# The b-spacing values of white mica from low-grade metapelites of central Nepal Lesser Himalaya and their tectono-metamorphic implications

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Although, enormous P-T data have been constrained from higher-grade rocks of the central Himalayan region (Hodges et al. 1988), P-T data from lower-grade rocks of the Lesser Himalaya are still lacking. In the low-grade metamorphic terrain, the recrystallization of rocks is often not immediately obvious because of the fine-grained character, apparent irregularity in the metamorphism, and only partial recrystallization with preservation of many relict features of the protoliths. Owing to this reason, palaeopressure estimation by thermodynamic calculations is not possible.

White micas are among the most abundant phyllosilicates in low-grade metamorphic rocks. The Tschermak substitution [(Mg, $Fe^{2+}$)$^{vi}$ $Si^{iv}$= $Al^{vi}$ $Al^{iv}$] between the ideal muscovite and celadonite end-members, which controls the chemistry of phengites, is thought to be particularly sensitive to pressure at low-temperature conditions and serves as a qualitative geobarometer (Guidotti and Sassi 1986). Although, the b-spacing values of white micas have been widely used to estimate the palaeopressure in low-grade terrains all over the world, its application in the Himalaya is relatively rare. In the present study, we present the b-spacing values of white mica across Pokhara-Butwal road and Kali Gandaki valley sections of the Lesser Himalaya in central Nepal, and discuss their tectono-metamorphic implications.

## Geological setting

The Lesser Himalaya in the Pokhara area is divided into four tectonic units from south to north: Parautochthon with Palpa Klippe lying between the Main Boundary Thrust (MBT) and the Bari Gad-Kali Gandaki Fault (BKF), Thrust Sheet I (TS I) situated between the BKF and the Phalebas Thrust, Thrust Sheet II (TS II) bounded by the Phalebas Thrust and the Lower MCT, and the MCT zone bounded by the Lower MCT and the Upper MCT, respectively. The Lesser Himalaya mostly comprises low-grade metamorphic rocks such as slates, phyllites, quartzites, and dolomites (Nawakot Complex) of the Precambrian age. The Nawakot Complex rocks are unconformably overlain by the Gondwana and post-Gondwana sedimentary rocks (Tansen Group) in the Parautochthon (Sakai 1983). Metamorphic grade gradually changes from diagenesis to lower anchizone in the Parautochthon to upper anchizone in the TS I, epizone in the TS II and garnet zone in the MCT zone (Paudel 2000).

## Sampling and analytical techniques

A total of 320 pelitic rocks with unique assemblage "Mica+Chl+Ab+Qtz" (Chl-zone) and lacking detrital white mica were used to measure b-spacing values. A few samples from the northern part of the TS II are from Bt-zone and samples from the MCT zone belong to Grt-zone. Measurement was done on <2µm powder fraction of each sample. Diffractometer setting was constant for all the samples (Rigaku Geigerflex diffractometer, Cu cathode, Ni filter, 35 kv tube voltage, 20 mA current, time constant=2 sec, scatter slit=1°, receiving slit=0.3 mm, divergence slit=1°). The 63-59.5° 2θ range was scanned at 0.25 2è/min, and b was determined from (060) peak (approx. 61.5° 2θ) using the (211) quartz reflection (approx. 60° 2θ) as an internal standard. Mean b-spacing values were calculated from five repeated measurements for each sample.

## Results and implications

The relationship between the b-spacing values with the composition of white mica was accessed by compositional analysis of white mica in the same samples. A fairly good positive linear correlation was found between the two **(Figure 1)**. This indicates that the b-spacing values serve as indirect measures of phengite content of white mica in the Lesser Himalaya and hence the pressure condition.

The plots of b-spacing values versus the whole rock compositions show no marked correlation indicating that the b-spacing values are sensitive to P-T condition rather than the bulk rock composition. The intensity and shape of the $CuK_{\alpha 1}$ XRD traces of white mica (060+331) peak gradually change from south (close to the MBT) to north (close to the MCT). Many of the samples from the Tansen Group, Palpa Klippe, Parautochthon, and the TS I show bifurcated or very wide, blunt and asymmetric (060+331) peaks, which are interpreted to be due to the presence of bimodal white mica compositions crystallized at different thermal events (polymetamorphic events, Paudel and Arita 2000).

The b-spacing values vary from 8.970Å to 9.060Å in the study area. The average b-spacing values are relatively smaller in the Tansen Group ($X_{26}$=8.993±0.033Å) compared to those of the Parautochthon ($X_{60}$=9.029±0.01Å) and the Palpa Klippe ($X_{20}$=9.039±0.005Å). Average b-spacing values from the TS I ($X_{109}$=9.041±0.011Å) are also similar to those of the Parautocthon and the Palpa Klippe. The b-spacing values sharply drop across the Phalebas Thrust. The average b-spacing values for the TS II and the MCt zone are ($X_{82}$=9.016±0.012Å) and ($X_{20}$=9.001±0.011Å), respectively.

The b-spacing value increase with depth to the south of the Phalebas Thrust, i.e., higher values for older units. It shows that the rocks attained peak pressure when they were at normal stratigraphic position. Therefore, older units experienced higher pressure due to thicker overload. However, it is interesting to note that the trend of b-spacing values is reversed to the north of the Phalebas Thrust, i.e., lower values for older units. It is argued that the decrease in b-spacing values is the result of thermal dephengitization of the white mica due to higher temperature condition in the northern part of the Lesser Himalaya.

A cumulative frequency plot of the total data of each tectonic unit from the present area **(Figure 2)** shows that the TS I, Parautochthon, and the Palpa Klippe have b-spacing values comparable to those of the Eastern Alps and Otago metamorphic belts suggesting a typical Barrovian-type (intermediate-P) metamorphism. On the other hand the MCT zone, TS II and the Tansen Group have b-spacing values similar to that of the Bosost, N. New Hampshire and Ryoke metamorphic belts. The Tansen Group occupies the shallowest position in the stratigraphic sequence. Therefore, the lower b-spacing values from the Tansen Group are likely due to low-P metamorphic condition.

Using the P-T-b grid of Guidotti and Sassi (1986), the approximate palaeopressures have been estimated to be about 4 kbars for the TS II , TS I and Parautochthon. The estimated pressures give approximate burial depths of 15 km assuming an average bulk density of 2.60 gm cm$^{-3}$ for the metasediments. Thus, the estimate of the average background geothermal gradient at the time of peak metamorphism would be 27°C/km for the TS II (using peak T=400 °C given by illite crystallinity; Paudel 2000), 22°C/km for the rest of the area to the south of the Phalebas Thrust (using peak T=325 °C given by IC).

The P-T structure for the Neohimalayan metamorphism revealed from b-spacing values can be explained in relation to the thrust tectonics, i. e., overthrusting of the hot Higher Himalayan rocks over the cold Lesser Himalayan (Le Fort 1975, Arita 1983). Lower geothermal gradient and lesser thickness of overburden during peak metamorphism in the southern part (frontal part of the orogen) of the Lesser Himalaya may be the reflection of cool and thin leading edge of the MCT.

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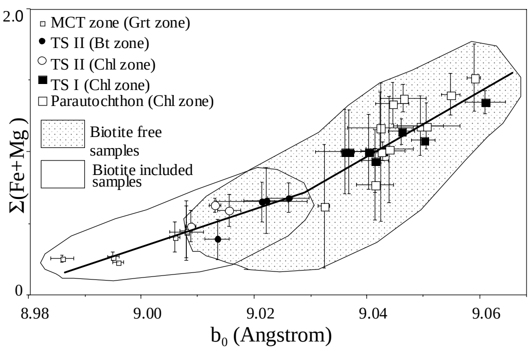


FIGURE 1. Plots of phengite content (Fe+Mg) versus the b-spacing values of white micas from the Tansen-Pokhara section. The two show good correlation (r=7.2) in the area

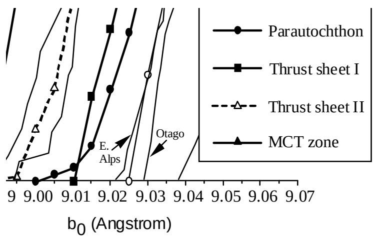


FIGURE 2. Cumulative frequency curves of b-spacing values for different tectonic units in the Lesser Himalaya. Cumulative frequency curves for the other orogenic belts are after Sassi and Scolari (1974)