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STATISTICAL PROPERTIES AND PETROGRAPHY OF THE MISRI BANDA QUARTZITE, NOWSHERA TEHSIL. N. W. F. P.

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ABSRACT

This paper presents the statistical properties and petrography of the Devonian aud Carboniferous Misri Banda Quartzite. It occurs interbedded and overlying the Nowshera Formation of Siluro-Devonian reef complex.

The statistical analysis shows that most oj the quartzite samples fall in the well-sorted range and are unimodal in their size distribution. The size fequency curves show maximum sorting towards the coarse grades and skewness towards finer grades. Kurtosis values of size distribution range between 0.27 and 0.24.

Microscopic examination of several slides reveals that quartz grains, embedded in a carbonate matrix, are elongated with their longer axis being parallel to each other and to the longer dimensions of calcite/dolomite grains, Well-rounded grains of zircon, tourmaline, and other heavy minerals are present in lesser amounts. The high degree of textural and mineralogical maturity of the Misri Banda Quartzite and its association with the reef carbonates indicate a long history of transporation, reworking. and winnowing in shallow waters dominated by stable shelf environments, Statistieal data, heavy mineral distribution, and field observations indicate that ihe Misri Banda Quartzite conformably overlying the Nowshera Formation. and beds and stringers of quartzite, occuring interbedded with the reef carbonates. are one and the same derived from a common source.

INTRODUCTION

This paper is an edited account of M. Sc. thesis presented to the Geology Department, University of Peshawar in October 1971. The field work was carried out during the whole month of April, 1971; and four months were spent on detailed laboratory studies. The paper presents a detalled account of

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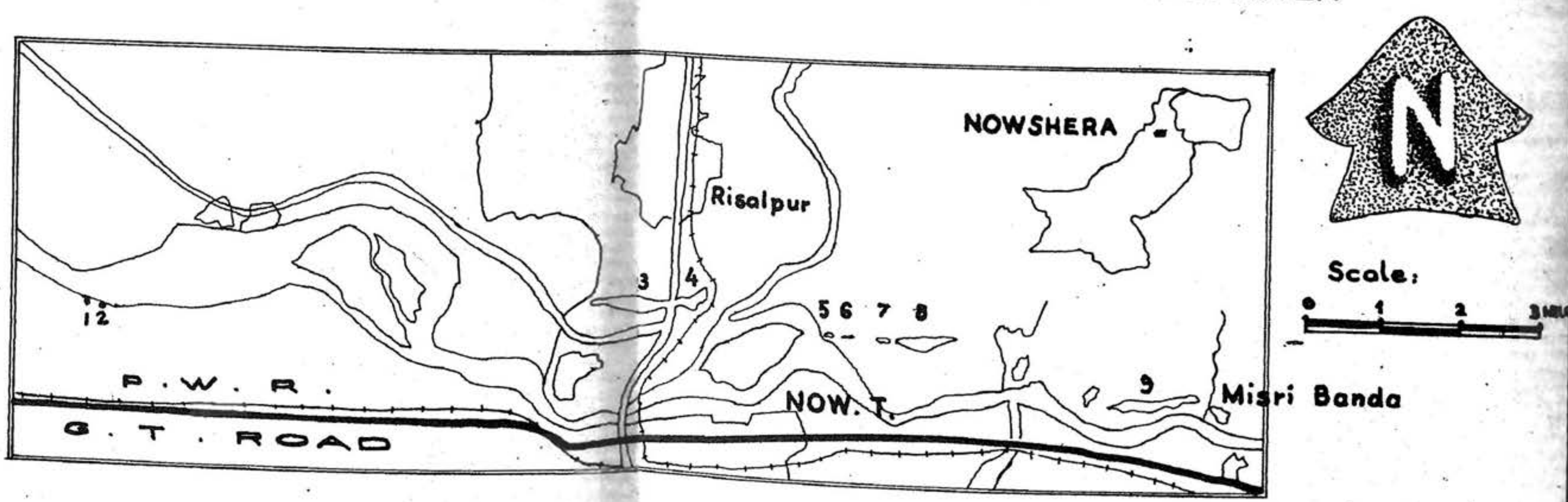
Fig. 1

LOCATION MAP

SHOWING REEF OUTCROPS

ON THE NORTHERN AND SOUTHERN BANK OF KABUL RIVER



statistical properties and petrography of the Misri Banda Quartzite of Devonian-Carboniferous age.

The area of investigation lies between Latitudes 34°.01′ and 34°.02′N and Longitudes 72°.00 and 72°.04′E (Fig. 1). In this area the major outcrops of the Misri Banda Quartzite occur associated with the "Nowshera Reef" in a linear belt between Kandar Village in the west and Pir Sabak in the east.

The quartzite is exposed along the northern parts of lowly rising hills in an East-West striking belt cropping out from the Recent alluvium of the Kabul River. The highest point of the outcrop No. 8 (Fig. 1) is 1276 feet above sea level. The Misri Banda Quartzite exposed at Kandar Village forms a low. isolated, oval-shaped hill north of the main reef complex. The highest level at this outcrop is about 1,000 feet. Large scale excavations, for marble and road metal, have extensively modified the topography of the area. Many fossil localities, within the Nowshera Formation, mapped and described by Stauffer (1967, 1968) are also quarried away.

Previous Work

Coulson (1936) mentioned the presence of the hills at Nowshera. He examined the carbonate rocks of the area for their marble content. In 1957, Kidwai of Geological Survey of Pakistan worked in the area to evaluate the marble reserves and prepared a topographic map by plane table survey. Announcement of the Palaeozoic Reef Discovery was made by Teichert and Stauffer in 1965. Later, Stauffer (1967) presented a summarized account of the Devonian rocks (both of definite Devonian and inferred Devonian age) of India and Pakistan. In 1968 Stauffer published a comprehensive account of the Siluro-Devonian rocks exposed near Nowshera. In fact, the stratigraphic nomenclature for the various formations belonging to Siluro-Devonian reef complex was evolved by him.

Ali and Anwar (1969) mapped the area and gave detailed geology of the complex. Siluro-Devonian reefoid rocks were also described from Jamrud, Khyber Agency, and Tangi Ghar by Khan (1969) and Tahirkheli (1969). Both of these were correlated with those of Nowshera.

General Geology

The Misri Banda Quartzite is the youngest unit conformably overlying the Siluro-Devonian reef. The reef mass. known as the Nowshera Formation, un-conformably overlies the Kandar Phyllite. Structurally the reef complex and the overlying Misri Banda Quartzite form the northern flank of an anticline which strikes in an east-west direction and dips 40°—45° north.

The quartzite occurs in two inches to three feet thick beds. At Pir Sabak, it occuts as two thick beds separated by the intervening Nowshera Formation. The upper and lower contacts are almost gradational. Besides these two beds, stringers of quartzite occur throughout the reef core at Pir Sabak and Nowshera. The other locality where it is extensively developed, is the type locality Misri Banda. Apparently the thickness increases in the soutneastern direction.

The quartzite is light gray to pink, medium to fine-grained with rounded quartz grains. Parts of the quartzite beds have a dolomitic matrix, less commonly calcite matrix (Stauffer, 1968, p. 1339). At two localities it shows cross-bedding and ripple marks. It has not yielded any fossils, however, on the bases of superposition of strata and lithology, the quartzite is assigned an Upper Devonian to Lower Carboniferous age (Stauffer, 1967; Ali and Anwar, 1969).

METHODS OF INVESTIGATION

(*a*) **Preparation of samples for grain size analysis.**

The rock samples, taken from outcrop Nos. 4 and 8 (Fig. 1) along the thickness of bed, and irregularly from outcrop No. 7, were crushed to one to two centimetre size and were treated with dilute hydrochloric acid to dissolve carbonates present as cement and matrix. Samples insoluble in dilute hydrochloric acid were treated with aqua regia untill the effervescence ceased and dolomite was completely eliminated. While the carbonates were removed, 'the clastic quartz and other iusoluble grains were left unaffected but disaggregated. The sand grains thus obtained were thoroughly washed on a filter paper. Care was taken so as the finer silt and clayey fraction of the residue was not removed by washing process. The washed material was allowed for three to four days in the sun to dry.

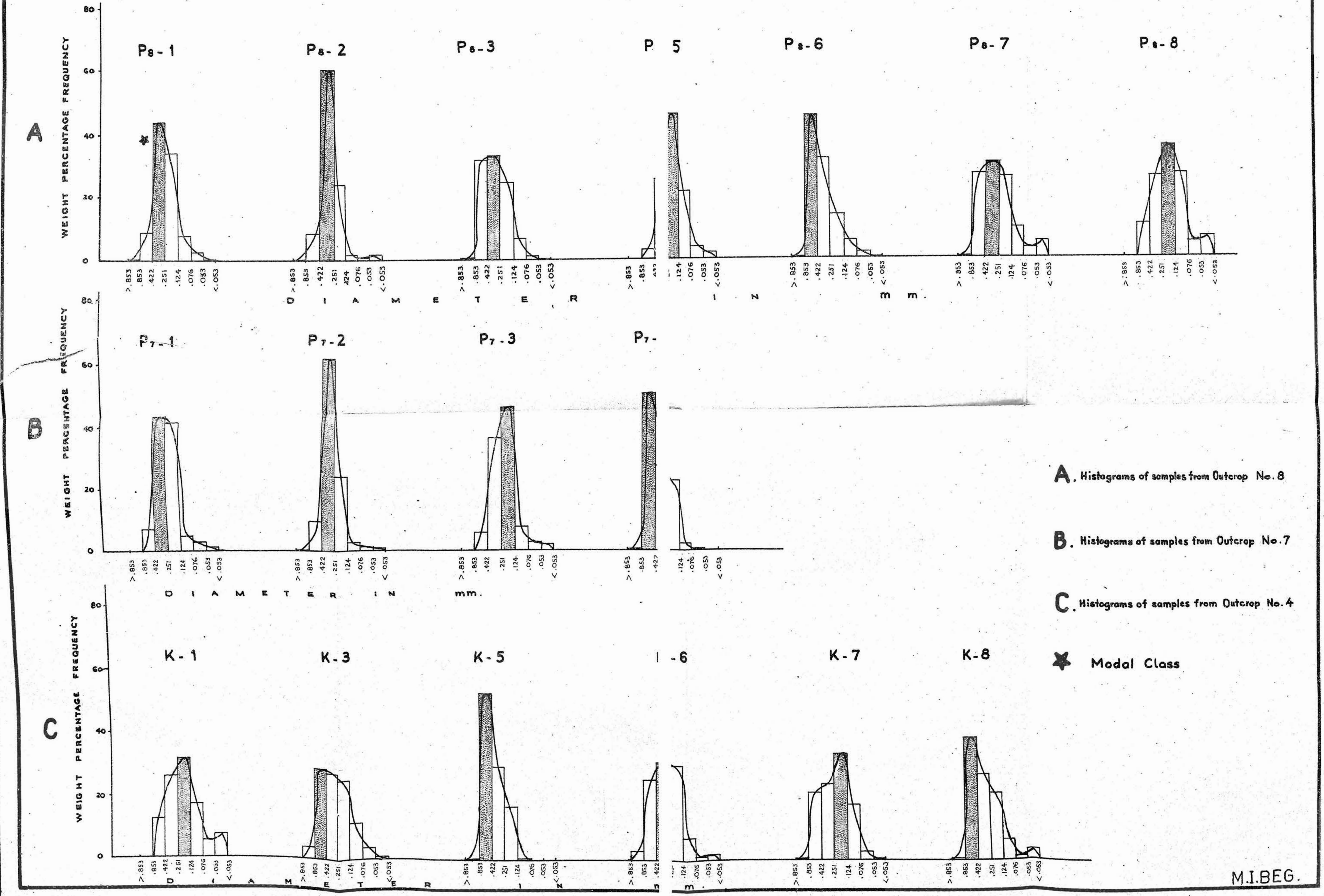
(*b*) **Size analysis.**

Samples of the dried material were seived on an electric shaker. A set of six seives was used with a container at the base to collect the finest grade. The order and mesh size of seives was as following

Mesh No.	Mesh size in mms.
18	greater than 0.853
36	0.853-0.422
60	0.422-0.251
120	0.351-0.124
200	0.124-0.076
300	0.076-0.053
Pan	less than .053

HISTOGRAMS & FREQUENCY CURVES OF SIEVE ANALYSIS OF MISRI BANDA QUARTZITE

FIG: 2



After shaking a 100 grams sample for twenty minutes, the seives were removed, and fractions thus obtained were weighed on electrical balance, accurate up to three decimal places. With the data thus obtained (Tab. I) cumulative curves (Pl. 1-3), histograms and frequency curves (Fig. 2) were drawm. For evaluating the nature of sediments the most commonly used size parameters were used. These are the first and third quartiles, representing 25% and 75% grade values respectively. The 10 and 90 percentiles represent 10 and 90 grade values respectively. From this data the sorting coefficient, skewness, and peakedness were calculated (Tab. II and III).

INTERPRETATION OF STATISTICAL DATA

(*a*) Size distribution.

The grade of sediment (Outcrop No. 4, Kandar) analysed ranges generally from 1 mm to 0.853 mm. The maximum accumulation falls in grades from 0.853 to 0.124 mm. This shows that the rock at Kandar is mainly in the coarse to medium sand-size grade. Modal diameter of the samples is calculated as 0.437 mm. The grade of material analyzed from outcrop 8 (Pir Sakak) shows that the maximum distribution of samples fall between the grade 0.422 and 0.124 that is medium sand. Modal diameter is calculated to be 0.337 mm.

Modal diameter of samples from two outcrops at Pir Sabak corrosponds to the mode given by Krumbein for the beach sand (Krumbein and Pettijohn, 1938, p. 245). Samples from all these outcrops show a grater percentage of coarse to medium sand admixture. Silt and clay-size material is negligible and is only zero to 6.23 percent of all the samples analysed.

(*b*) Median.

Median, the measure of the central tendency of size distribution as read from the cumulative curves, is given in table III. Average median diameter from outcrop No. 4 is 0.301 mm., that from outcrop No. 7 is 0.301 mm, and from outcrop No. 8 is 0.281 mm. Median values for samples from outcrops 4 and 7 are found to be very close to the value 0.320 mm for beach sand as given by Krumbein (Krumbein and Pettijohn, 1938, p. 245),

(*c*) Coefficient of Sorting.

Sorting is a measure of the dimensional spread of a sediment (Twenhoffel and Tyler, 1941, p. 111). Individual sorting coefficients (So) of the samples are given in the table III. However, averages for six samples from outcrop No. 4, four samples from outcrop No. 7, and seven samples from outcrop No. 8 are 1.50, 1.29, and 1.39, respectively. Sorting coefficient of the samples from the three outcrops falls in the well-sorted marine group of Trask.

All the samples analysed are unimodal in their size distribution. Samples K-1, K-8, P_8-7, and P_8-8 show bimodalism. However, if the silt and clay size fractions (less 0.053 mm) be further analysed to separate the silt and clay grades, it will be found that these samples are also unimodal and give no secondary made in their size distribution.

No systematic change in So values from base to top of the bed is observed. However, the sorting coefficient of the base of outcrop No. 4 and the top of outcrop No. 8 are found to be the same (0.27), thereby suggesting a correlation of the two. Field observations and petrographic studies also suggest such a correlation,

(*d*) **Skewness.**

"The coefficient of skewness indicates the symmetry of the size distribution with respect to the median" (Twenhofel and Tyler, 1941. pp. 111-112). Only one sample (K-6) gives Sk as 1.00 and shows symmetrical distribution. One sample gives Sk as 1.02. Its distribution is seen skewed towards the coarser side and the maximum sorting is towards the finer grades (coarser or finer refers to the coarser or finer than the modal class). All the other samples from the three outcrops have Sk less than unity and their frequency curves are skewed towards finer grades. The skewness values for the samples from the three outcrops No. 4, 7, and 8 are 0.92. 0.93. and 0.93. and 0.87, respectively (Pl. III). The skewness values are suggestive of an overall skewness towards finer grades and the maximum sorting towards the coarser grades.

(*e*) **Kurtosis.**

Kurtosis refers to the flat toppedness or peakednes of a frequency curve. Not much is known about the significance of kurtosis in sediments. However, for the sake uf completion, kurtosis is discussed here. Average kurtosis values of samples from the outcrops 4, 7, and 8 are 0.27, 0.24, and 0.25, respectively (Pl. III).

ROUNDNESS AND SHAPE

The coarsest grains obtained by acid treatment were selected for roundness and shape examinations. From their largest projection, area figures enlarged about seventy times, the radius of curvature of corners and edges were measured and the roundness calculated. Average of fifteen grains from Pir Sabak (outcrop No. 8) is 0.37, and that of nine grains from Kandar (outcrop No. 4) is 0.42 (Tab. IV). However, the figures do not reflect the original roundness of the grains, as the grains have been affected by corrosion by carbonates and deformation by regional metamorphism.

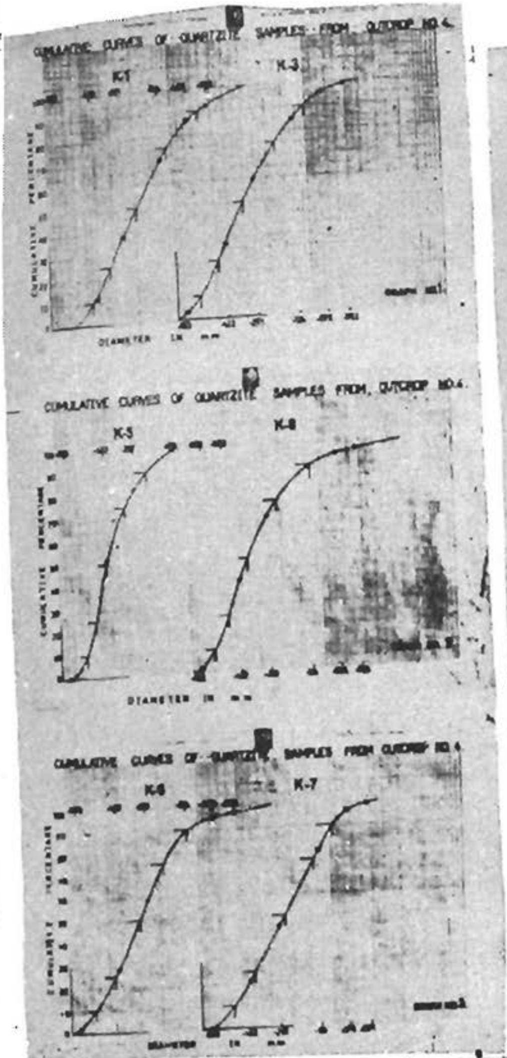


PLATE I

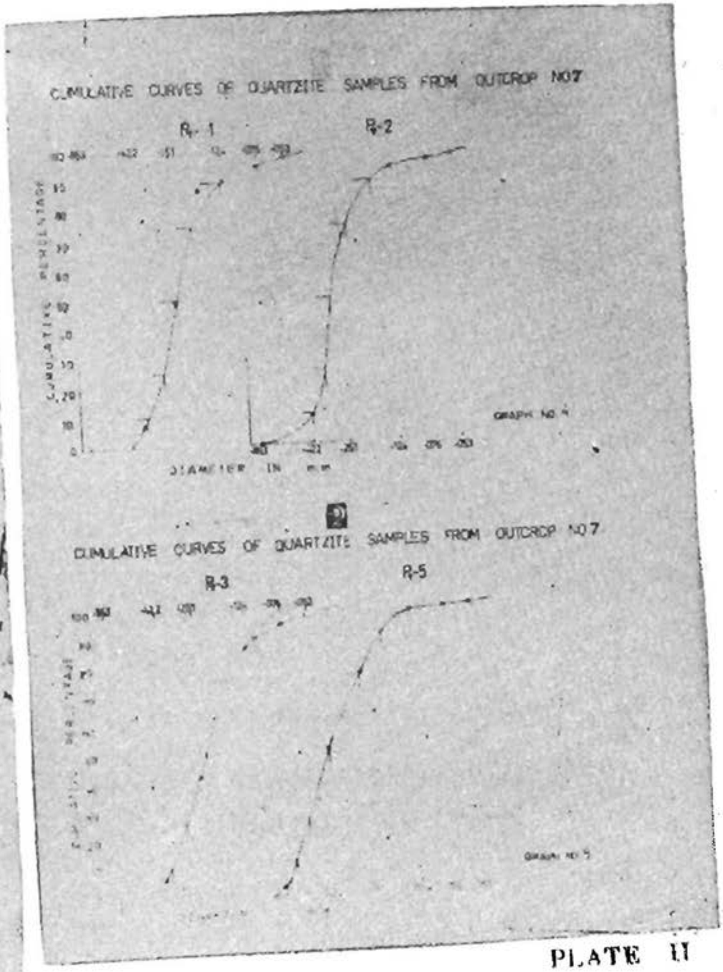


PLATE II

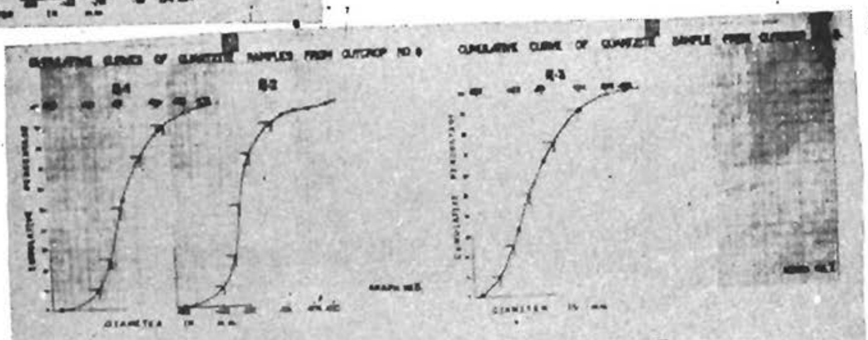


PLATE III

The spericity estimates were made by comparing the largest projection area figures with the visual estimation charts presented by Krumbein and Sloss (1963. p. 111) The sphericity values for fifteen grains from Pir Sabak is 0.78 and that of nine grains from Kandar is 0.69.

OTHER FEATURES

The quartz grains are light pink to light gray. The larger grains are dull and sub-transparent. This is because the coarse grains are more affected by pitting, etching or corrosion than the finer ones. The central nuclei of the enlarged quartz grains are very well-rounded aud high in sphericity values. Zircon, an important accessory mineral in the quartzite, is very well-round and spherical in shape. All the observations point out that the sediments have undergone repeated cycles of transport, winnowing, and deposition.

As the percentage of the coarser material (0.422—0.251 mm) in the rock is greater, and that the coarser grades are more rounded, it is concluded that the sand is mature beach sand of an nnmixed paıentage. It is further concluded that before final deposition, this sand has undergone a prolonged abrasion and repeated winnowing action over a stable shelf area.

PETROGRAPHY

The Misri Banda Quartzite has well-rounded detrital grains embedded in calcite matrix and cement. Distinct layering of quartz and carbonate grains occurs in some samples. The stable detrital minerals, quartz, zircon, and tourmaline, form the bulk of the Misri Banda Quartzite. Quartz, dolomite, and calcite constitute the essential minerals, whereas feldspar (plagioclase and microcline), zircon, tourmaline, magnetite/ilmenite, hematite, and sericite constitute accessory minerals. Visual estimates of the percentages of various miaerals (stable and unstable) worked out from microscopic examination of 12 thin sections are given in table V.

Texture.

Quartz grains in various thin sections are medium to fine-grained, some are secondarily enlarged. These are etched and corroded by the carbonates which are present as matrix and cement. Distinct layering of cabonates and quartz grains occur in some samples (Pl. 8). Thin sections of many quartzite samples show profuse cracking and shearing of quartz grains. These cracks are later filled by the carbonates. Layering, banding, and cracking is the affect of low grade metamorphism which has affeeted the entire northwestern region of the province.

The carbonates occur as irregular interlocking crystals, occasionally developing transverse to the surface of sand grains. A few feldspar grains show authigenesis. The crystallized grains have a rhombic outline. Zircon, magne-ite, and tourmaline occur as rounded grains embedded in a carbonate groundmass.

Microscopic examination of many thin slides of the quartzite samples from the upper part of the outcrop No. 8 and lower part of outcrop No. 4 reveals striking textural similarities.

Cementation and Diagenesis.

The detrital grains are cemented by carbonates, which also fill the cracks of the quartz and detrital (?) calcite/dolomite grains. The quartz grains, which are corroded and etched by carbonates, are secondarily enlarged. The nucleus of the enlarged quartz grain is more or less rounded, however, no overlay of quartz shows crystal faces.

From the foregoing petrographic discussion it is concluded that with the exception of K:2 (quartzite) and K-9 (dolomite), the composition of the Misri Banda Quartzites ranges from arenaceous limestone to calcareous sandston (Fig. 4).

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REFERENCES

ALI, K. B. and ANWAR, J., 1969—Stratigraphic studies of the Nowshera reef complex, Nowshera Tehsil, West Pakistan. Geol. Bull. Univ. Peshawar, vol. 4, pp. 33-43.

COULSON, A. L., 1936—Marble of the North-West Frontier Province. Rees. Geol. Surv. India vol. LXXI, pt. 3, pp. 328-44.

KHAN, M. A,, 1969—Siluro-Devonian reef complex of Ghundai Sar and vicinity, Jamrud, Khyber Agency. Geol. Bull.Univ. Peshawar, vol. 4, pp. 79-82.

KRUMBEIN, W. C. and SLOSS, L. L., 1963—Stratigraphy and Sedimentation. W. H. Freeman and Company, San Francisco.

QUARTILE MEASURES DERIVED FROM CUM. CURVES

Sample No.		50 Percentile Md	25 Percent Quartile Q_1	75 Percent Quartile Q_3	10 Percentile P_{10}	30 Percentile P_{90}
Outcrop No. 4.	K—1	0.195	0.323	0.110	0.450	0.063
	K—3	0.308	0.485	0.172	0.668	0.103
	K—5	0.430	0.525	0.300	0.640	0.202
	K—6	0.288	0.450	0.184	0.641	0.120
	K—7	0.227	0.387	0.136	0.750	0 096
	K—8	0.360	0.520	0.210	0.662	0.118
Outcrop No. 7.	P_7—1	0.250	0.315	0.193	0.422	0.127
	P_7—2	0.308	0.348	0.247	0.425	0.162
	P_7—3	0.228	0.310	0.160	0.385	0.106
	P_7—5	0.420	0.580	0 260	0 710	0.186
Outcrop No. 8.	P_8—1	0.264	0.328	0.177	0.420	0.113
	P_8—2	0.290	0.320	0.232	0.410	0.153
	P_8—3	0.335	0.468	0.208	0.620	0.130
	P_8—5	0.184	0.260	0.120	0.338	0.087
	P_8—6	0.405	0.503	0.280	0.640	0.155
	P_8—7	0.285	0.420	0.160	0.550	0.084
	P_8—8	0.196	0.308	0.114	0.422	0.065

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TABLE IV

Crain No.	Radius of inscribed circle (R)	RARII OF CORNERS & EDGES (in m.m.)										Roundness (P)
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	
I	28	4	5	8	2	6	7	12	8	10	—	0.25
II	32	11	3	8	5	5	8	6	4	8	3	0.19
III	27	12	11	8	14	23	10	10	9	—	—	0.44
IV	29	5	5	16	15	12	16	—	—	—	—	0.40
V	26	10	26	22	4	—	—	—	—	—	—	0.60
VI	23	2	8	8	5	12	6	7	14	—	—	0.30
VII	27	4	9	3	10	8	14	7	—	—	—	0.30
VIII	18	8	10	9	2	5	5	—	—	—	—	0 36
IX	23	23	4	15	—	—	—	—	—	—	—	0.61
X	30	6	9	8	14	26	12	—	—	—	—	0.42
XI	30	6	9	8	14	26	—	—	—	—	—	0.42
XII	25	10	6	7	7	11	15	4	—	—	—	0.35
XIII	26	11	9	9	4	8	8	8	3	—	—	0.29
XIV	35	11	9	13	11	9	5	13	5	—	—	0.27
XV	30	11	3	4	14	14	11	8	11	—	—	0.32
											AVERAGE :-	0.37
XVI	40	40	10	20	12	—	—	—	—	—	—	0.51
XVII	31	18	12	9	15	6	5	—	—	—	—	0.35
XVIII	31	10	19	18	7	—	—	—	—	—	—	0.44
XIX	30	29	9	8	16	—	—	—	—	—	—	0.52
XX	4	7	9	15	8	8	7	—	—	—	—	0.38
XXI	25	3	3	25	5	8	18	8	14	21	—	0.47
XXII	22	18	13	3	12	17	3	16	—	—	—	0.53
XXIII	17	6	5	2	5	6	4	3	3	7	5	0.27
XIV	22	4	6	8	14	4	—	—	—	—	—	0.33
											AVERAGE :-	0.37

Formula : $\dfrac{P = \Sigma\, r_i\ /R}{N}$

Where R is the radius of inscribed circle.
r_i is the radii of corners & edges
and N is the number of corners & edges.

MINERALOGICAL COMPOSITION TABLE V

Slide No.	Quartz	Carbe-nates	Feldspars		Zircon	Tourma-line	Magne-tite	Hema-tite	Sericite	Name
			Plagio-clase	Micro-cline						
K—1	57	35	An^2_{42}	T***	1	T	1	—	1	Calcareous sandstone
K—2	90*	6	An^2_{42}	T	—	—	—	—	1	Quartzite
K—3	50	43	An^2_{40}	1	T	1	T	1	T	Calcareous sandstone
K—5	55**	40	An^1_{40}	—	T	2	—	1	T	Calcareous sandstone
K—7	70	25	An^1_{40}	—	1	—	—	T	T	Protoquartzite
K—8	40	58	An^1_{41}	—	T	T	T	T	T	Arenaceous Limestone
K—9	10	87	An^1_{45}	—	—	—	T	—	T	Arenaceous limestone
PSD—1	35	60	An^1_{40}	—	—	T	1	T	T	Arenaceous limestone
PSD—3	50	47	An^1_{42}	—	—	1	—	2	T	Calcareous sandstone
PSD—5	38	57	An^1_{40}	—	—	T	2	T	T	Arenaceous limestone
PSD—6	70	28	—	—	—	1	T	—	T	Protoquartzite
PSD—8	42	53	An^3_{42}	1	1	1	T	—	T	Arenaceous limestone

*Includes both calcite and dolomite. Some of these detrital.

**Quartz and Chert.

***In traces.

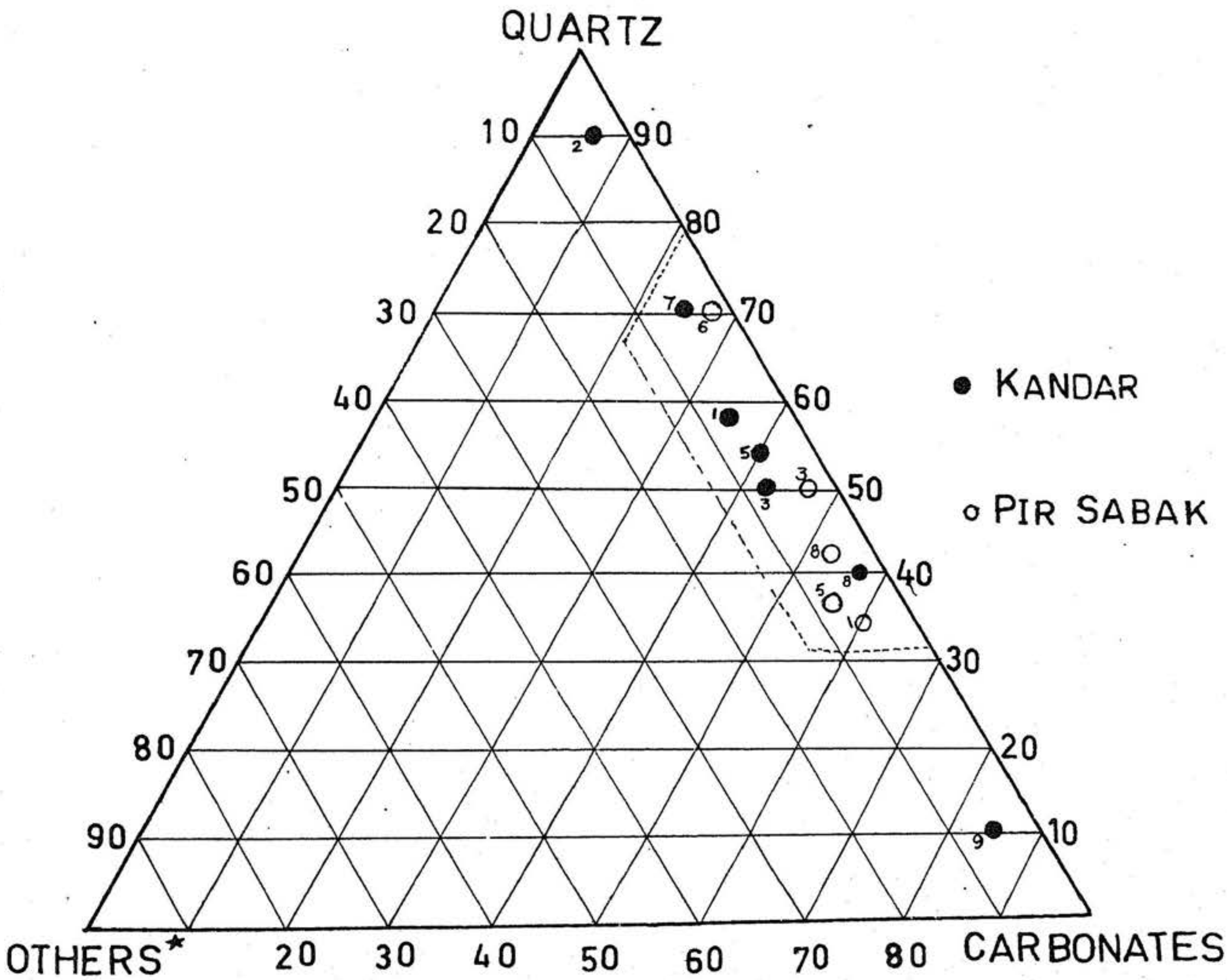

FIG. 3: THE COMPOSITION OF MISRI BANDA QUARTZITE SAMPLES COLLECTED FROM KANDAR AND PIR SABAK VILLAGES.

* Include Feldspars, Zircon, Tourmaline, Magnetite, Ilmenite, Leucoxene and Sericite.

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TABLE I

SIZE ANALYSIS OF MISRI BANDA QUARTZITE

Mesh Size in m.m.......	Sample NOS.	Mesh 18 > 0.853	Mesh 36 0.853 — 0.422	Mesh 60 0.422 — 0.251	Mesh 120 0.251 — 0.124	Mesh 200 0.124 — 0.076	Mesh 300 0.076 — 0.053	Pan < 0.053
Outcrop No. 4.	K—1	....	12.037 (12.037)	25.894 (37.931)	31.329 (69.260)	17.146 (86.406)	5.614 (92.020)	7.373 (99.393)
	K—3	3.569 (3.569)	28.649 (32,218)	27.422 (59.640)	25.022 (84.662)	11.144 (95.806)	3.018 (98.824)	0.644 (99.468)
	K—5	0.011 (0.011)	52.765 (52.776)	29.892 (82.668)	16.486 (99.154)	0.157 (99.311)	....	....
	K—6	2.537 (2.537)	25.650 (28.187)	30.857 (59.004)	30.028 (89.072)	6.515 (95.587)	1.243 (96.830)	1.850 (98.680)
	K—7	0.033 (0.033)	21.252 (21.285)	23.985 (45.270)	33.857 (79.127)	17.513 (96.640)	2.455 (99.095)	0.055 (99.150)
	K—8	1.198 (1.198)	39.030 (40.228)	27.220 (67.448)	21.166 (88 614)	6.154 (94.768)	1.425 (96,193)	3.012 (99.205)
Outcrop No. 7.	P_7—1	....	7,098 (7.098)	42.867 (49.965)	40.704 (90.669)	4.870 (95.539)	2.990 (98.529)	1.688 (100.217)
	P_7—2	0.015 (0.015)	9.857 (9.872)	61.217 (71.089)	23.520 (94.609)	2.299 (96.908)	1.692 (98,600)	1.138 (99,738)
	P_7—3	....	5.987 (5.987)	35.595 (41.582)	45.324 (86.906)	7.690 (94.596)	2.253 (97.849)	2.080 (98 929)
	P_7—5	0.211 (0.211)	49.350 (49.561)	26.122 (75.683)	21.947 (97.630)	1.265 (98.895)	0.105 (99.000)	....
Outcrop No. 8.	P_8—1	0.014 (0.014)	9.686 (9.700)	44.137 (53.837)	34.235 (88.072)	8.104 (96.176)	3.100 (99.276)	0.461 (99.737)
	P_8—2	0.083 (0.084)	8.868 (8.951)	60.665 (69.616)	24.078 (93.694)	2.525 (96.219)	1.242 (97.461)	2.000 (99.461)
	P_8—3	1.079 (1.079)	31.739 (32.892)	32.866 (65.682)	24.566 (90.248)	7.066 (97.314)	1.666 (98.980)	0.441 (99.421)
	P_8—5	....	2.892 (2.892)	24 844 (27.736)	45.349 (73.085)	20.705 (93.890)	3.893 (97.683)	2.184 (199.867)
	P_8—6	0.020 (0.020)	44.230 (44.250)	35.009 (79.250)	13.750 (93.000)	5.420 (98.420)	1.870 (100.290)	0.010 (100.300)
	P_8—7	0.029 (0.029)	26.449 (26.478)	30.133 (56·591)	25,579 (82.170)	9.130 (91.300)	3.062 (94.362)	5.729 (100.091)
	P_8—8	....	10,631 (10.631)	25,611 (36.422)	35.274 (71.516)	16.298 (87.814)	4.782 (92.596)	6.230 (98.826)

CUMULATIVE PERCENTAGES ARE SHOWN IN BRACKETS.

TABLE II

QUARTILE MEASURES DERIVED FROM CUM. CURVES

Sample No.		50 Percentile Md	25 Percent Quartile Q_1	75 Percent Quartile Q_3	10 Percentile P_{10}	30 Percentile P_{90}
Outcrop No. 4.	K–1	0.195	0.323	0.110	0.450	0.063
	K–3	0.308	0.485	0.172	0.668	0.103
	K–5	0.430	0.525	0.300	0.640	0.202
	K–6	0.288	0.450	0.184	0.641	0.120
	K–7	0.227	0.387	0.136	0.750	0 096
	K–8	0.360	0.520	0.210	0.662	0.118
Outcrop No. 7.	P_7–1	0.250	0.315	0.193	0.422	0.127
	P_7–2	0.308	0.348	0.247	0.425	0.162
	P_7–3	0.228	0.310	0.160	0.385	0.106
	P_7–5	0.420	0.580	0 260	0 710	0.186
Outcrop No. 8.	P_8–1	0.264	0.328	0.177	0.420	0.113
	P_8–2	0.290	0.320	0.232	0.410	0.153
	P_8–3	0.335	0.468	0.208	0.620	0.130
	P_8–5	0.184	0.260	0.120	0.338	0.087
	P_8–6	0.405	0.503	0.280	0.640	0.155
	P_8–7	0.285	0.420	0.160	0.550	0.084
	P_8–8	0.196	0.308	0.114	0.422	0.065

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SIGNIFICANT VALUES DERIVED CUMULATIVE CURVES

TABLE III

Attribute	Parameter	Formula								
			OUTCROP NO. 4							
			K—1	K—3	K—5	K—6	K—7	K—8		Average
"Average"	Median (Md)	50 Percentile	0.195	0.308	0.430	0.288	0.227	0.360	—	0.301
"Sorting"	Coefficient of Sorting (SO)	$\sqrt{Q_1/Q_3}$	1.71	1.68	1.32	1.56	1.69	1.07	—	1.50
Symmetry	Coefficient of Skewness (Sk)	Q_1Q_3/Md^2	0.93	0.88	0.85	1.00	1.02	0.84	—	0.92
Peakedness	Kurtosis (K)	$\frac{Q_1-Q_3}{2\,(P_{10}-P_{90})}$	0.27	0.28	0.25	0.26	0.26	0.28	—	0.27
			OUTCROP NO. 7							
			P_7—1	P_7—2	P_7—3	P_7—8				
"Average"	Median (Md)	50 Percentile	0.250	0.308	0.228	0.420	—	—	—	0.301
"Sorting"	Coefficient of sorting (SO)	$\sqrt{Q_1/Q_3}$	1.21	1.11	1.39	1.46	—	—	—	1.29
Symmetry	Coefficient of skewness (Sk)	$Q_1.Q_3/Md^2$	0.94	0.91	0.96	0.90	—	—	—	0.93
Peakedness	Kurtosis (K)	$\frac{Q_1-Q_3}{2\,(P_{10}-P_{90})}$	0.21	0.19	0.27	0.30	—	—	—	0.24
			OUTCROP NO. 8							
			P_8—1	P_8—2	P_8—3	P_8—5	P_8—6	P_8—7	P_8—8	
"Average"	Median (Md)	50 Percentile	0.264	0.290	0.335	0.184	0.405	0.285	0.196	0.281
"Sorting"	Coefficent of sorting (SO)	$\sqrt{Q_1/Q_3}$	1.31	1.88	1.50	1.47	1.34	1.62	1.09	0.39
Symmetry	Coefficent of skewness (Sk)	$Q_1.Q_3/Md^2$	0.83	0.88	0.87	0.92	0.86	0.83	0.91	0.87
Peakedness	Kurtosis (K)	$\frac{Q_1-Q_3}{2\,(P_{10}-P_{90})}$	0.25	0.17	0.26	0.28	0.23	0.28	0.27	0.25

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TABLE IV

Crain No.	Radius of inscribed circle (R)	RARII OF CORNERS & EDGES (in m.m.)										Roundness (P)
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	
I	28	4	5	8	2	6	7	12	8	10	—	0.25
II	32	11	3	8	5	5	8	6	4	8	3	0.19
III	27	12	11	8	14	23	10	10	9	—	—	0.44
IV	29	5	5	16	15	12	16	—	—	—	—	0.40
V	26	10	26	22	4	—	—	—	—	—	—	0.60
VI	23	2	8	8	5	12	6	7	14	—	—	0.30
VII	27	4	9	3	10	8	14	7	—	—	—	0.30
VIII	18	8	10	9	2	5	5	—	—	—	—	0 36
IX	23	23	4	15	—	—	—	—	—	—	—	0.61
X	30	6	9	8	14	26	12	—	—	—	—	0.42
XI	30	6	9	8	14	26	—	—	—	—	—	0.42
XII	25	10	6	7	7	11	15	4	—	—	—	0.35
XIII	26	11	9	9	4	8	8	8	3	—	—	0.29
XIV	35	11	9	13	11	9	5	13	5	—	—	0.27
XV	30	11	3	4	14	14	11	8	11	—	—	0.32
										AVERAGE :-		0.37
XVI	40	40	10	20	12	—	—	—	—	—	—	0.51
XVII	31	18	12	9	15	6	5	—	—	—	—	0.35
XVIII	31	10	19	18	7	—	—	—	—	—	—	0.44
XIX	30	29	9	8	16	—	—	—	—	—	—	0.52
XX	4	7	9	15	8	8	7	—	—	—	—	0.38
XXI	25	3	3	25	5	8	18	8	14	21	—	0.47
XXII	22	18	13	3	12	17	3	16	—	—	—	0.53
XXIII	17	6	5	2	5	6	4	3	3	7	5	0.27
XIV	22	4	6	8	14	4	—	—	—	—	—	0.33
										AVERAGE :-		0.37

Formula : $\frac{P=\Sigma r_i\ /R}{N}$

Where R is the radius of inscribed circle.
r_i is the radii of corners & edges
and N is the number of corners & edges.

MINERALOGICAL COMPOSITION

TABLE V

Slide No.	Quartz	Carbe-nates	Feldspars		Zircon	Tourma-line	Magne-tite	Hema-tite	Sericite	Name
			Plagio-clase	Micro-cline						
K—1	57	35	An^2_{42}	T***	1	T	1	—	1	Calcareous sandstone
K—2	90*	6	An^2_{42}	T	—	—	—	—	1	Quartzite
K—3	50	43	An^2_{40}	1	T	1	T	1	T	Calcareous sandstone
K—5	55**	40	An^1_{40}	—	T	2	—	1	T	Calcareous sandstone
K—7	70	25	An^1_{40}	—	1	—	—	T	T	Protoquartzite
K—8	40	58	An^1_{41}	—	T	T	T	T	T	Arenaceous Limestone
K—9	10	87	An^1_{45}	—	—	—	T	—	T	Arenaceous limestone
PSD—1	35	60	An^1_{40}	—	—	T	1	T	T	Arenaceous limestone
PSD—3	50	47	An^1_{42}	—	—	1	—	2	T	Calcareous sandstone
PSD—5	38	57	An^1_{40}	—	—	T	2	T	T	Arenaceous limestone
FSD—6	70	28	—	—	—	1	T	—	T	Protoquartzite
PSD—8	42	53	An^3_{42}	1	1	1	T	—	T	Arenaceous limestone

*Includes both calcite and dolomite. Some of these detrital.

**Quartz and Chert.

***In traces.

———and Pettijohn, F. J., 1938—Manual of sedimentary petrography. Appleton-Century-Crofts Inc., New York.

STAUFFER, K. W., 1967—Devonian in India and Pakistan. Internat. Symposium Devonian System, Calgary, Canada. pp. 545-56.

———1968—Siluro-Devonian reef complex near Nowshera, West Pakistan. Geol. Soc. America Bull., vol. 79, pp. 1331-50.

TAHIRKHELI, R. A., 1969—Another Palaeozoic reef discovery in Tangi Ghar. Peshawar Distt. Geol. Bull. Univ. Peshawar. vol. 4, pp. 90-91.

TEICHERT, CURT, and STAUFFER, K. W., 1965—Palaeozoic reef discovery in Pakistan. Science, vol. 150, no. 3701, pp. 1287-8.

TWENHOFEL, W. H., and TYLER, S. A., 1941—Methods of study of sediments. McGraw-Hlil Book Company Inc., New York.