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Size Analysis of the Middle Miocene Lower Siwalik Sediments Exposed in the Type Area Nahan and Adjoining Regions in Northwestern Himalaya, India

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Abstract – Size analysis of the Middle Miocene Lower Siwalik sediments comprising the Nahan Formation in the type area and adjoining regions reveals that the sediments are unimodal to polymodal in nature, dominantly fine grained and are moderately sorted. The log probability plot reveals that saltation mode is the dominant mode of transportation of detritus. The sediments are continental in character and derived from crystalline, metamorphic and sedimentary rocks of the Himalaya exposed to the North of the type area Nahan.

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1. INTRODUCTION

Size analysis is the quantitative determination of size frequency distribution. Size analysis is helpful in working out the nature of the parent rock, mode, distance of transport of the detritus, paleoenviornmental and paleotectonic set up of the positive and negative areas, energy conditions of the medium, rate of supply of the sediments and post-depositional changes experienced by the sediments. The Himalaya, a product of continent-continent collision, represents the youngest active mountain range of the world. The Himalayan orogenic belt has been divided into the Frontal Himalaya, the Lesser Himalaya and the Great Himalayan belt. The frontal Himalayan belt is made up of low lying Siwalik Hills. The Siwalik Group is exposed in a linear fashion along the Himalayan foot-hills for a distance of about 2400 Km. from near Jammu in the West to near Tripura in the East. It represents a huge thickness of sediments ranging from 3300 m to 6300 m which were deposited in a foredeep. The Middle Miocene Lower Siwalik Formation is very well exposed in the type area Nahan and adjoining regions.

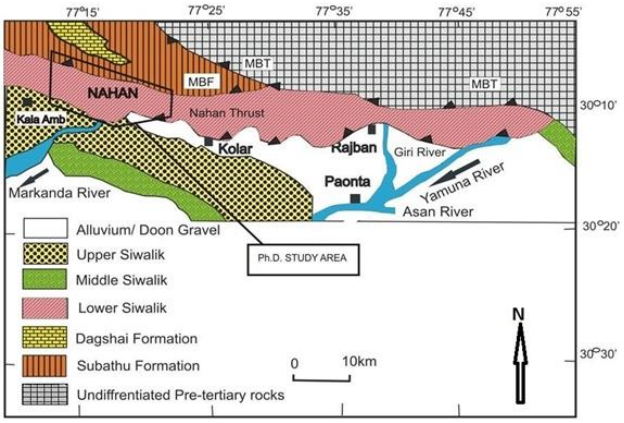


Fig.1 Geological map of Nahan and surrounding regions (*modified after Rohtash et al*., 2002)

Lithological the Nahan Formation is composed of an alternating sequence of sandstones and clays. The sandstones are fine grained and shows dominantly purple and grayish purple color in the lower part while in upper part grayish purple colour is dominant. The clays are dominantly maroon in colour. The Siwalik sediments have been studied by Chaudhri (1971a, 1971b and 1991). Chaudhri in (2000) recorded that the Siwalik sediments are a product of two coarsening up mega cycles. The Lower Siwalik/Nahan Formation represents the first mega cycle. It recorded a slow pace of erosion and sedimentation and stable palaeotectonic conditions. The Middle and the Upper Siwalik formations characterized by coarsening of the sediments represent the second mega cycle indicating a fast rate of degradation processes.

This paper deals with the size characteristics of the Middle Miocene Lower Siwalik sediments to know the provenance and the sedimentation environment of the detritus constituting the Nahan Formation of the type area Nahan and adjoining regions.

ANALYTICAL TECHNIQUE –

Sieve technique has been utilized for size determination of the sediments constituting the Nahan Formation. The granulometric analysis of sand sized fraction was carried out by sieve technique. The method has an edge over other methods as the results are in weight percentage frequency which is a better representation of natural process than number percentage frequency. The method is rapid and involves arrangements of sieves at half or quarter Phi interval depending upon the character of the sediments to be analyzed.

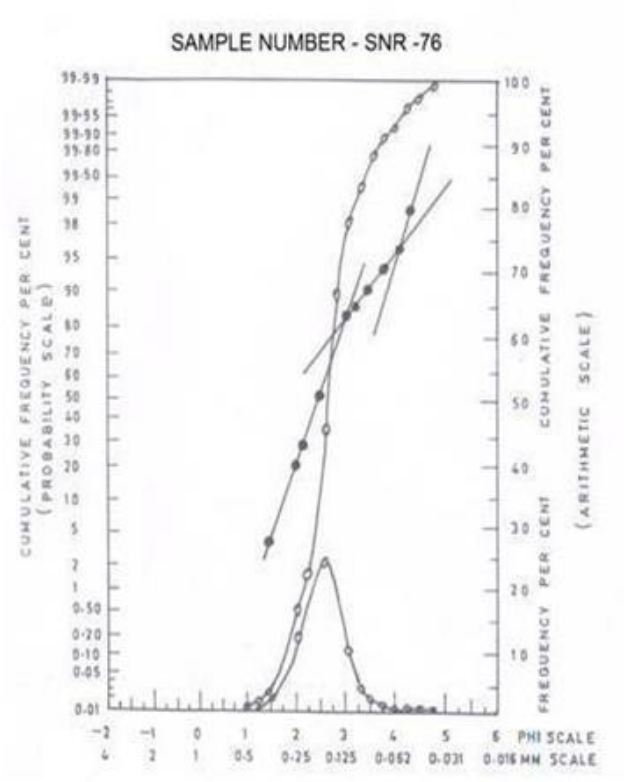
After preliminary examination of the thin section of samples from different lithological units of the Nahan Formation, 70 representative samples from the three measured sections namely the Shambhuwala – Nahan section, Renuka – Nahan section, Satuan – Rajban section and random samples were selected for textural analysis. The major criteria for the selection of the samples were the variation in grain size as the objective was to obtain a comprehensive picture of the Nahan Formation.

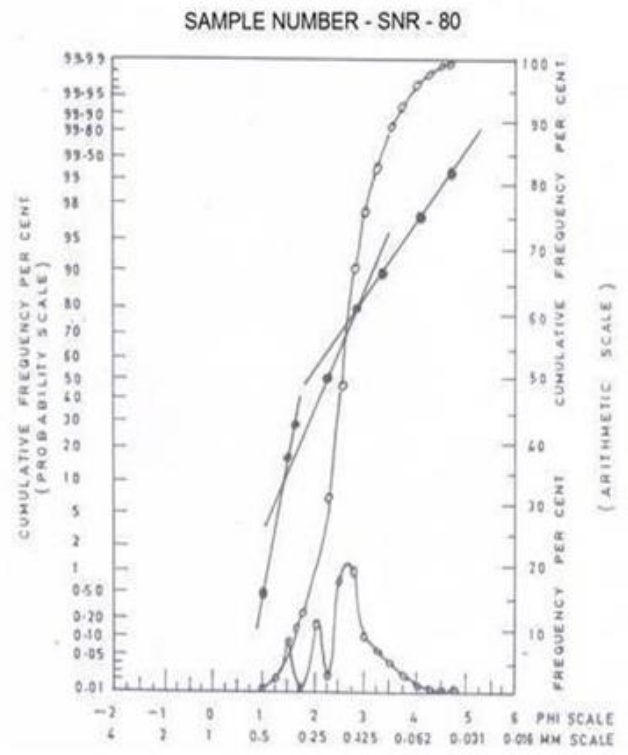
The size analysis of loose sand sediments was carried out by sieve technique. About 100 gram of the representative sample collected after coning and quartering was subjected to sieving at quarter phi interval. The ASTM sieves were placed in a Ro-Tap sieve shaker and were allowed to move for 30 minutes. The sand fraction retained in each of the sieves was collected and weighted on an electronic balance. The various size classes were made and weight percentage frequency distribution and cumulative weight percentage frequency distribution were computed at quarter phi interval. Frequency curves, cumulative curves, log probability plots and binary plots were prepared to work out the various parameters. Graphic measures by Folk and Ward (1957) and moment measures by Friedman and Sanders (1978) were computed.

STATISTICAL SIZE DISTRIBUTION PATTERN -

Mode-

The sediments of the Nahan Formation are unimodal to poly-modal in nature. Lithologically Nahan Formation Lower Siwalik shows fine sand grains mode is from 2.50 Phi to 3.00 Phi in Shambhuwala – Nahan section. In Sataun – Rajban section, the value of mode is from 2.50 Phi to 2.90 Phi so it shows the fine sand sized grains in the sediments. In Renuka – Nahan section the value of mode is also in-between 2.25 Phi to 2.60 Phi so again it shows the fine sand sized grains in the sediments.





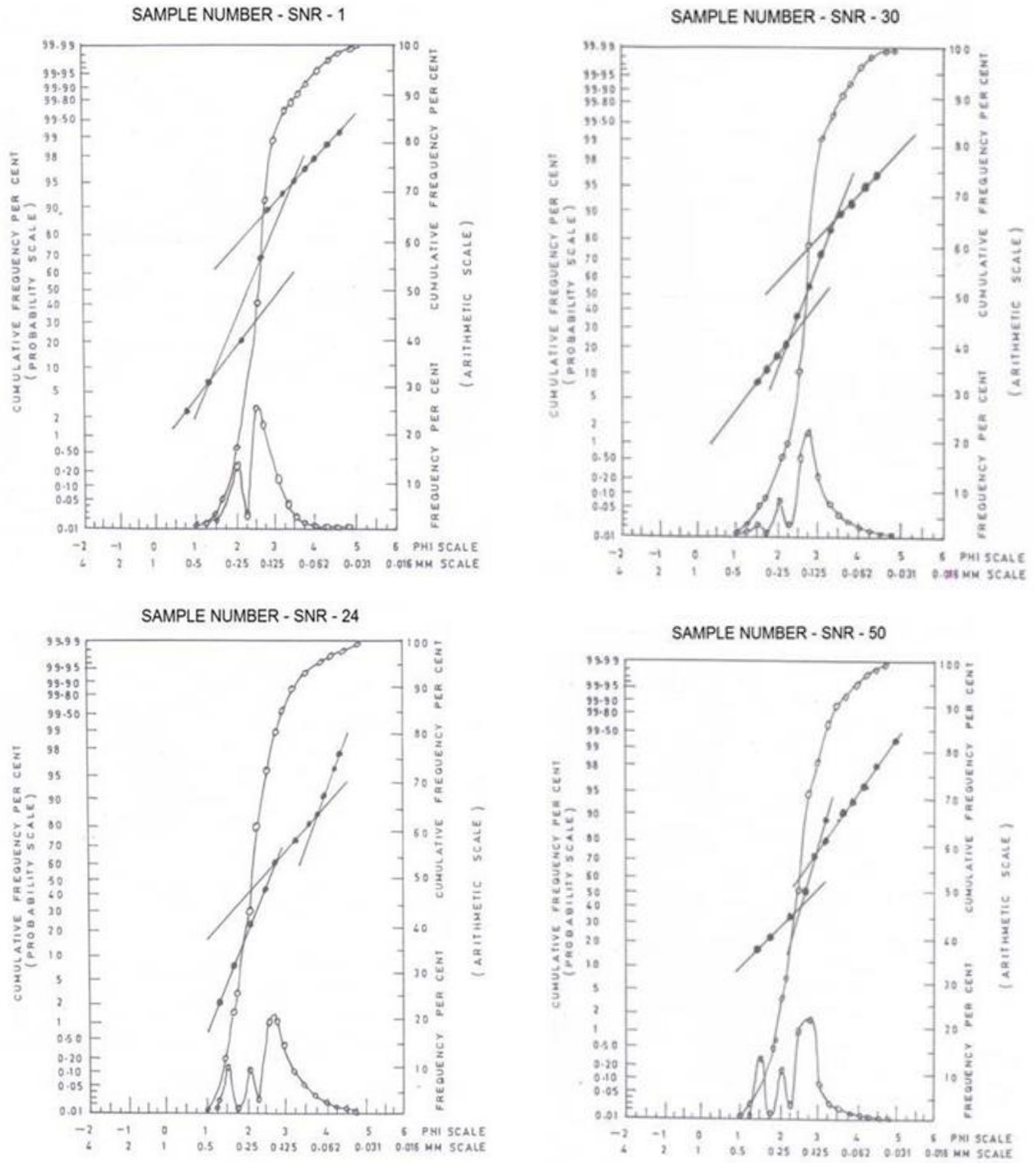


Fig. 2 Frequency curves, cumulative curves and log probability plots of the selected samples of Nahan Formation.

Median –

In Shambhuwala – Nahan section the median values ranges from 2.25 Phi to 2.60 Phi in all samples thus exhibiting a dominance of fine sized sand grains. In

Sataun – Rajban section median values ranges from 2.50 Phi to 2.75 Phi indicating the presence of fine sand sized grains. Renuka – Nahan section the values range from 2.25 Phi to 2.80 Phi suggesting the dominance of fine sand sized grains.

Mean (MZ) -

The value of graphic mean in the Shambhuwala – Nahan section ranges from 2.10 Phi to 2.60 Phi indicating that the sediments are fine sand sized. In Sataun – Rajban section the values of mean ranges from 2.40 Phi to 2.83 Phi suggesting the dominance of fine sand sized grains. In Renuka – Nahan section the mean values range from 2.33 Phi to 2.83 Phi for all the selected samples so this section is also made up of fine sand size grains.

Standard Deviation (σI)

In Shambhuwala – Nahan section the value of inclusive graphic standard deviation is from 0.12 Phi to 0.23 Phi. In Sataun – Rajban section the value of inclusive graphic standard deviation is from 0.18 Phi to 0.24 Phi for all the selected samples. In Renuka – Nahan section the value of inclusive graphic standard deviation is from 0.15 Phi to 0.24 Phi for all of the selected samples.

Simple Sorting Measure (SOS) -

In Shambhuwala – Nahan section the value of sorting measure range 0.27 Phi to o.35 Phi and 0.70 Phi to 1.00 Phi. Sataun – Rajban section the values of sorting measure are 0.35 Phi and 0.37 Phi to 0.50 Phi. The value of simple sorting measure in Renuka – Nahan section 0.27 Phi to 0.35 Phi.

Kurtosis (KG) –

In Shambhuwala – Nahan section the values of kurtosis is from 0.24 Phi to 1.38 Phi. In Sataun – Rajban section the values of kurtosis ranges from 0.72 Phi to 2.60 Phi. In Renuka - Nahan section the values are 0.14 Phi to 3.50 Phi.

Skewness (Sk1) -

In Shambhuwala – Nahan section the values of skewness is ranging from -0.04 Phi to 0.55 Phi. In Sataun – Rajban section the values of skewness ranges from -0.31 Phi to 0.60 Phi. The value of skewness in Renuka – Nahan section, -0.04 Phi to 1.49 Phi.

Table 1. Textural parameters (graphic measures) of the Lower Siwalik Nahan sediments

SAMPLE NUMBER	MODE	MEDIAN	GRAPHIC MEAN (Mz)	INCLUSIVE GRAPHIC STANDARD DEVIATION (σI)	INCLUSIVE GRAPHIC SKEWNESS (SkI)	GRAPHIC KURTOSIS (KG)	SIMPLE SORTING MEASURE (Sos)	SIMPLE SKEWNESS MEASURE (αs)
SNR -1	2.50	2.50	2.80	0.18	-0.04	1.14	0.27	-4.45
SNR -24	2.75	2.0	2.10	0.19	0.30	0.48	0.32	-3.55
SNR -30	2.75	2.50	2.60	0.15	-0.26	1.38	0.25	-4.90
SNR -50	2.75	2.50	2.43	0.23	-0.23	0.88	0.37	-4.05
SNR -76	2.60	2.50	2.60	0.18	-0.04	1.06	0.27	-4.65
SNR -80	2.80	2.60	2.58	0.18	-0.10	0.24	0.32	-4.55
SNR -90	2.70	2.50	2.56	0.22	-0.13	1.06	0.32	-4.55
SNR -115	2.60	2.60	2.60	0.15	-0.39	1.52	0.27	-4.65
SNR -125	2.70	2.25	2.23	0.23	0.17	0.95	0.70	-3.70
SNR -145	3.0	2.25	2.35	0.12	0.55	1.33	1.00	-4.20
SNR -147	2.50	2.50	2.53	0.14	0.22	0.24	0.22	-4.55
SNR -149	2.60	2.40	2.28	0.19	0.20	3.00	0.30	-3.90
SRR - 7	2.90	2.70	2.83	0.24	0.10	1.31	0.37	-4.80
SRR – 10	2.60	2.70	2.83	0.22	0.60	1.14	0.35	-4.90
SRR – 20	2.50	2.50	2.81	0.18	-0.47	0.10	0.37	-4.95
SRR – 21	2.50	2.75	2.95	0.22	0.13	1.56	0.37	-4.95
SRR – 23	2.60	2.75	2.78	0.20	0.26	0.72	0.35	-4.80
SRR – 26	2.50	2.50	2.40	0.32	-0.31	1.17	0.37	-4.00
SRR – 30	2.60	2.60	2.86	0.20	0.32	1.14	0.50	-4.80
SRR – 31	2.70	2.50	2.81	0.22	0.34	2.60	0.35	-4.65
RNR -4	2.50	2.50	2.73	0.23	0.56	6.25	0.35	-4.80
RNR -19	2.60	2.80	2.83	0.24	0.60	1.09	0.37	-4.70
RNR -20	2.50	2.50	2.78	0.22	0.62	10.0	0.40	-4.80
RNR -23	2.50	2.50	2.78	0.20	0.19	3.50	0.40	-4.50
RNR -25	2.60	2.50	2.63	0.22	0.80	1.14	0.35	-4.60
RNR -26	2.60	2.50	2.60	0.19	0.50	1.00	0.35	-4.10
RNR -31	2.30	2.30	2.33	0.15	0.26	1.66	0.30	-4.60
RNR -36	2.30	2.30	2.58	0.17	1.49	1.50	0.25	-4.05
RNR -40	2.25	2.25	2.33	0.15	0.48	0.90	0.30	-4.05
RNR -43	2.30	2.25	2.50	0.18	-0.04	0.14	0.27	-4.45

DISCUSSION AND CONCLUSIONS –

The analytical results of the statistical parameters reveal that the sediments of the Lower Siwalik Nahan Formation are unimodal to polymodal in nature suggesting their derivation from a tectonically active terrain where abundant sediments were being brought to the basin of sedimentation from different sources. The sediments are of medium to fine grain size suggesting their moderate to not very long distance of transport. A moist and well drained palaeoenvironment for the lower Siwalik succession of the kumaun Himalaya has been documented by Shukla et al. (2009). Sharma (2001) considered the fine grained sediment of the Lower Siwalik sediments of Jammu area to have been deposited by over bank flooding. A humid palaeoclimate for the Middle Siwalik sub-group in Tista vally has been suggested by (2012). The inclusive graphic standard deviation and moment standard deviation values of the Nahan Formation indicate that the sediments have well sorted to suggest their deposition in shallow to moderately deep agitated waters. Reineck and Singh (1973) postulated that the deposition of such sediments usually takes place under fluvial condition. These observations are in consonance with the views expressed by (1979). The log probability plots indicate that the sediments of the Nahan Formation were deposited in fluvial environment by traction, saltation and suspension mode, but the saltation mode dominated the depositional process. The Nahan Formation sediments are polymodal in nature and as such skewness value has limited interpretation significance in such a setting (1987). The fine skewed to nearly skewed nature of the

sediments reflects the presence of levee and channel microenvironment sediments.

The Lower Siwalik sediments show platykurtic to very leptokurtic character. Chaudhri and Khan (1981,1982,1983 and 1987) observed that kurtosis is not a very good parameter for distinguishing the environment of sedimentation. To sum up, the detritus of the Nahan Formation in the type area Nahan and adjoining regions appear to have been deposited in shallow agitated to moderately agitated deep water environments. The Nahan sediments are continental in character and were deposited by fluvial agencies. These conclusions are in broad harmony with the views expressed by Chaudhri (1972,1975,1979 and 1991).

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REFERENCES

A. Kundu, A. Matin and M. Mukul (2012). "Depositional Environment and Provenance of the Middle Siwalik Sediments in Tista Valley, Darjiling District, Eastern Himalaya, India," Journal Earth System Science, Vol. 121, No. 1, 2012, pp. 73-89.

A. R. Chaudhri and M. Singh (2012). "Clay Minerals as Climate Change Indicators—A Case Study," American Journal of Climate Change, Vol. 1, No. 4, pp. 231-239.

A. R. Chaudhri, M. Singh and A. Kumar (2009). "Textural Parameters of the (Saraswati) River Sediments from Bhor Sayidan, Kurukshetra, India," In: A. R. Chaudhri, Ed., Saraswati River, Saraswati Nadi Shodh Sansthan, Haryana, 2009, pp. 58-63.

A.R. Chaudhri, Rajesh Ranga, M. Singh, Vikram Sharma, Sarita Mann (2016). "Heavy mineral assemblage of the Lower Siwalik Nahan Formation NW Himalaya and its significance in deciphering provenance" Jour of Geoscience Research, Vol. 1, No. 2, pp. 175-182.

G. M. Friedman (1979). "Difference in Size Distribution of Populations of Particles among Sands of Various Origins, Ad-dress of Retiring President of the International Association Sedimentologists," Sedimentology, Vol. 26, No. 1, pp. 3-32.

G. M. Friedman and J. E. Sanders (1978). "Principles of Sedimentology," John Wiley and Sons, New York, 1978, p. 792.

G. T. S. Gill (1983). "Sedimentology of the Siwalik Group Ex-posed between the Rivers Ghaggar and Markanda North-western Himalaya," Publication Centre Advanced Studied Geology, Panjab University, Vol. 13, pp. 274-312.

H. E. Reineck and I. B. Singh (1973). "Depositional Sedimentary Environments," Springer-Verlag, Berlin, p. 439.

M. Singh (2009). "Sedimentology of the Pinjor Formation Ex-posed in the Type Area Pinjore and Surrounding Re-gions," Unpublished Ph.D. Thesis, p. 339.

M. Singh (2012). "Heavy Mineral Assemblage of the Pinjor Formation of the Northwestern Himalaya and Its Significance in Deciphering the Provenance of the Sediments," Geosciences, Vol. 2, No. 6, pp. 157-163.

M. Singh (2012). "Sedimentary Structures of the Pinjor Formation Exposed in the Type Area Pinjor, Northwestern Himalaya," PARIPEX-Indian Journal of Research, Vol. 1, No. 6, pp. 73-75.

Mahavir Singh, A. R. Chaudhri (2013). "Size Analysis of the Late Pliocene-Early Pleistocene Upper Siwalik Sediments, Northwestern Himalaya, India". International Journal of Geosciences, Vol. 4, pp. 1120-1130.

R. L. Folk and W. C. Ward (1957). "Brazos River Bar—A Study in the Significance of Grain Size Parameters," Journal Sedimentary Petrology, Vol. 27, No. 1, 1957, pp. 3-26.

R. S. Chaudhri (1971a). "Petrogenesis of Cenozoic sediments of northwestern Himalayas", Geol. Mag., 108, pp. 43-48.

R. S. Chaudhri (1971b). Nahan- a problematic horizon of northwestern Himalaya. Jour. Geol. Soc. India, 12: pp. 373-377.

R. S. Chaudhri (1972). "Petrogenesis of the Siwalik Sediments of Northwestern Himalaya," Journal Geological Society In-dia, Vol. 13, pp. 399-402.

R. S. Chaudhri (1975). "Sedimentology and Genesis of Cenozoic Sediments of the Northwestern Himalayas (India)," Ge-ology Rundschau, Vol. 64, No. 3, pp. 958-977.

R. S. Chaudhri (1983). "Sedimentological Parameters of the Re-cent Sediments from the River, Beach and Desert Do-mains and Their Bearing on the Interpretation of Ancient Depositional Environments," Publication Centre Advanced Studied Geology, Panjab University, Vol. 13, pp. 44-70.

R. S. Chaudhri (1987). "Textural Behaviour of Modern Cratonic Sediments and Its Application in Deciphering Ancient Analogues," Bulletin Indian Geological Association, Vol. 20, No. 2, pp. 103-119.

R. S. Chaudhri (1991). Sedimentology and genesis of the Cenozoic sediments of the Himalaya. Publ. Cent. Adv. Stdy. Geol.Pb. Univ., 4 (N.S.): pp. 1-32.

R. S. Chaudhri (2000). "Geology of the Siwalik Group of west-ern and central Himalaya: Fifty Years of Research on Sustainable Resource Management," S. P. Mittal, R. K. Aggarwal and J. S. Samra, Eds., Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh, pp. 3-18.

R. S. Chaudhri and A. Chakarborty (1982). "Textural Parameters of the River Sediments-Ghaggar River, India," Contem-porary Geoscience Research in the Himalaya, Vol. 2, pp. 105-116.

R. S. Chaudhri and H. M. M. Khan (1981). "Textural Parameters of Desert Sediments-Thar Desert, India," Sedimentary Geology, Vol. 28, No. 1, pp. 43-62.

R. S. Chaudhri and S. Chandra (1982). "Textural Parameters of Lake Sediments-Sukhna Lake, Chandigarh," Research Bulletin (Science) Panjab University, Chandigarh, Vol. 33, pp. 113-121.

Rajesh Ranga (2017). "Clay mineral assemblage of the Lower Siwalik Nahan Formation in the type area Nahan, northwestern Himalaya, India", Ignited Mind Journal , Journal of Advances and scholarly Researches in Allied Education, Vol. 13, No. 1, pp. 83-90.

Rajesh Ranga (2017). "Petrography of the Nahan Formation exposed in the type area Nahan and adjoining regions in northwestern Himalaya, India," Ignited Mind Journal, Journal of Advances and scholarly Researches in Allied Education, Vol. 12, No. 2, pp. 151-155.

S. Sharma, M. Sharma and I. B. Singh (2001). "Facies Characteristics and Cyclicity of Lower Siwalik Sediment, Jammu Area: A New Perspective," Geological Magazine, Vol. 138, No. 4, pp. 455-470.

U. K. Shukla, D. S. Bora and C. K. Singh (2009). "Geomorphic Positioning and Depositional Dynamics of River Systems in the Lower Siwalik Basin, Kumaun Himalaya," Journal Geological Society India, Vol. 73, No. 3, pp. 83-89.

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