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Depositional Environment of the Bara Formation, Fort Ranikot Area, Sindh

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Abstract: Bara Formation is well exposed at Ranikot Fort area. Twenty two samples of the Bara Formation from the eastern flank of the Ranikot anticline of Fort Ranikot area have been investigated to interpret its environment of deposition. The values of different statistical parameters of the studied sediments for their grain size data, e.g., mean, median, standard deviation, skewness, and kurtosis were determined for plotting the cumulative curves and histograms to analyze the data. The 92% negative and 8% positive values of skewness, respectively, indicated that the studied sediments are composed of coarse grained to fine grained sediments and were deposited under the high-low energy conditions of fluviatile environment. The presence of abundant amounts of Quartz (SiO_2) in the bulk-rock samples also suggested fluviatile environment. The inclusive graphic standard deviation diagrams and the size distribution data also indicates that fine-medium grained sediments were deposited in the study area. Occurrence of three groups of sediments e.g., sediments from lower lagoon; sediments from upper lagoon and river; and the sediments from the dead-end marsh channels from the deeper parts of the basin of deposition have been recognized. The kurtosis values indicate that studied sediments are composed of Platykurtic, Leptokurtic and Mesokurtic groups of sediments, respectively.

Keywords: Depositional Environment, Grain size analysis, Sorting, Skewness, Fluviatile, Leptokurtic and Mesokurtic.

1. INTRODUCTION

The purpose of this paper is to interpret the environment of deposition of the Bara Formation at Fort Ranikot area. The studied area is located to the western side of Sann Railway Station, District Jamshoro. Bara Formation has been investigated for its coal deposits by many workers including (Abbas, *et.al.* 2005, Khan 1994 and 1998), Shah 1998) and Shah 1997 and 2002). These workers have contributed to the stratigraphy, coal resources and its paleontological record. Prior to this study, none of the previous workers had investigated its environment of deposition. The present study is first of its kind in this direction. Sedimentologists have used the values of the diameters of sedimentary grains, nature of sorting, values of the median, mode, kurtosis, and skewness, for the interpretation of environment of deposition of sediments. The grain size data of the studied sediments was obtained by the sieving method for plotting the cumulative curves and histograms. Different methods of statistical analysis including the plotting of grain size data as cumulative curves and histograms were applied for collecting information regarding the environments of the deposition.

2. General Geology and Stratigraphy

The Bara Formation is composed of sandstones, shales and minor amount of siltstones. It is the second oldest Formation of the Ranikot anticline, whereas the Manchhar Formation is the youngest Formation of this area and occurs on the flanks of the Ranikot anticline. Structurally the Ranikot anticline is a part of Lakhi range, which runs north-south direction and exists in the Survey of Pakistan (SOP) Toposheet No. 35 O/13. The Geological Map of Ranikot area and the stratigraphic succession respectively, are shown by **(Map-1 and Table-1)**. The exposed section of the Bara Formation in Fort Ranikot area is 250 meter thick. It is located, near Ranikot dhoro, and is composed of sandstones, shales and minor siltstones. The sandstone is about two third of the Formation and displays variegated colors. It is fine to coarse grained, soft, crumbly, and poorly sorted, ripple marked and cross-bedded. Massive beds are calcareous and ferruginous. The lower contact of the Bara Formation is confirmable with the Khadro Formation whereas the upper contact is unconfirmable with the Laki Formation in the studied area.

Table- 1: Stratigraphy of Fort Ranikot Area, Sindh Province.

Age	Formation	Lithology
Upper Miocene to Pliocene	Manchhar 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.

3. MATERIALS AND METHODS

Twenty two samples were collected from the outcrop of the Bara Formation, from the eastern flank of Ranikot anticline. One stratigraphic section was measured from the eastern flank of Ranikot anticline for recording the thickness of the Bara Formation of Ranikot Group. Stratigraphic section is illustrated in

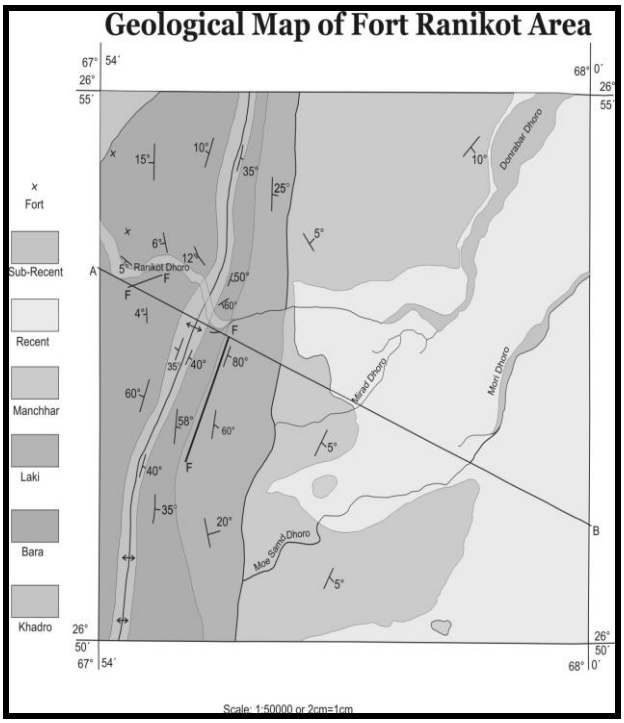
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(Fig-1). The measurement of this section was carried out by the Jacob's staff method. The Quardinates of Fort Ranikot east section is (Latitude: 25° 38' 35"N, Longitude: 68° 09' 09"E to Latitude: 25° 41' 03"N, Longitude: 68° 10' 46"E). At eastern section the Bara Formation started from contact between Khadro and Bara Formation of the Ranikot anticline to the contact of Laki Formation towards east along the Ranikot Nala.

The grain size data of sediments obtained by the sieve analysis method is commonly used for knowing the distribution of the grains of sands and other sediments. The grain size analysis of the studied sediments was done by the procedure, described by Folk (1968). Twenty two samples of the friable sandstone of the Bara Formation were prepared for the Sieve analysis. The sieve analysis was completed at the Sedimentology Lab of the Department of Geology, University of Karachi. One hundred gram (100g) of each sample was used for the sieving analysis. The sieves used were of -2φ, -1 φ (granules), 0 φ (very coarse sand), 1 φ (coarse sand), 2 φ (medium sand), 3 φ (fine sand), and 4 φ (very fine sand) for sieving the samples. The sieved data of the friable sandstone of the Bara Formation is demonstrated by the histogram and cumulative curves **(Figs. 2 and 3).**

4. RESULTS AND DISCUSSION

The Bara Formation at Ranikot anticline is composed of sandstones, shales and minor amount of siltstones. The sandstone is variegated i.e. yellow, whitish yellow, blackish yellow, whitish purple, purple, light blackish, blackish yellow, red, pink, light blackish yellow, grey, light orange, dirty white, whitish pink, and multi-colored in colors. It is fairly cemented to friable in nature. The sandstones are poor to moderately sorted. Geological map of the studied area has been prepared carefully (Map 01). Section measurement data of the Bara Formation at Ranikot area is shown in **(Fig.1).** The histograms and the cumulative curves of the loose sediments of the Bara Formation are shown by **(Fig..2-3)** which was prepared by the data of the sieving **(Tables 2A-2V).** The statistical parameters are described in **(Table-3).**



Map 01: Geological Map of Fort Ranikot area, Sindh. (Produced by Author)

The results of the studied sediments of the Bara Formation provided evidences which helped in the interpretation of the environment of deposition. According to Selley (1970), sedimentary environment is a "part of the earth's surface which physically, chemically and biologically is distinct from the adjacent areas." Selley (1985a) used the grain size data of sediments for the interpretation of the environment of deposition. The graphical representation of the grain size data has been considered as the most important and meaningful method, for understanding the environments of deposition of sediments (Folk1968). Farshori (1967) used the values of Skewness, kurtosis and the sphericity, for knowing the trends of the distribution of the grains, and the provenance of the sediments of the Indus River. According to Sahu (1964,) the presence of coarse grains of clastic sediments, reflect the fluidity (viscosity) factor of the depositing medium and the energy factor of the environment of deposition.

Table 2A: Data Sheet of Ranikot Sample 01 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	0.2	0.2	0.2
WT of sieve	0	Coarse sand	2.2	2.2	2.4
WT of sieve	1	Coarse sand	10.5	10.5	12.9
WT of sieve	2	Medium sand	12.5	12.5	25.4
WT of sieve	3	Fine sand	47	47	72.5
WT of sieve	4	V. Fine sand	26.5	26.5	99.0
WT of sieve	Silt/Clay	Silt/Clay	1	1	100

Table 2B: Data Sheet of Ranikot Sample 02 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	0.3	0.3	0.3
WT of sieve	0	V.Coarse sand	4	4	4.3
WT of sieve	1	Coarse sand	27.5	27.5	31.8
WT of sieve	2	Medium sand	27	27	58.8
WT of sieve	3	Fine sand	21.2	21.2	80
WT of sieve	4	V. Fine sand	14.5	14.5	94
WT of sieve	Silt/Clay	Silt/Clay	5.5	5.5	100

Table 2C: Data Sheet of Ranikot Sample 03 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	0.3	0.3	0.3
WT of sieve	0	V.Coarse sand	3	3	3.3
WT of sieve	1	Coarse sand	23	23	26.3
WT of sieve	2	Medium sand	28.7	28.7	55
WT of sieve	3	Fine sand	27.5	27.5	82.5
WT of sieve	4	V. Fine sand	11.5	11.5	94
WT of sieve	Silt/Clay	Silt/Clay	6	6	100

Table 2D: Data Sheet of Ranikot Sample 04 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	1	1	1
WT of sieve	0	V.Coarse sand	4.5	4.5	5.5
WT of sieve	1	Coarse sand	40.2	40.2	45.7
WT of sieve	2	Medium sand	23.5	23.5	69.2
WT of sieve	3	Fine sand	28.5	28.5	97.7
WT of sieve	4	V. Fine sand	2.3	2.3	100
WT of sieve	Silt/Clay	Silt/Clay	0	0	

Table 2E: Data Sheet of Ranikot Sample 05 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	3	3	3
WT of sieve	0	V.Coarse sand	3	3	6
WT of sieve	1	Coarse sand	17	17	23
WT of sieve	2	Medium sand	35	35	58
WT of sieve	3	Fine sand	33	33	91
WT of sieve	4	V. Fine sand	8	8	99
WT of sieve	Silt/Clay	Silt/Clay	1	1	100

Table 2F: Data Sheet of Ranikot Sample 07 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	2.1	2.1	2.1
WT of sieve	0	V.Coarse sand	7	7	9.1
WT of sieve	1	Coarse sand	45	45	54.1
WT of sieve	2	Medium sand	24.7	24.7	78.8
WT of sieve	3	Fine sand	15.8	15.8	94.6
WT of sieve	4	V. Fine sand	4	4.5	99.1
WT of sieve	Silt/Clay	Silt/Clay	0.9	0.9	100

Table 2G: Data Sheet of Ranikot Sample 10 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	2	2	2
WT of sieve	0	V.Coarse sand	5	5	7
WT of sieve	1	Coarse sand	26	26	33
WT of sieve	2	Medium sand	30	30	63
WT of sieve	3	Fine sand	29.5	29.5	92.5
WT of sieve	4	V. Fine sand	6.5	6.5	99
WT of sieve	Silt/Clay	Silt/Clay	1	1	100

Table 2H: Data Sheet of Ranikot Sample 11 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		7	7	7
WT of sieve	-1	Granules	26	26	33
WT of sieve	0	V.Coarse sand	27	27	60
WT of sieve	1	Coarse sand	22	22	82
WT of sieve	2	Medium sand	11	11	93
WT of sieve	3	Fine sand	4	4	97

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	2	2	2
WT of sieve	0	V.Coarse sand	5	5	7
WT of sieve	1	Coarse sand	26	26	33
WT of sieve	2	Medium sand	30	30	63
WT of sieve	3	Fine sand	29.5	29.5	92.5
WT of sieve	4	V. Fine sand	6.5	6.5	99
WT of sieve	Silt/Clay	Silt/Clay	1	1	100
WT of sieve	4	V. Fine sand	3	3	100
WT of sieve	Silt/Clay	Silt/Clay	0	0	100

Table 2I: Data Sheet of Ranikot Sample 12 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	2	2	2
WT of sieve	0	V.Coarse sand	6.5	6.5	8.5
WT of sieve	1	Coarse sand	21	21	29.5
WT of sieve	2	Medium sand	38.5	38.5	68
WT of sieve	3	Fine sand	21.5	21.5	89.5
WT of sieve	4	V. Fine sand	6.5	6.5	96
WT of sieve	Silt/Clay	Silt/Clay	4	4	100

Table 2J: Data Sheet of Ranikot Sample 13 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	2	2	2
WT of sieve	0	V.Coarse sand	3	3	5
WT of sieve	1	Coarse sand	7.5	7.5	12.5
WT of sieve	2	Medium sand	22.5	22.5	35
WT of sieve	3	Fine sand	53.5	53.5	88
WT of sieve	4	V. Fine sand	11	11	99
WT of sieve	Silt/Clay	Silt/Clay	1	1	100

Table 2K: Data Sheet of Ranikot Sample 16 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	4	4	4
WT of sieve	0	V.Coarse sand	8.5	8.5	12.5
WT of sieve	1	Coarse sand	17	17	29.5
WT of sieve	2	Medium sand	15.5	15.5	45
WT of sieve	3	Fine sand	43	43	88
WT of sieve	4	V. Fine sand	11.5	11.5	99.5
WT of sieve	Silt/Clay	Silt/Clay	0.5	0.5	100

Table 2L: Data Sheet of Ranikot Sample 17 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	3.7	3.7	3.7
WT of sieve	0	V.Coarse sand	12	12	15.7
WT of sieve	1	Coarse sand	66.5	66.5	81.7
WT of sieve	2	Medium sand	16	16	97.7
WT of sieve	3	Fine sand	1.3	1.3	99
WT of sieve	4	V. Fine sand	1	1	100
WT of sieve	Silt/Clay	Silt/Clay	0	0	100

Table 2M: Data Sheet of Ranikot Sample 24 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	0	0	0
WT of sieve	0	V.Coarse sand	0.5	0.5	0.5
WT of sieve	1	Coarse sand	15.5	15.5	16
WT of sieve	2	Medium sand	51	51	67
WT of sieve	3	Fine sand	26	26	93
WT of sieve	4	V. Fine sand	6.5	6.5	99.5
WT of sieve	Silt/Clay	Silt/Clay	0.5	0.5	100

Table 2N: Data Sheet of Ranikot Sample 28 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	7	7	7
WT of sieve	0	V.Coarse sand	6	6	13
WT of sieve	1	Coarse sand	14	14	27
WT of sieve	2	Medium sand	25	25	52
WT of sieve	3	Fine sand	37	37	89
WT of sieve	4	V. Fine sand	9	9	98
WT of sieve	Silt/Clay	Silt/Clay	2	2	100

Table 2O: Data Sheet of Ranikot Sample 31 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	0.6	0.6	0.6
WT of sieve	0	V.Coarse sand	2.5	2.5	3.1
WT of sieve	1	Coarse sand	32	32	35.1
WT of sieve	2	Medium sand	39	39	74.1
WT of sieve	3	Fine sand	21	21	95.1
WT of sieve	4	V. Fine sand	4.6	4.6	99.7
WT of sieve	Silt/Clay	Silt/Clay	0.3	0.3	100

Table 2P: Data Sheet of Ranikot Sample 37 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	1	1	1
WT of sieve	0	V.Coarse sand	5	5	5
WT of sieve	1	Coarse sand	19	19	19
WT of sieve	2	Medium sand	20	20	20
WT of sieve	3	Fine sand	34	34	34
WT of sieve	4	V. Fine sand	17	17	17
WT of sieve	Silt/Clay	Silt/Clay	4	4	4

Table 2Q: Data Sheet of Ranikot Sample 41 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		1	1	1
WT of sieve	-1	Granules	9	9	10
WT of sieve	0	V.Coarse sand	13.5	13.5	23.5
WT of sieve	1	Coarse sand	26.5	26.5	50
WT of sieve	2	Medium sand	13	13	63
WT of sieve	3	Fine sand	21.5	21.5	84.5
WT of sieve	4	V. Fine sand	13.5	13.5	98
WT of sieve	Silt/Clay	Silt/Clay	2	2	100

Table 2R: Data Sheet of Ranikot Sample 47 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	2	2	2
WT of sieve	0	V.Coarse sand	1	1	3
WT of sieve	1	Coarse sand	12	12	15
WT of sieve	2	Medium sand	35	35	50
WT of sieve	3	Fine sand	31.5	31.5	81.5
WT of sieve	4	V. Fine sand	16.5	16.5	98
WT of sieve	Silt/Clay	Silt/Clay	2	2	100

Table 2S: Data Sheet of Ranikot Sample 48 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	0.8	0.8	0.8
WT of sieve	0	V.Coarse sand	1.5	1.5	2.3
WT of sieve	1	Coarse sand	45.5	45.5	47.8
WT of sieve	2	Medium sand	32	32	79.8
WT of sieve	3	Fine sand	13	13	92.8
WT of sieve	4	V. Fine sand	3.5	3.5	96.3
WT of sieve	Silt/Clay	Silt/Clay	3.7	3.7	100

Table 2T: Data Sheet of Ranikot Sample 49 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	4	4	4
WT of sieve	0	V.Coarse sand	9.5	9.5	13.5
WT of sieve	1	Coarse sand	22	22	35.5
WT of sieve	2	Medium sand	19	19	54.5
WT of sieve	3	Fine sand	21.5	21.5	76
WT of sieve	4	V. Fine sand	20	20	96
WT of sieve	Silt/Clay	Silt/Clay	4		100

Table 2U: Data Sheet of Ranikot Sample 50 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	4	4	4
WT of sieve	0	V.Coarse sand	12	12	16
WT of sieve	1	Coarse sand	17	17	33
WT of sieve	2	Medium sand	7	7	40
WT of sieve	3	Fine sand	11	11	51
WT of sieve	4	V. Fine sand	45	45	96
WT of sieve	Silt/Clay	Silt/Clay	4	4	100

Table 2V: Data Sheet of Ranikot Sample 51 Ra (E)

Weight of sample is 100gram	Phi Value	Grain Size	Weight	Weight Percentage	Cumulative Percentage
WT of sieve	-2		0	0	0
WT of sieve	-1	Granules	3	3	3
WT of sieve	0	V.Coarse sand	6	6	9
WT of sieve	1	Coarse sand	17	17	26
WT of sieve	2	Medium sand	14.5	14.5	40.5
WT of sieve	3	Fine sand	39	39	79.5
WT of sieve	4	V. Fine sand	18.5	18.5	98
WT of sieve	Silt/Clay	Silt/Clay	2	2	100

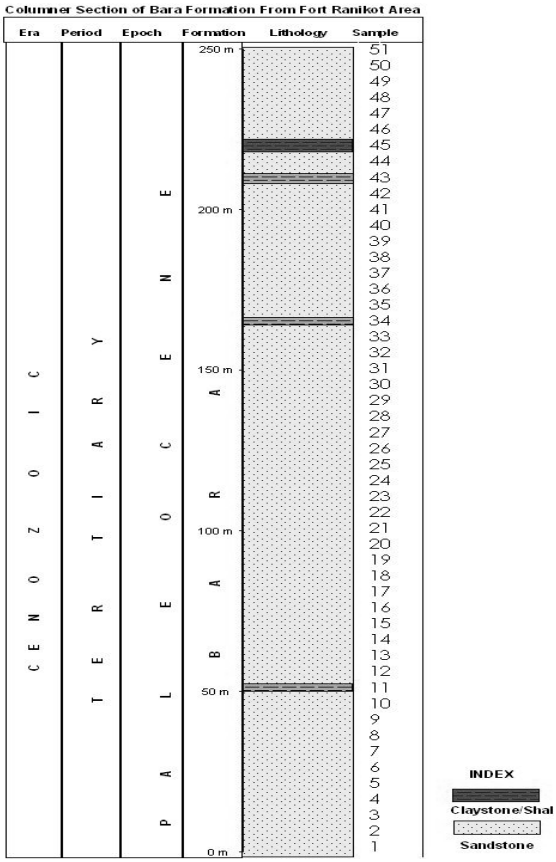
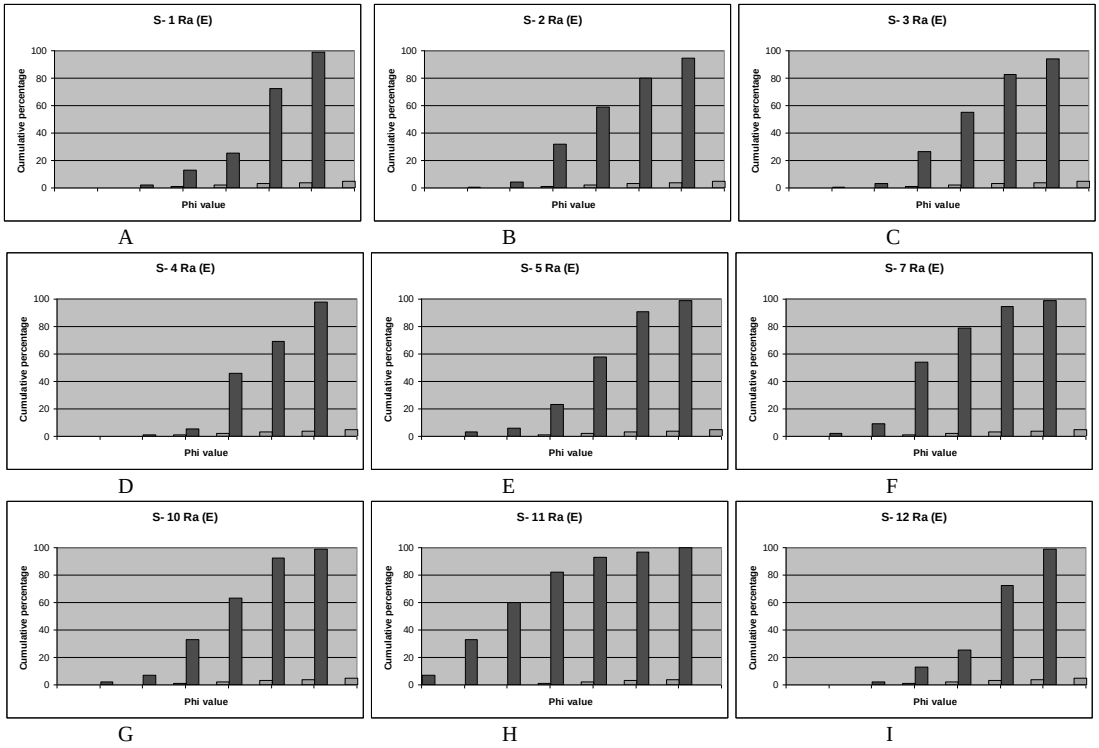


Fig. 1: Shows the Columnar Section of the Bara Formation from Fort Ranikot section.

The cumulative curve normally produces an S-shaped curve. The slope of the central part of the cumulative curves in the present study, reflected a very poor to good sorting of the grains by the very gentle and very steep slopes, respectively. The central parts of the cumulative curves of the Bara Formation from Fort Ranikot section are gentle while some are between steep and gentle **(Fig. 3).** The sediments of the Bara Formation which showed the medium range of the central part between steep and the gentle, they indicate the poor to moderate sorting nature of the sediments. The poor and moderate, both type of sorting exhibited by the grains, further suggested that these sediments were deposited under the fluviatile environments, respectively. (Baqri, 1997) studied the distribution of sulphur in the paleocene coals of Sindh province. He has reported a systematic variation and gradual increase of sulphur from east to west and concluded that the Paleocene coal deposits of Sindh in the eastern areas were deposited under shallow continental to lagoonal condition, whereas the deposition in the west area took place in deeper areas under brackish waters (deltas, estuarine) toward the Ranikot.



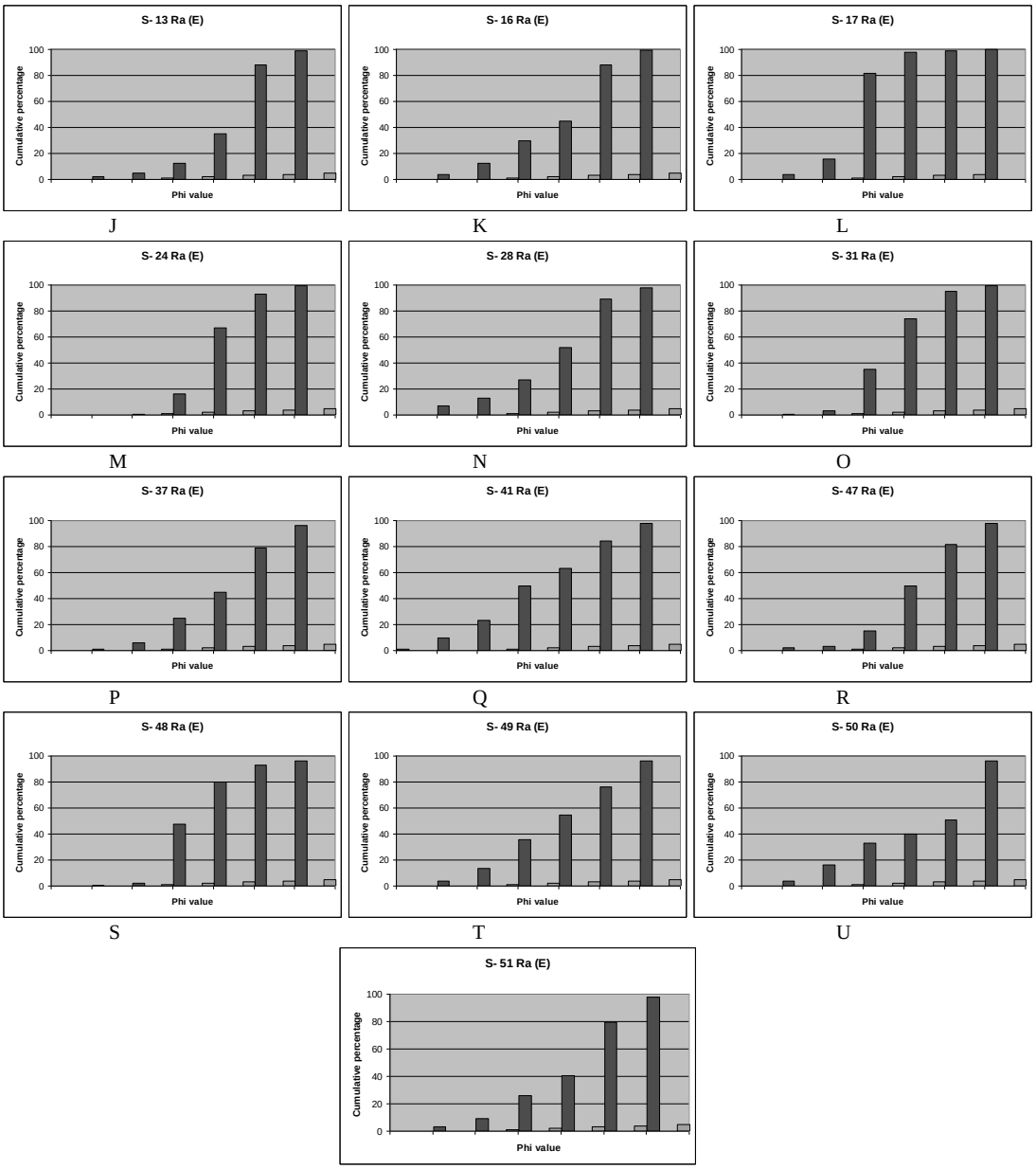
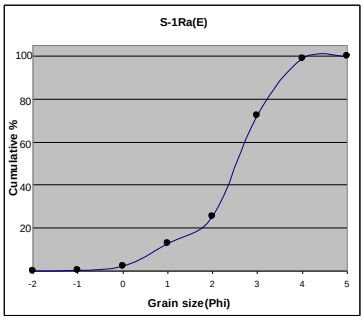
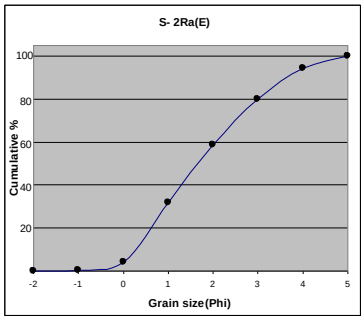


Fig. 2: Histograms of Fort Ranikot section.

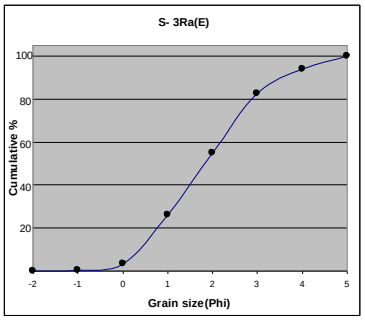
A= Histogram of S-1Ra (E), Fort Ranikot area;B= Histogram of S-2Ra (E), Fort Ranikot area; C= Histogram of S-3Ra (E), Fort Ranikot area;D= Histogram of S-4Ra (E), Fort Ranikot area;E= Histogram of S-5Ra (E), Fort Ranikot area;F= Histogram of S-7Ra (E), Fort Ranikot area;G= Histogram of S-10Ra (E), Fort Ranikot area;H= Histogram of S-11Ra (E), Fort Ranikot area);I= Histogram of S-12Ra (E), Fort Ranikot area;J= Histogram of S-13Ra (E), Fort Ranikot area;K= Histogram of S-16Ra (E), Fort Ranikot area;L= Histogram of S-17Ra (E), Fort Ranikot area. M= Histogram of S-24Ra (E), Fort Ranikot area;N= Histogram of S-28Ra (E), Fort Ranikot area;O= Histogram of S-31Ra (E), Fort Ranikot area;P= Histogram of S-37Ra (E), Fort Ranikot area;Q= Histogram of S-41Ra (E), Fort Ranikot area;R= Histogram of S-47Ra (E), Fort Ranikot area;S= Histogram of S-48Ra (E), Fort Ranikot area;T= Histogram of S-49Ra (E), Fort Ranikot area;U= Histogram of S-50Ra (E), Fort Ranikot area;V= Histogram of S-51Ra (E), Fort Ranikot area.



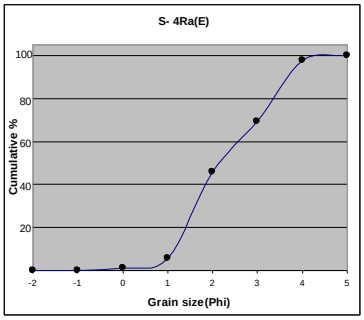
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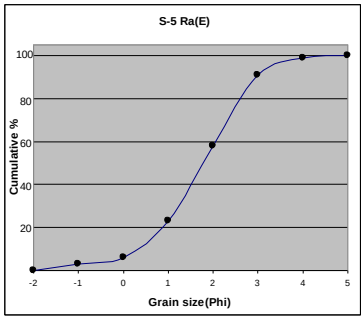
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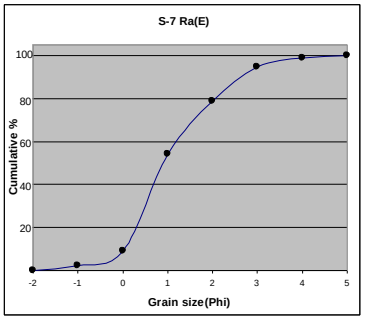
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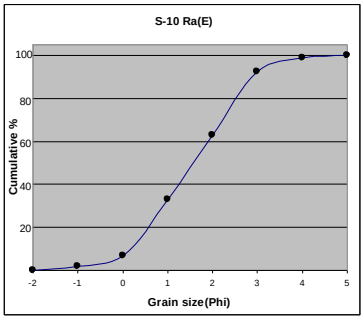
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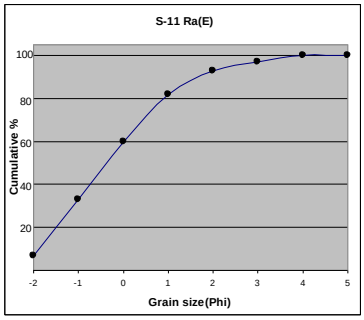
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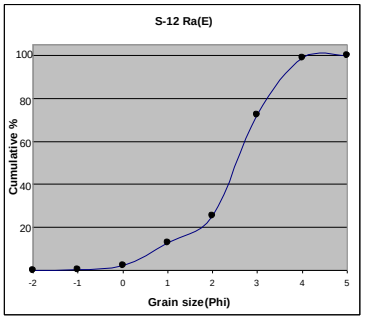
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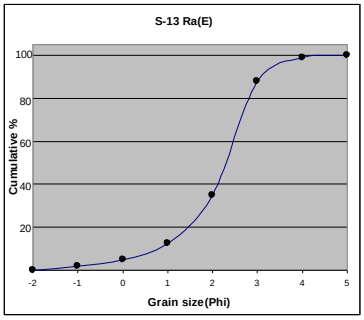
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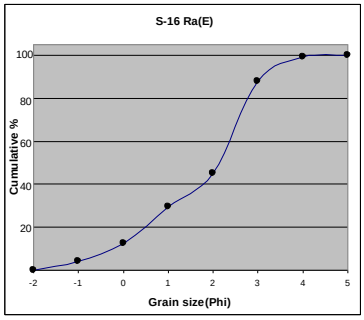
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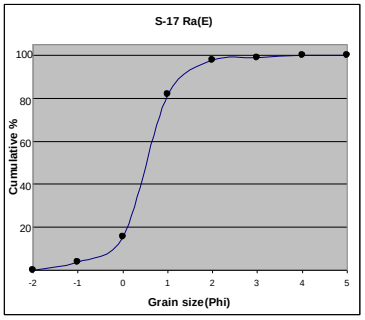
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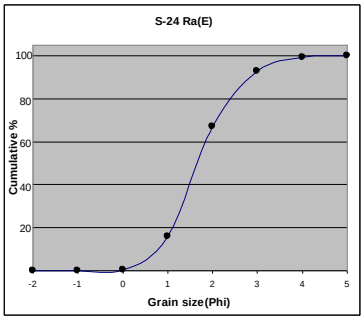
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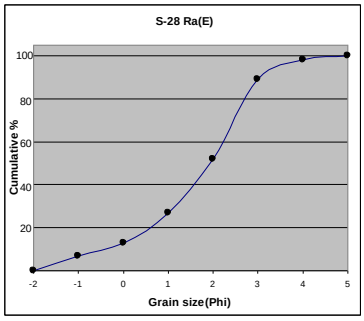
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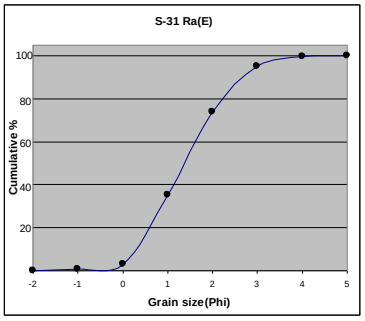
L



M



N



O

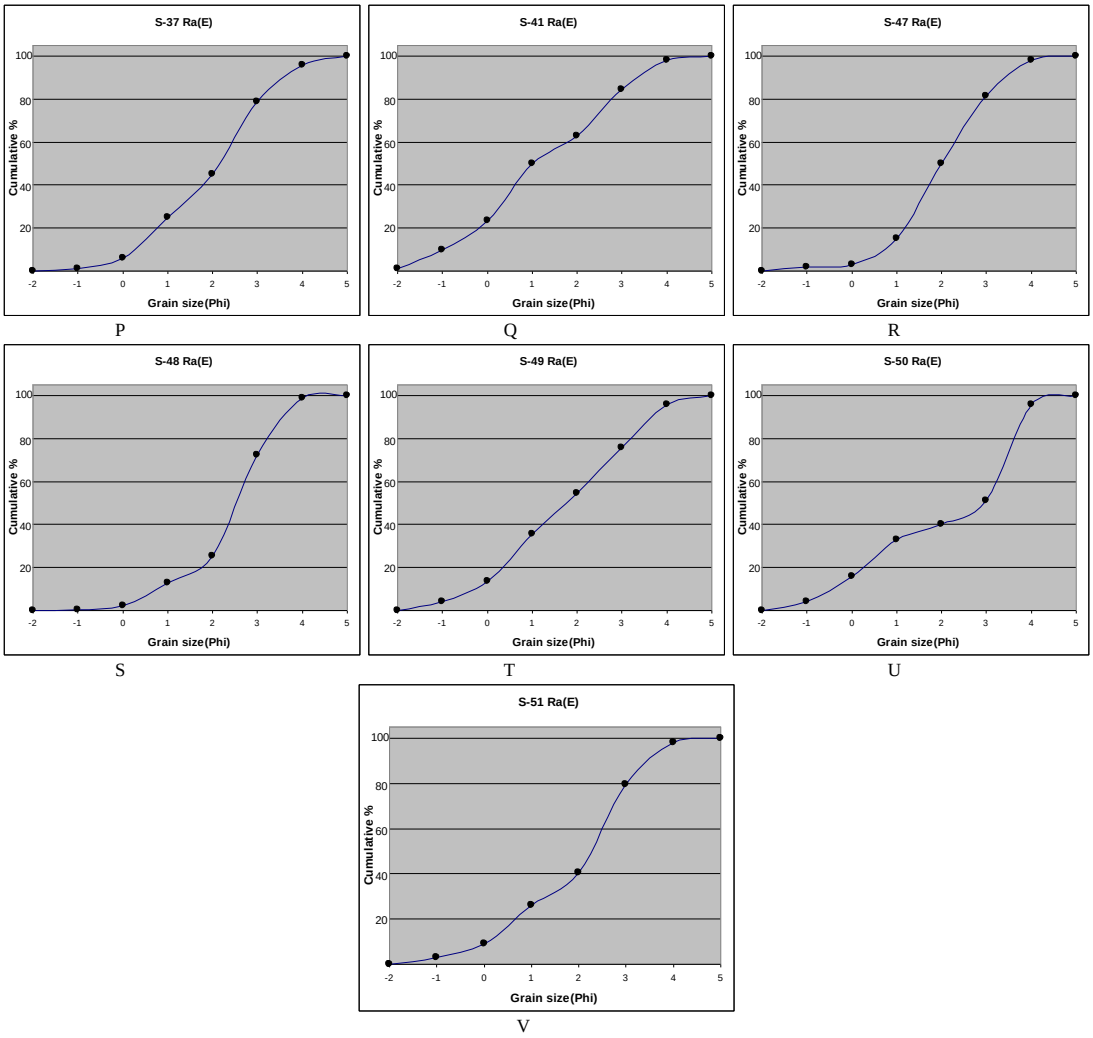


Fig. 3: Cumulative curves of Fort Ranikot section.

Explanation: A= Cumulative Curve of S-1Ra (E), Fort Ranikot area, B= Cumulative Curve of S-2Ra (E), Fort Ranikot area; C= Cumulative Curve of S-3Ra (E), Fort Ranikot area; D= Cumulative Curve of S-4Ra (E), Fort Ranikot area; E= Cumulative Curve of S-5Ra (E), Fort Ranikot area; F= Cumulative Curve of S-7Ra (E), Fort Ranikot area; G= Cumulative Curve of S-10Ra (E), (BFFR);H= Cumulative Curve of S-11Ra (E), (BFFR);I= Cumulative Curve of S-12Ra (E), (BFFR);J= Cumulative Curve of S-13Ra (E), (BFFR);K= Cumulative Curve of S-16Ra (E), (BFFR);L= Cumulative Curve of S-17Ra (E), (BFFR);M= Cumulative Curve of S-24Ra (E), (BFFR);N= Cumulative Curve of S-28Ra (E), (BFFR);O= Cumulative Curve of S-31Ra (E), (BFFR);P= Cumulative Curve of S-37Ra (E), (BFFR);Q= Cumulative Curve of S-41Ra (E), (BFFR);R= Cumulative Curve of S-47Ra (E), (BFFR);S= Cumulative Curve of S-48Ra (E), (BFFR);T= Cumulative Curve of S-49Ra (E), (BFFR);U= Cumulative Curve of S-50Ra (E), (BFFR);V= Cumulative Curve of S-51Ra (E), (BFFR).

Mc Cammon (1962) stated when the values of more percentiles are read in cumulative curves, they confirm that the method is accurate. The percentile values of the loosely cemented sediments of the Bara Formation from Fort Ranikot section were read from the cumulative curves. The values of the percentile read are 5% (-2.4 to 0.3 φ), 16% (-2.3 to 1.2 φ), 25% (-2.7 to 1.7 φ), 50% (-1.5 to 2.9 φ), 75 %(0.6 to 3.4 φ), 84% (1.0 to 3.5 φ), and 95 % (1.7 to 4.9 φ). These values were plotted for the statistical analysis of the grain size data of loose sandstones of the Bara Formation from the Fort Ranikot section.

Statistical parameters of sedimentary grains e.g., mean, median, kurtosis, Skewness and the dimensions of grains of sediments, play important role in understanding the environments of deposition, shown

in **(Table-3).** Folk (1968) mentioned that the average graphic mean of the average size of sediments can be determined by the formula MZ= (φ 16+ φ 50+ φ 84)/3. The graphic mean values of the friable sandstones of the Bara Formation from Fort Ranikot section were determined by using the above mentioned formula and the calculated values are shown in **(Table-3).** The Graphic mean of the Bara Formation in the light of the Folk's standard value of Graphic mean, suggested that the sands of the Bara Formation of the Fort Ranikot section, are composed of different sizes of the sand grains (14 samples showed medium grain size, 5 samples indicated fine grain size, 2 samples exhibited coarse grain size and one sample coarse grain size.

Table- 3: Statistical characteristics of the samples from Fort Ranikot section.

Sample Number	Graphic Mean	Median	Sorting	Graphic Skewness (SK_I)	Graphic Kurtosis (K_G)
1 Ra(E)	2.43	2.5	1.1	-0.26	1.52
2 Ra(E)	1.76	1.8	1.2	0.21	0.84
3 Ra(E)	1.9	1.9	1.3	0.11	1.07
4 Ra(E)	1.23	1.3	1.7	0.07	1.37
5 Ra(E)	1.7	1.6	1.3	-0.23	2.01
7 Ra(E)	1.16	1.3	1.2	0.24	1.71
10Ra(E)	1.53	1.4	1.2	-0.39	1.33
11Ra(E)	-0.9	0.6	1.2	1.38	0.29
12Ra(E)	1.66	1.7	1.3	-0.15	1.87
13Ra(E)	2.23	2.0	0.9	-0.58	1.26
16Ra(E)	1.76	1.5	1.3	-0.56	0.82
17Ra(E)	0.56	0.5	0.6	0.12	2.37
24Ra(E)	1.73	1.7	0.8	-0.78	1.76
28Ra(E)	1.7	1.5	1.1	-0.31	1.83
31Ra(E)	1.4	1.4	0.8	0.18	1.04
37Ra(E)	2.1	2.4	1.9	-0.34	1.36
41Ra(E)	0.8	1.0	2.0	-0.09	1.19
47Ra(E)	1.96	2.0	0.9	-0.02	1.13
48Ra(E)	1.2	1.0	1.2	0.46	1.79
49Ra(E)	1.73	1.8	1.6	-0.63	0.80
50Ra(E)	2.2	2.9	1.4	-0.66	0.95
51Ra(E)	2.06	2.2	1.7	-0.13	1.36

The Median formula (MD= φ 50), given by Folk (1968), is commonly used measure in the study of sedimentology. It facilitates in the determination of the median grain size. The application of this formula in the present study indicated that particles of half of the samples, by weight are coarser, than the median, and the remaining half are finer. (It is the diameter corresponding to the 50% mark on the cumulative curve and may be expressed either in φ (MDφ size). The median values of the studied sediments are tabulated in (Table-3).

The inclusive graphic standard deviation or sorting formula, $\sigma I = (\varphi 84 - \varphi 16)/4 + (\varphi 95 - \varphi 5)/6.6$, formula given by Folk (1968), is one of the most useful methods, to determine the nature of the sorting of sediments. Its application provides information regarding the effectiveness of the depositional medium in separating the grains of different classes. The sorting of sediments of the Fort Ranikot section ranges from 0.8 to 1.9φ. The sediments are composed of different grain size (17 samples are poorly sorted, 4 samples are moderately sorted and 1 sample is moderately well sorted). The majority of the samples are poorly sorted. The poorly sorted sediments dominantly are deposited under the fluvial system. The sorting values of Fort Ranikot section samples are given in Table (3).

The skewness is the measure which depicts the uniformity of the distribution of sediments. The zero value of skewness is taken as a normal distribution of sediments which means that the cumulative curve is symmetrical and does not possess any tail. If the finer fraction is present in excess than the coarser fraction, in that case the value of the skewness generally is positive (Phi value -) and in the reverse situation the skewness value is negative (Phi value +). In the present investigation the Inclusive Graphical Skewness values were determined by Folk's (1968) formula, which is shown below:

$$SKI = \frac{\varphi 84 + \varphi 16 - 2(\varphi 50)}{2(\varphi 84 - \varphi 16)} + \frac{\varphi 95 + \varphi 5 - 2\varphi 50)}{2(\varphi 95 - \varphi 5)}$$

The fluviatile environments of deposition of sediments are indicated, by the sediments which are composed of large amount of clay and silt, commonly carried by rivers, and showing the positive values of Skewness. The inclusive graphic skewness values of the loose cemented sandstones are shown in Table (3). The results of 8 samples vary from 0.07 to 1.38 phi, 14 samples range from -0.02 to -0.78 phi. Sixty three percent (63%) samples showed the negative skewness, which indicates flooding of the river channels. The sorting of the most of the samples is poor (Table- 3), therefore, these observations indicated that the environment of deposition was fluvial. Thirty six percent (36%) samples of the same section, showed the positive skewness which also indicated the fluvial environments of deposition for the Bara Formation. The results of the skewness and sorting, acquired in the present study, suggest that the investigated sediments were laid down, mostly under the fluviatile environments, where the flooding of the river channels was common, which transported the remains of woods and vegetation into the local troughs, lakes, depressions, and low lying areas to form the lenticular coal seams.

The values of Graphic Kurtosis of the loose cemented sandstone of the Bara Formation at Fort

Ranikot section, shown in Table-3, was determined by using the Folk's (1968) formula, KG = φ 95 – φ 5 / 2.44 (φ 75 – φ 25). The Graphic Kurtosis of loose cemented sandstones of Bara Formation from Fort Ranikot Section ranges from 0.29 to 2.37. The results of the present study, were compared with the values reported by Folk (1968) for kurtosis. The data falls in the classes of Very platykurtic (1 samples), Platykurtic (3 samples), Mesokurtic (3 samples), Leptokurtic (8 samples) and Very leptokurtic (7 samples).

5. CONCLUSION

Considering the above discussion, this study may be concluded as under:

1. Geological map of the studied area has been prepared to depict the stratigraphy and structure of Fort Ranikot section.
2. The sediments of the Bara Formation from the Ranikot section are composed of friable, loose and consolidated sandstones, displaying a variety of colors.
3. The grain size of the studied sediments ranges from coarse grained- medium grained and from medium grained- fine grained.
4. Plots of the cumulative curves of the studied samples indicated that during the deposition of studied sediments, the sorting of sedimentary grains was variable, and the sediments were deposited under the river/ fluvial environments. It can be concluded that the Bara Formation sediments were deposited under the fluvial, river, the river wave's environment under the transitional condition, between the waves and river systems.
5. The Inclusive graphic standard deviation diagrams indicate that sediments are Heterogonous, composed of fine-medium grains and were deposited under the high energy condition and fluviatile environment.
6. The kurtosis values of the studied sediments indicate that these sediments are composed of Platykurtic, Mesokurtic and Leptokurtic groups of sediments.

6. ACKNOWLEDGEMENT

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