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Tracking the Monsoon: Late Holocene Signals from NE Lake Sediments

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Abstract: We aim to develop comprehensive picture of late Holocene climate variability over the North-Eastern India to address the existing large spatial gaps in paleoclimate data coverage in Indian subcontinent. This region receives precipitation only from the Indian Summer Monsoon (ISM) and lies in the region sensitive to the impact of various teleconnections (e.g., El-Niño, North Atlantic oscillations and Indian Ocean Dipole). A grain size study has been performed on short sediment cores (ca. 1.0 m long) retrieved from Shilloi Lake, Nagaland, NE India (25◦35′44″N, 94◦47′33″E) to decipher climate vis-à-vis vegetation dynamics in the region. The grain size parameters (D [4,3]-De Brouckere Mean Diameter) also demonstrate enhanced ISM precipitation from 1000 cal yr BP. The present work will provide an improved picture of the ISM variability and helps to identify the possible teleconnections responsible for the changes in regional paleoclimate during the late Holocene.

I. INTRODUCTION

The dominant portion (ca. 80%) of the annual precipitation on most regions of the Indian subcontinent is contributed by the Indian Summer Monsoon (ISM). The differential heating of the landmass and ocean resulting in the retreat of the Inter Tropical Convergence Zone (ITCZ) along the equator drives the kinetics of the ISM (Wang et al., 2002). The shift of the ITCZ is influenced by many factors such as distance of the earth from the sun, amount of solar radiation received, positioning of the continental and oceanic masses (e.g. Kale et al., 2007 and references therein). This in turn affects the dynamics of ISM bringing about periods of humid and dry conditions over the Indian subcontinent. Also, the monsoon rainfall is not evenly distributed over the subcontinent (Kale et al., 2006, Singhvi et al., 2004). Even around the recent time frame, the dynamics of the ISM keeps changing spatially and temporally (Zhisheng et al., 2011). Therefore, it is reasonable to assume that such fluctuations or even more intense deviations in the climatic conditions operated by the ISM might have also occurred in the past. Instrumental and satellite records can give us information of last few decades only. In order to unravel the mystery of the past beyond few decades, a different approach has to been considered. The precipitation in Northeastern (NE) part of the Indian subcontinent is majorly contributed by the ISM. The sedimentary deposits and lacustrine sediments from the region can be utilized as archives for understanding the paleoclimatic conditions of the region. The interpretation of the conditions and mechanisms involved in these depositions can help us understand the climate undulations that the region might have experienced. The Shilloi Lake present in the Phek district of Nagaland preserves the records of the climatic fluctuations that the region went through for a time period beyond instrumental records. However, in order to disentangle these records preserved in lacustrine sediments, different proxies must be applied. For our study, we adopted a multi-proxy approach in which core sediments were collected and analyzed. Also, a robust chronology of the core sediments was obtained by C-14 dating method. Since, each proxy has its own limitations application of a single proxy approach for paleo-climatic interpretation can be debatable. Therefore, multi-proxy approach is being utilized to get a more resolved idea about the climatic variations in the past 2 millenia. The various proxies used in our study include grain size analysis, stable isotope and palynological investigations. Grain size analysis helps us understand the energy of the system during which the deposition might have occurred (Holz et al., 2004; Folk, 1980). As suggested by the Hjulstrom model, the grain size range deposited in a particular environment is directly dependent on the velocity of the transporting medium. Hence, obtaining knowledge about the dominant grain size of a particular time period can help us understand the energy condition and the transportation medium. Therefore, grain size analysis can serve as an ideal proxy for paleo-climatic reconstruction (McManus., 1988; Stanley-Wood and Lines, 1992).

II. Study Area

The present study is focused on the Shilloi Lake (250 -37’-37” to 250-39’-47” N (LT), 940- 35’- 18” to 940- 38’-09” E (L), height) situated in the southern fringe of Nagaland (Figure 1). The foot shaped freshwater lake lies in Patkai range, near Latsum village in Nagaland. The lake is smaller in size (0.25 to 0.30 sq km) and the water depth varies between 3 to 5 m with an average depth of 4.

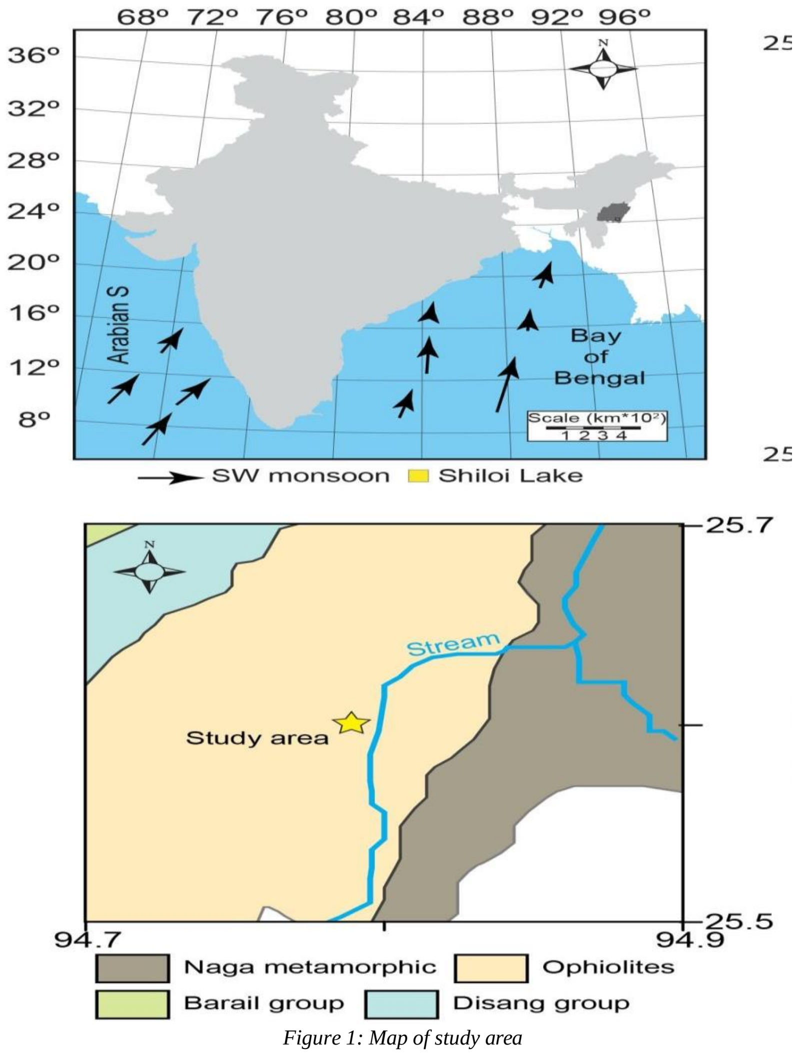

Figure 1: Map of study area

III. Methodology

The grain size analysis was performed at 3 cm intervals using the wet sediment analysis in Malvern Mastersizer (3000E) at Indian Institute of Science and Education Research (IISER)- Mohali (India). For its analysis, the samples were pre-treated with 30% H_2O_2 to remove the organic carbon. The treated solution was then further washed with milli-Q water and centrifuged several times to remove excess H_2O_2 solution. The samples were measured for the grain size between 0.02 to 100 µm. Before analysis, the samples were kept in an ultrasonic bath for atleast 15 minutes to disperse the sediments. The instrument measured each sample for five times, and the average values were used for the interpretation (Lopez, 2016).

Figure 2: Grain Size Analyzer (Malvern Mastersizer)

IV. Results and Discussion

Based on the sediment characteristics (grain size), and presence of the organic matter, the core has been divided into three parts: (i) Zone-I (102-56 cm)- dominance of clay material and presence of shell fragments; (ii) Zone-II (56-33 cm)- gradational decrease in clay size fraction, fragments of organic matter increased relative to the preceding stage; and (iii) Zone-III (33-0 cm)- dark brown, organic rich material. The grain size variability shows coarsening upward from Zone I ($Sand_{avg.}$= 1.9%; $Clay_{avg.}$= 27.5%) to Zone II ($Sand_{avg.}$= 26.1; $Clay_{avg.}$=6.8%).

The dominance of coarse grains in the upper part of the core suggests a high-energy environment prevailing in the lake system from ca.1000 cal yr BP. The lower part of the core is characterized by finer grain sediments. This indicates a low energy environment, suggesting a relatively dryer period around ca. 2000 cal yr BP to 1000 cal yr BP.

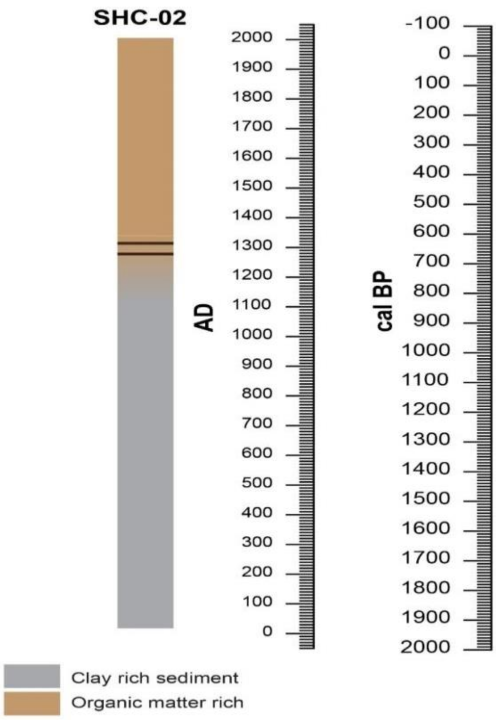

Figure 3: Grain Size distribution along the core.

V. Conclusion

The grain size variability data of Shilloi core sediments demonstrate increased ISM precipitation from ca. 1000 cal yr BP.

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