

## Variations of paleoclimate and paleoenvironment during the last 40 kyr recorded in clay minerals in the Kathmandu Basin sediments

Yoshihiro Kuwahara†\*, Mukunda Raj Paudel†, Takeshi Maki†, Rie Fujii‡ and Harutaka Sakai†

† *Department of Evolution of Earth Environments, Graduate School of Social and Cultural Studies, Ropponmatsu, Fukuoka 810-8560, JAPAN*

‡ *Department of Chemistry, Faculty of Science, Okayama University of Science, Ridaicho1-1, Okayama 700-0005, JAPAN*

\* *To whom correspondence should be addressed. E-mail: ykuwa@rrc.kyushu-u.ac.jp*

The Asian monsoon system and its evolution are known to be closely linked to the Himalayan-Tibetan orogen. The Kathmandu Basin is the best target for clarifying the variability of the Asian monsoon climate and its linkage to the uplifting of the Himalayan-Tibetan orogen, since it is located on the southern slopes of the central Himalayas and filled with thick sediments from late Pliocene to Quaternary (Sakai 2001). Unfortunately, previous studies could not critically and completely resolve on the paleoclimatic and paleoenvironmental changes in the Kathmandu Basin because of samples from discontinuous surface exposures.

Our group has proceeded on a Japan-Nepal collaborative project "Paleo-Kathmandu Lake (PKL) Project". In the project, we have carried out core drilling within the Kathmandu Basin and have investigated the cores and surface exposures from various viewpoints and methods. The reconstruction of paleoclimatic and paleoenvironmental variations recorded in the Kathmandu Basin sediments is one of many purposes of our project. We have already reported the results of fossil pollen analysis and characteristics of sediments for a drilled core sample obtained from the Kathmandu Basin and surface geological survey in the southern part of the Kathmandu Basin.

Clay minerals represent useful markers of successive climates, since they formed through weathering or hydrolysis processes during successive periods of the geological history and basically express the intensity of weathering or hydrolysis in the land masses adjacent to sedimentary basin. The information provided from such clay minerals fundamentally integrates the combined effects of temperature and precipitation. Detrital clay minerals can also be used as tracers of sediment transport processes, dispersal and provenance. Clay minerals in the Kathmandu Basin sediments do contain good information on the paleoclimate and paleoenvironment in this area, because they are directly formed through the weathering or hydrolysis process only from the parent minerals, feldspars and micas, in both gneiss and granite of the Shivapuri injection complex and weakly metamorphic rocks of the Phulchauki Group.

In order to reconstruct the paleoclimatic and paleoenvironmental changes during the last 40 kyr recorded in the Kathmandu Basin, we examined the estimation of the amount of the clay size fraction, the relative amounts of individual clay minerals, and the crystallinity of illite in the drill-core sediments by using the decomposition procedure of X-ray diffraction (XRD) patterns and the mineral reference intensity (MIF) method. In this paper, we report the paleoclimatic and paleoenvironmental information in the Kathmandu Basin deduced from the clay mineral data.

For clay mineral analysis, we used core sediment samples collected at 10 cm interval between 7 m and 40 m in depth of the RB core, which was drilled at Rabibhawan in the western central part of the Kathmandu Basin and is 218 m long (Sakai et

al. 2001). The topmost part of the RB core from 7 m to 12.15 m in depth is generally composed of medium- to very coarse-grained micaceous granitic sand. The core sediments between 12.15 m and 40 m in depth are organic black or dark gray mud called "Kalimati Clay". A  $^{14}\text{C}$  age of the Kalimati clay at 38.3 m in depth of the RB core is  $44690 \pm 360$  yr. B.P. and the mean sedimentation rate between 7 m and 40 m in depth of the RB core is about 900 mm/kyr.

The clay fraction under  $2\mu\text{m}$  was separated from each sediment sample by gravity sedimentation. Then, about 200 mg of this fraction was collected by the Millipore® filter transfer method to provide an optimal orientation. The thickness of a clay cake formed on the filter is over  $15\text{ mg/cm}^2$ , which is adequate for XRD quantitative analysis. The clay cake was then transferred onto a glass slide. Both air-dried (AD) and ethylene glycol solvated (EG) preparations were done for each sample. The EG preparation was carried out to expose the sample to the vapor of the reagent in desiccator over 8 hr at  $60^\circ\text{C}$ .

All XRD data were collected on a Rigaku X-ray Diffractometer RINT 2100V, using  $\text{CuK}\alpha$  radiation monochromatized by a curved graphite crystal in a step of  $0.02^\circ$  with a step-counting time of 4 seconds. The decomposition of the obtained XRD patterns was performed with an Apple Power Macintosh computer and a program XRD MacDiff, according to Lanson (1997) and Kuwahara et al. (2001). The crystallinity of illite and the relative amounts of clay minerals in the Kathmandu Basin sediments were estimated by the decomposition data and the MIF method using a program NEWMOD.

The variations of the two illite crystallinity indices, Lanson index (LI) and modified Lanson index (MLI) for the upper part of the RB core are in harmony with the pollen analysis results of the same samples. The increasing hydrolysis condition expected from the results of illite crystallinity indices corresponds to the pollen zone in which some pollen as warm and wet climate indicators increase, while the decreasing hydrolysis condition corresponded to the pollen zone showing the increase of pollen as cold and dry climate indicators.

However, the variations of the illite crystallinity indices and the amount of the clay size fraction show roughly mirror image of that of the smectite/illite ratio. In the Kathmandu basin sediments, illite is the main constituent of the clay size fraction and the amount of smectite is very low relative to the other clay minerals (Figure 1). Therefore, the smectite/illite ratio depends strongly on the amount of illite. It is predicted that, in the Paleo-Kathmandu Basin, the weathering of mica formed illitic minerals but did not advance up to the ample formation of smectite even under wet climate, because of the rapid erosion of the parent rocks and rapid transport of sediments.

The variation of the hydrolysis condition inferred from the illite crystallinity indices were congruous with the variation of  $\delta^{18}\text{O}$  GISP2. These results show that the major climatic variations

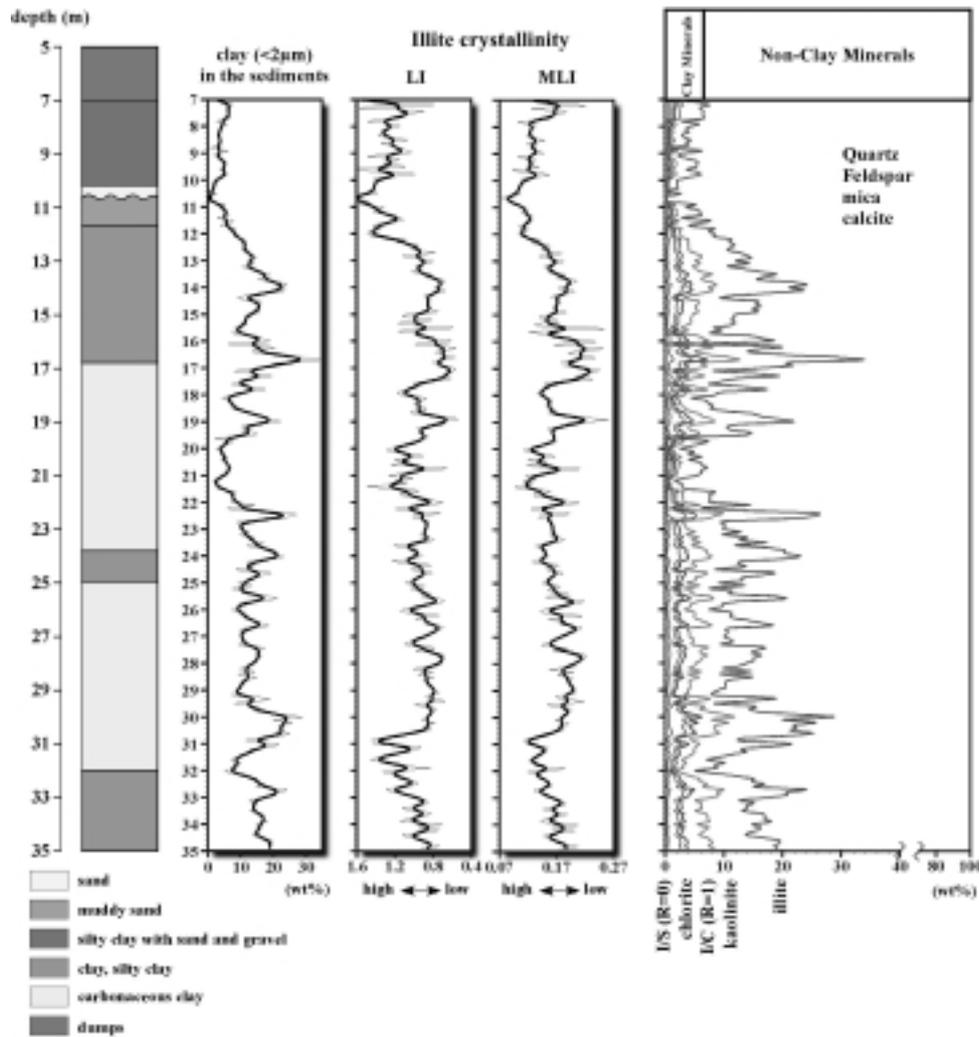


FIGURE 1. Variation curves of clay amount in the sediments, Lanson index (LI), modified Lanson index (MLI), and amount of each clay mineral in the sediments from 7 m to 35 m depth of RB-core

in the Kathmandu Basin during the last 40 kyr were closely related to global climate.

The sedimentation rate of the upper part (~40 m in depth) of the RB core tends to vary, depending on the dry-wet condition in the Kathmandu basin. Under dry climate expected from the results of clay mineral analysis, the sedimentation rate is estimated to be 300–800 mm/kyr, while that under wet climate runs to ~4700 mm/kyr, at least five times faster than that under dry climate. It is, therefore, clear that the supply of sediments into Paleo-Kathmandu Lake was strongly controlled by precipitation at least during the last 40 kyr, just like strong seasonal variation in water and suspended sediment discharge of the combined Ganges-Brahmaputra-Meghna River system under present Indian monsoon climate (Islam et al. 2002).

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