacial -interglaciation transformation.

expeditions to the Southern Ocean to characterize the precipitation and atmospheric-vapour isotopic signatures. The isotopic signatures recorded in the precipitation strongly correlated with the trend of latitudinal temperature and wind strength; the governing process of moisture generation and transport. Isotopic mass balance approach using the field measurements carried out on precipitation and atmosphere water-vapour revealed inclusion of ~33% recycled moisture in the cloud generated near the Inter Tropical Convergence Zone (ITCZ), while the contribution of recycled moisture diminishes to ~13% on approaching the latitudes north and south of the convergence zone (Rahul et al., 2018). The Group has recently proposed a new tool of stable isotope in rice grain as recorder of relative humidity condition (Kaushal and Ghosh, 2018a and b), which has potential utility in deriving the atmospheric moisture level from archaeobotanical remains

Reference:

Ghosh, P., Prasanna, K., Banerjee, Y., Williams, I. S., Gagan, M.K., Chaudhuri, A. & Suwas, S. Rainfall seasonality on the Indian subcontinent during the Cretaceous greenhouse. Scientific Reports 8, 8482 (2018).

Huguet, C., Routh, J., Fietz, S., Lone, M.A., Kalpana, M.S., Ghosh, P., Mangini, A., Kumar, V. & Rangarajan, R. Temperature and monsoon tango in a tropical stalagmite: Last glacial-interglacial climate dynamics. Scientific Reports 8, 5386 (2018).

Rahul, P., Prasanna, K., Ghosh, P., Anilkumar, N., & Yoshimura, K. Stable isotopes in water vapor and rainwater over Indian sector of Southern Ocean and estimation of fraction of recycled moisture. Scientific Reports 8, 7552 (2018).

Kaushal, R. & Ghosh, P. Stable oxygen and carbon isotopic composition of rice (Oryza sativa L.) grains as recorder of relative humidity. Journal of Geophysical Research Biogeosciences 123 (2), 423-439 (2018a).

Kaushal, R. & Ghosh, P. Oxygen isotope enrichment in rice (Oryza sativa L.) grain organic matter captures signature of relative humidity. Plant Science 274, 503-513 (2018b).