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Depositional Pattern of the Siwalik Group (Manchar Formation) Southwest of LalBagh, Sehwan Area, Sindh, Pakistan

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Abstract: The present study indicates Comprehensive analysis of the particle size of 21 specimens of sandstone of the Siwalik Group (Manchar Formation) from southwest of LalBagh, Sehwan. The parameters of the particle size indicate that almost all of the Siwalik Group (Manchar Formation) unconsolidated sediments are mostly fine to medium grained, poorly to moderately sorted, and mostly coarse skewed to fine skewed and leptokurtic, to platykurtic in nature. This study's main goal is to assess the depositional setting of the Siwalik Group (Manchar Formation) The discriminated analysis reveal that most of specimens are clustered, This is probably a combination of two types of bimodal sediments of equivalent magnitude or well sorting of unimodal sediments. The amples from Manchar formation, the linear discriminant function analysis indicates mostly rivers under the impact of marine settings. The delta-dominated deposition environment with the impact of fluvial deposits is supported by interpretation diagrams.

Keywords: Manchar Formation, Siwalik Group, Sieve analysis, Depositional setting, linear discriminated function (LDF).

1. INTRODUCTION

The Study area is located at southwest of LalBagh, Sehwan, District Jamshoro, Sindh, Pakistan. The Sehwan is about 120 Km northeast from the University of Sindh, while the study area is approximately 5 Km along the JhangaraBajara link road, southeast of sehwan town fig 1a & 1b. The present study shows the detailed grain size analysis of Siwalik Group (Manchar Formation). This study's main goal is to assess the depositional setting of the Siwalik Group (Manchar Formation)through particle size analysis. Study of particle size is among the most important expressive properties of sedimentary rock and it is fundament characteristic of clastic sedimentary rocks (Baiyegunhi, Liu, & Gwavava, 2017). Grain size parameter are extensively used to interpret depositional setting and hydrodynamics conditions (Boggs Jr & Boggs, 2009). Study of particle size is often used to distinguish sedimentary rocks, describe clastic sedimentary rock properties and pattern of deposition(Edwards, 2001).

In present study twenty one (21) friable sandstone samples of Manchar Formation are selected for grain size analysis by adopting the (Folk, 1968) procedure. Several procedures of statistical study i.e. from grain size data histograms and cumulative frequency curves are produces to acquire information regarding the depositional environment. In environmental analysis studies two component variation diagram and linear discriminated function plots are widely used as graphical plots when analyzing the size of the grain. The drawing of diagram of two different components in which are statistical component is plotted against one another was supported by (Friedman, 1961, 1967). Many workers including (Blandford, 1876, 1879; Shah, 2009; Verdenburg, 1906)contributed to paleontology and stratigraphy. Previously, the data on textural evaluation of Siwalik Group (Manchar Formation) is lacking.

2. GEOLOGY OF AREA

Siwalik Group (Manchar Formation) contains sandstone, shale and conglomerate; in upper part of the formation sandstone increase in thickness. Sandstone is light gray, greenish gray, coarse grained to gravel, unconsolidated and cross-bedded. Shale is loose, yellow, brown and bricks colored. Manchar Formation in study area lies in western flank of Laki anticline. The geological map and stratigrapic succession of study area are shown in Fig. 1a and 1b and table 1. Geologically it lies in northern laki range, Kirthar Province, Southern Indus Basin, Pakistan. A section is measure southwest of LalBagh with true thickness methods. Twenty-eight (28) representative samples of Siwalik Group (Manchar Formation) from all the identified lithofacies at section were collected. For particle size analysis, twenty-one (21) unconsolidated sandstone samples were chosen.

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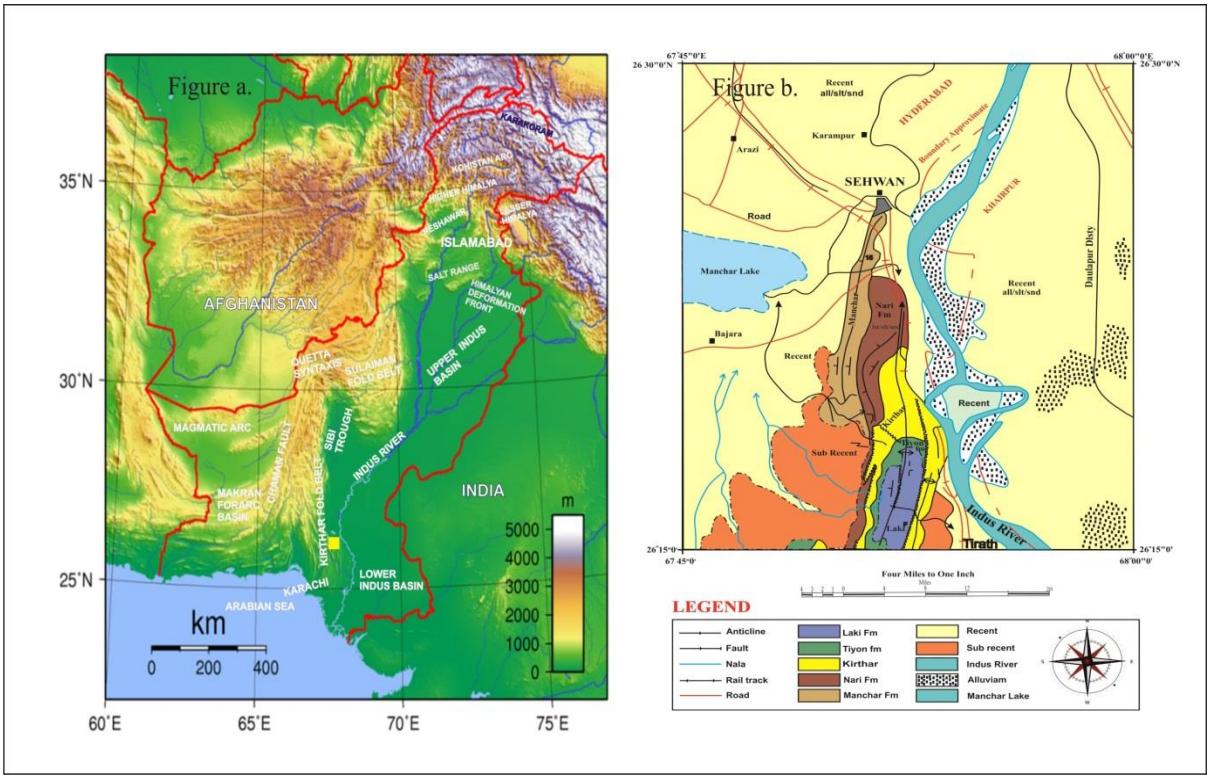

Fig. 01a and 1b shows the location of the study area

Table -1 shows the stratigraphy of study area

Age	Formation	Lithology
Upper Miocene to Pliocene	Siwalik Group (Manchar Formation)	Sandstone, shale and conglomerate.
Eocene	Laki Formation	Limestone, Sandstone and shale
Paleocene	Bara Formation Khadro Formation	Sandstone, Siltstone and Shale. Sandstone and shale with minor limestone.

Table -3 shows the statistical formulae given (Folk, 1968)

STATISTICAL PARAMETER	FORMULA
Graphic Mean	MZ= (16φ+ 50φ+ 84φ)/3
Median	(MD = 50φ
Standard Deviation	SD = (84φ-16φ)/4+ (95φ-5φ)/6.6
Graphic Skewness	SKI= 84φ+ 16φ -2(50φ)/2(84φ-16φ) + 95φ + 5φ -2 (50φ)/ 2(95φ-5φ)
Graphic Kurtosis	KG = (95φ - 5φ) (75φ - 25φ)/2.44

3. MATERIALS AND METHODS

The stratigraphic section was measured for recording the true thickness method through bed to bed because the position of beds were low dipping and almost were in horizontal form. Stratigraphic section illustrated in (Fig 2). The Coordinates of section is (Latitude: 25o 23' 40"N, Longitude: 67o 51' 12"E to Latitude: 26o 23' 35"N, Longitude: 68o 10' 46"E). Sediment grain size information acquired using the sieve analysis technique frequently used to estimate the spread of sand grains. The method outlined by (Folk, 1968)was use to investigate the particle size of the selected samples. For the grain size analysis test, one hundred grams (100gm) of each sample were used. Each sample was put on a paper sheet then crumbled with the help of fingers gradually and carefully. Furthermore, the sample was mixed by picking corners of papers so that all particles of unconsolidated sediments were mixed with each other. For the particle size analysis stake of sieve uses are -2 and -1phi for granules, 0 phi for very coarse sand, 1phi for coarse sand, 2 phi for medium sand, 3 phi fine sand, and 4 phi for very fine sand. Samples were weighed in an electronic balance; Screens were not touched by fingers and washed with a soft bursh. The grain size measurement was performed with digital octagon machine at Center for Pure and Applied Geology, University of Sindh, Jamshoro. Udden and Wentworth classes were used to determine determined grain size classes and frequency of grain size ranges were calculated (Udden, 1914; Wentworth, 1929) The attributes of grain size in millimeter were converted to a phi scale given by (Krumbein, 1934), which is logarithmic scale to base 2. (Phi= -log2D) here phi is scale and D is grain size diameter in millimeter.

4. RESULTS AND DISCUSSION

The cumulative frequency curve shows that most of the Manchar Formation sandstone In nature, the samples are unimodal with peaks at 1φ to 3φ phi. The

unimodality nature of Siwalik Group (Manchar Formation) sandstone indicates the uniform depositional setting during which the sediments were deposited. The Siwalik Group (Manchar Formation) shows the finer fraction in abundant in depositional setting and this is indicated by positive skewness. Almost all frequency curves shows variable trend showing poor to moderately sorting. The existence and superiority of fine to medium grain groups in the study area may be related to sediment deposition primarily due to low-energy marine currents. Cumulative curves of friable sandstone sample of Siwalik Group (Manchar Formation) are form by placing grain size of sediments on X-axis versus cumulative weight percentage as Y-axis and usually S-shaped curve is formed. The central slope of the curve reflects sorting, the steep slope suggests well-sorted sediments whereas, gentle slope indicates poorly sorted sediments Fig 3. The calculated statistical parameters are tabulated in Table 2.

The results of the Siwalik Group (Manchar Formation)unconsolidated sediments presented evidences that helped in the interpret the depositional environment. A graphical illustration of the grain size information was regarded the most significant and relevant method for interpreting the sediment depositional conditions (Folk, 1966). From the cumulative curves of unconsolidated sediments from the Siwalik group of the southwest portion of the LalBagh section selected percentile values were noted.

The Median formula (Table-03), proposed by (Folk, 1968), usuallyutilizedto measure central values for the analysis of Particle size. In the current research, the implementation of this formula stated that half of the samples are coarser by weight and the remaining half are finer. Diameter of the cumulative curve which corresponds to the 50 percent mark and can be represented either in Md.

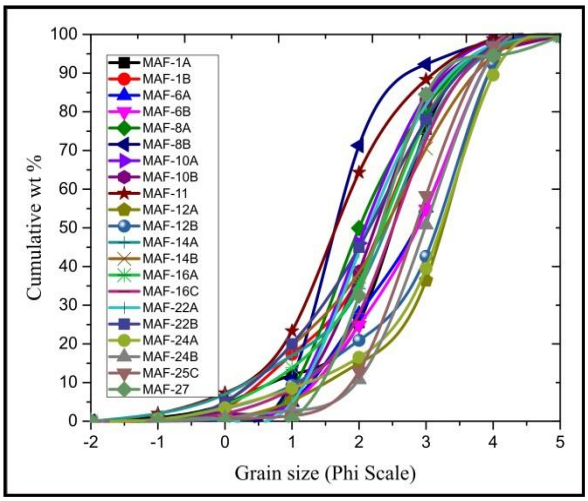

Fig. 3 shows the frequency curves of sieved samples.

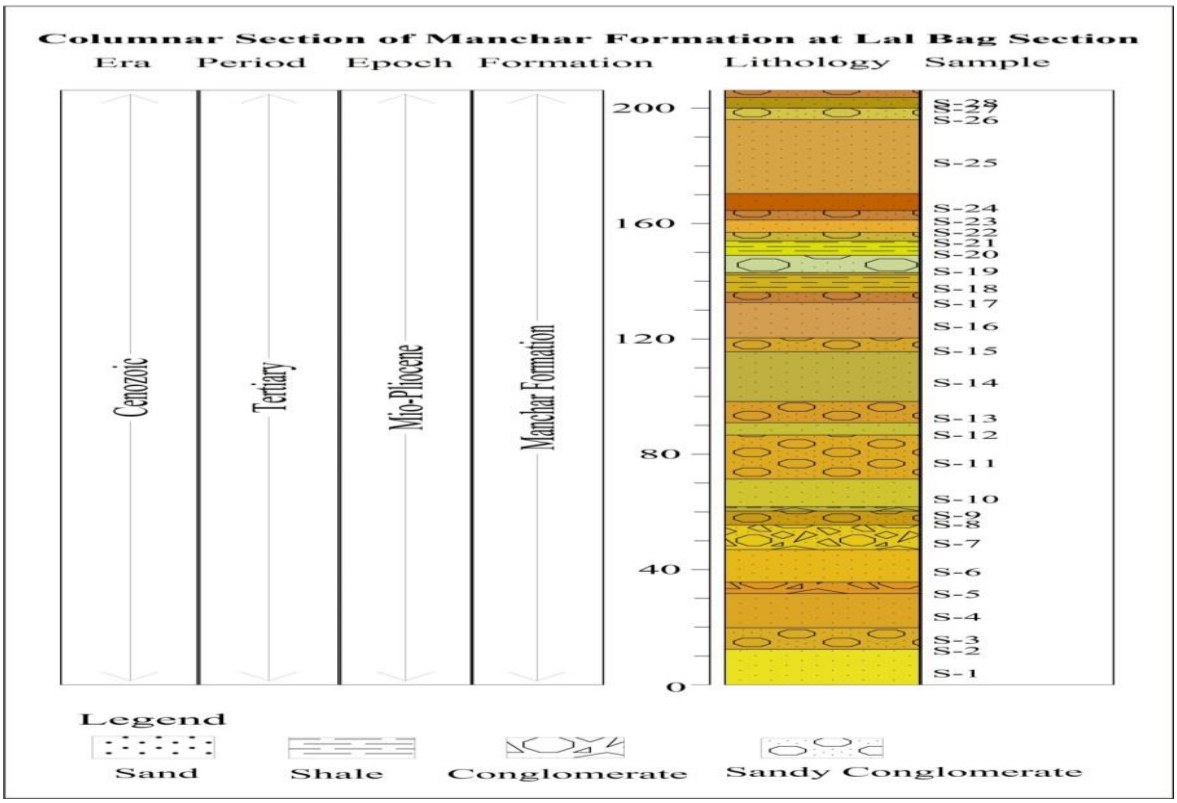

Fig. 2 shows the columnar section of study area.

Table -2 shows the calculated statistical parameters.

Sample Name	Graphic Mean	Median	Standard	Skewness	Graphic Kurtosis
MNF-1A	2.37	2.5	1.12	-0.22	1.48
MNF-1B	2.17	2.3	1.18	-0.16	1.03
MN-F-6A	2.64	2.8	1.03	-0.21	0.78
MNF-6B	2.7	2.82	0.99	-0.17	0.82
MNF-8A	2.13	2	1.01	0.16	1
MNF-8B	1.77	1.62	0.82	0.26	1.246
MNF-10A	2.1	2.1	0.88	0.06	0.94
MNF-10B	2.18	2.13	0.94	0.09	1.08
MNF-11	1.64	1.62	1.20	-0.006	1.46
MNF-12A	2.99	3.12	0.96	-0.26	1.15
MNF-12B	2.86	3.18	1.17	-0.43	1.12
MNF-14A	1.93	2.4	1.54	-0.36	1.17
MNF-14B	2.23	2.35	1.31	-0.14	0.88
MNF-16A	2.26	2.32	1.15	-0.13	1.03
MNF-16C	2.44	2.48	1.04	-0.1	1.16
MNF-22A	2.18	2.18	0.91	0.08	0.925
MNF-22B	2.08	2.18	1.24	-0.13	0.96
MNF-24A	2.99	3.22	1.15	-0.36	1.30
MNF-24B	2.79	2.5	0.82	0.34	1.85
MNF-25C	2.85	2.82	0.79	-0.04	1.1
MNF-27	2.27	2.35	0.82	0.06	1.17

The selected percentile read ranges from 5% (-0.5 to 1.32φ), 16% (-0.05 to 2.58φ), 25% (1.05 to 2.43φ), 50% (1.62 to 3.22φ), 75 %(2.20 to 3.65φ), 84% (2.60 to 3.82φ), and 95% (2.9 to 4.50φ). These measurements have been computed from the southwest part of LalBagh for the numerical approach of the grain size information of Manchar Formation. The graphical mean of sediment size are calculated formula proposed by (Folk, 1968)(Table-03). The mean values of the Siwalik Group (Manchar Formation) 14%and 86% samples revealed medium grain and fine grain size. The meanvalue varies from 1.64 to 2.99 phi (average 2.36 phi). In Manchar Formation (Siwalik Group) sandstone shows majority of fine sand this may indicate overall variability in mean size of changes in energy situations during deposition of sediments. In addition to this the majority of fine grain unconsolidated sediments and be deficient in of coarse grain sediments specify to low energy situation of depositional setting (Baiyegunhi *et al.*, 2017; Boggs Jr & Boggs, 2009).

The sorting formula (Table-03), presented by (Folk, 1968), one of the most valuable approaches for determining the nature of sediment sorting and it alsooffers information about the efficiency of the transport agent in dividing the clasts of various classes. The standard deviation of sediments in the studied section varies from 0.79 to 1.54φ. The results shows that 48% sediments are moderately sorted and 52% are poorly sorted.

The symmetry in grain size distribution of sediment measured by Skewness. Normally zero value in skewness is considered as an ordinary grain size distribution in sediments, meaning that the cumulative frequency curve is symmetrical and has no tail.so if the finer fraction exceeds the coarser fraction, the skew value is usually positive in that situation (Phi value+) and skewness estimate is negative in the inverse scenario (Phi value -). Skewness of the current studies has been determined by(Folk, 1968) formulae (Table-03). The results of skewness ranges from -1.22 to 0.34 phi (29%) are nearly symmetrical, (43%) are coarse skewed, (9%) are fine skewed (5%) are strongly fine skewed and (14%) is strongly coarse skewed.

The Kurtosis of unconsolidated sediments of the Siwalik Group (Manchar Formation) at Lal Bag section was determined by using the formulae, **(Table-3).** The Kurtosis of unconsolidated sediments of Manchar Formation varies from 0.78 to 3.10φ. The outcomes of this study were correlated with the published parameters (Folk, 1968) for kurtosis. The results show thatsamples are platykurtic, Leptokurtic, and Very leptokurtic 14%, 43%and 38% respectively. (Stewart, 1958) diagrams.

Produced Two discriminate diagrams produced by (Stewart, 1958) plotting the values of median versus sorting and skewness. In these diagrams he has described the three depositional processes river, wave,

and quite water slow deposition. The calculated values of median, sorting and skewness of unconsolidated sandstone of Manchar Formation were plotted in (Stewart, 1958) diagrams Fig 4a and 4b. In figure 4a indicates that almost all samples clustered in wave field, however, few samples plotted in the boundary of river field and few samples falls between the boundary of wave and river. In figure 4b almost all samples falls within the boundary of wave environment, very few samples falls within river field. It is also observed that sample no 19, 5 and 6 falls close to the boundary of quite water of slow deposition.

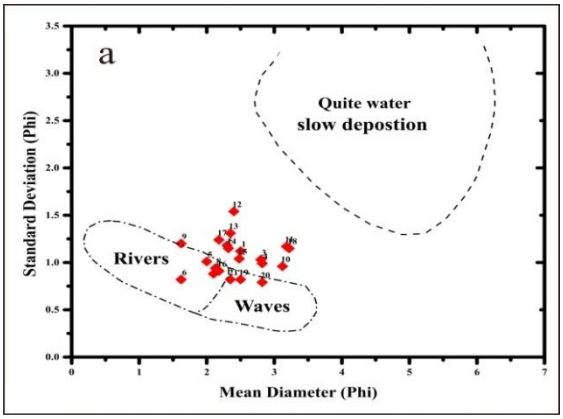

Fig. 4a interpretation diagram median against sorting after (Stewart, 1958).

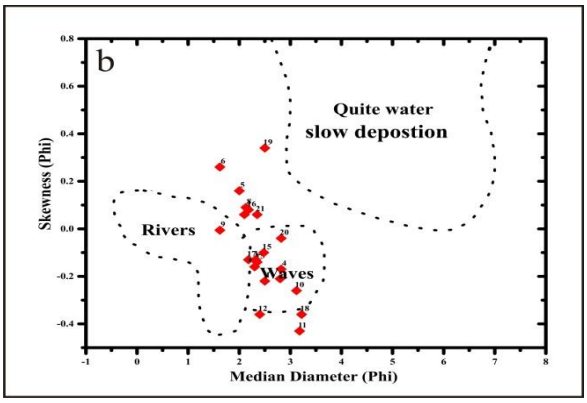

Fig. 4b. interpretation diagram median against skewness after (Stewart, 1958).

Sohu (1964) linear discriminate function diagrams.

Statistical data analysis was used to identify fluctuations in energy and fluidity parameters after or before sediment sedimentation seems to have a very good connection with the different depositional environments. (Sahu, 1964). He modified the linear discriminant functions Y1, Y2, Y3 and Y4 and used to differentiate between processes and environments of deposition. Mathematical expression (I) used to differentiate amongst shallow agitated water and beach.

If the Y1 value is less than −2.7411 it represents shallow agitated water environment, and reverse represents the beach environment.

To discriminate beach and shallow marine environments following mathematical expression (II) used.

If Y2 is less than −63.3650, it shows "beach" environment and in reverse represents "shallow marine" environment.

Mathematical expression (III) used to distinguish between deltaic or lacustrine and shallow marine environments.

If Y3 is greater than −7.4190, it represents "shallow marine" environment and in reverse represents "deltaic or lacustrine" environment.

Mathematical expression (IV) used to distinguish between deltaic and turbidity current deposits,.

If Y4 is greater than 9.8433, it indicates deltaic deposits in reverse indicates turbidity current deposits.

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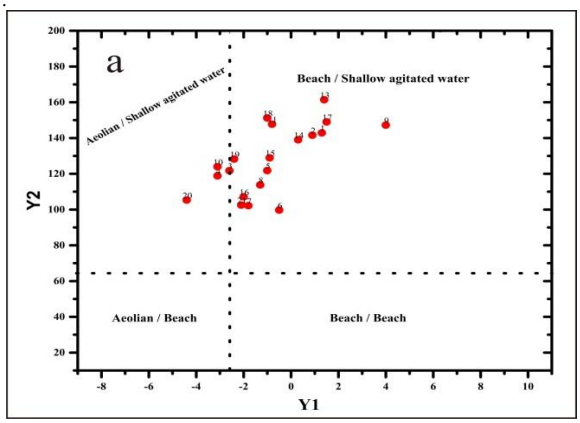

Fig. 5a Binary plot of Y1 against Y2 after (Sahu, 1964) Y1 = −3.5688M +3.7016r2 −2.0766SK +3.1135KG (I), Y2=15.6534M+65.7091r2+18.1071SK+18.5043KG (II) here M, r, SK, and KG represent mean, sorting, kurtosis and skewness.

The Bivariate diagram of Y1 against Y2 (Fig.5a) reveals that most of the samples from Siwalik Group (Manchar Formation) clustered in beach/shallow Agitated water, whereas, few samples fall in and around the boundary of aeolin/Shallow Agitated environment.

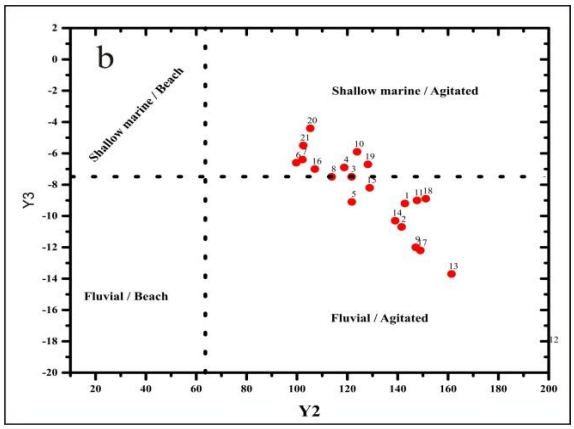

Fig. 5b Binary plot of Y2 against Y3 after (Sahu, 1964) Y3= 0.2852M − 8.7604r2 − 4.8932SK + 0.0482KG (III)Y4= 0.7215M − 0.4030r2 + 6.7322SK + 5.2927KG (IV) here M, r, SK, and KG represent mean, sorting, kurtosis and skewness.

The Bivariate diagram of Y3 againstY2 after (Sahu, 1964) (Figure 5b) specifies that nearly half of the samples from Manchar Formation clustered in fluvial/Agitated environments, whereas, half samples fall in and around the boundary of Shallow marine/Agitated depositional environment. The interpretation diagram of Y4 versus Y3 (Figure 5c) reveals that most of the samples from Siwalik Group (Manchar Formation) falls in the boundary of Fluvial/Turbidity current environment however other half of samples clustered in and around the Turbidity currents/Shallow marine environment.

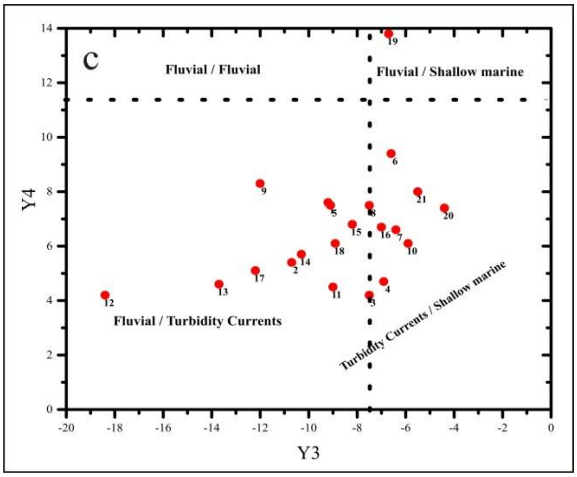

Fig. 5c Binary plot of Y3 against Y4 after (Sahu, 1964)

5. CONCLUSION

The clastic sediments of Siwalik Group (Manchar Formation) indicate unimodal to bimodal nature of sediments. The analytical result spacifies that sandstone of the formation is almost fine grain with subordinate medium grains. The sediments are mostly poorly to moderately sorted, coarse skewed to nearly symmetrical and leptokurtic to mesokurtic in nature. Most of the two-component variation diagram supports the deltaic depositional setting with influence of fluvial and shallow marine environment.

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