SIZE ANALYSIS OF THE INDUS RIVER SANDS WEST PAKISTATN

By

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ABSTRACT

In this paper an attempt has been made to evaluate the grade of the sand-sized material in the Indus alluvium between Kalabagh and Skardu. The most widely used statistical devices of quartile measures were applied to describe the sediments. Some of the results obtained are comparable with those of similar work carried out by the authors in other parts of the world.

INTRODUCTION

The River Indus originates at an elevation of 1700 feet on the northern flank of Kailash mountains in Tibet, and before it joins the Indian Ocean near Karachi in West Pakistan, it flows for about 2000 miles, partly in the mountainous terrain of the Himalayas and partly over the plains of Sind and the Punjab. This investigation relates to a study of the alluvial deposits in the upper reaches of the river, along a strech of about 500 miles between Skardu in the Great Himalayas and Kalabagh in the Outer Himalayas.

From Kalabagh to Amb, for a distance of about 165 miles, the river is easily reached. Most of this sector is serviced by metalled and fairweather roads. The sample sites at Kalabagh, Khushalgarh and Attock are also accessible by railway. Upstream from Amb, right up to Skardu, the Indus is approachable only by mule-track and foot-path running in a zig-zag fashion along the steep slopes of the valley. The construction of an all weather road, intended ultimately, to connect Gilgit and Skardu with the area investigated is already in progress. Gilgit and Skardu are also linked by air with Rawalpindi.

The Indus alluvium has been investigated by the previous workers including the author and most of the published works describe the mineralogy and economics of the Indus sands. No studies on the size analysis of the Indus alluvium have so far been published.

PHYSIOGRAPHY

The region under investigation lies between longitudes 75°38' and 71°35', and between latitude 35°18' and 32°55' N. The southern limit of the area is thus about 10° north of the tropic of the Cancer. The mountains gradually rise from around 3000 feet in altitude at the southern limit of the area to over 20,000 feet in the north. These mountain ranges have been classified on the basis of altitude as Great Himalayas with an elevation of over 20,000 feet, Lesser Himalayas between 12,000 and 15,000 feet and in the Outer Himalayas the elevation varies between 3000 to 4000 feet. All these mountain systems have distinct topographical features depending on the rock formations and their attitude to the sculpturing agents.

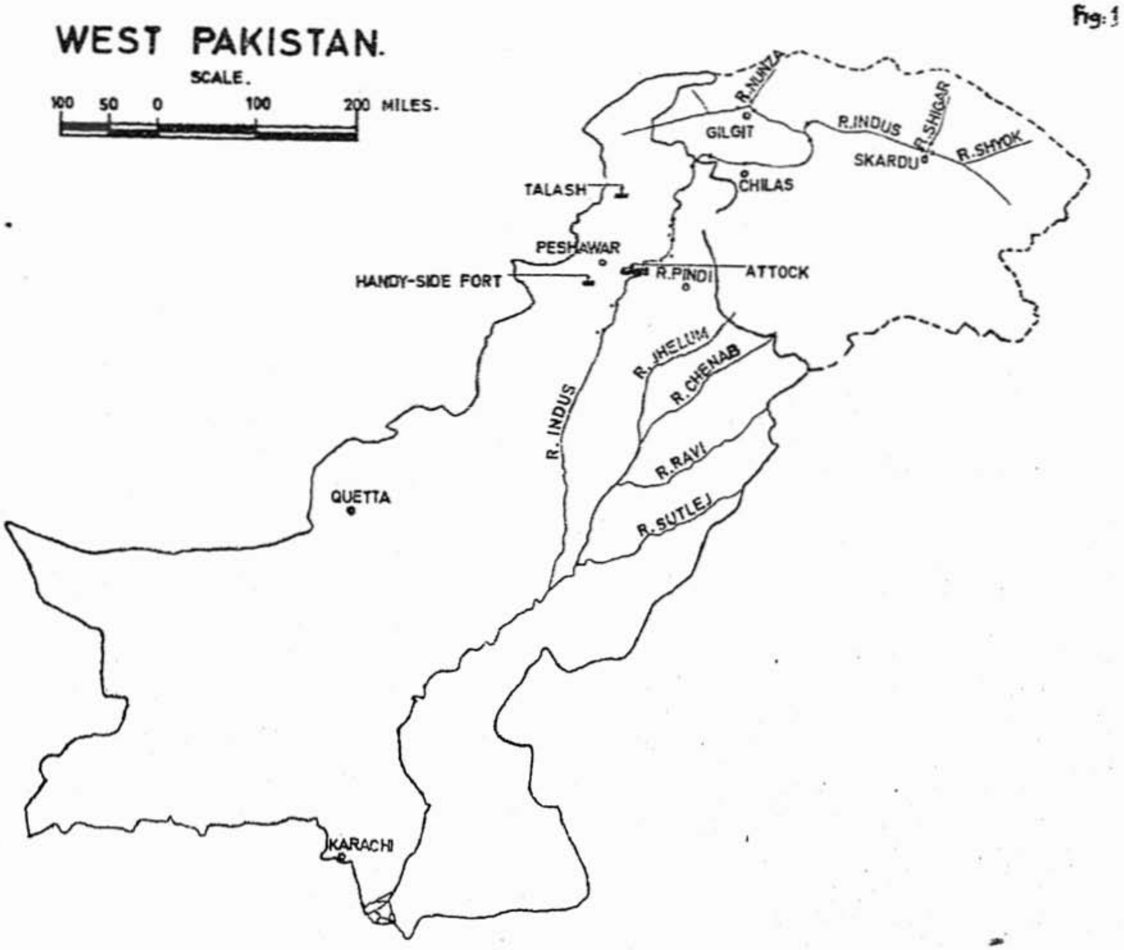
In the upper reaches, where the river Indus traverses the Great and Lesser Himalayas, it flows through valley gorges which are attributed to antecdent drainage. Above the present valley floor steep walls rise abruptly for two to three thousand feet. Near the confluence with tributaries the valley tends to widen and lake type features are displayed. Many of the tributaries are hanging valleys with cirques displayed in their upper reaches.

The gradient of the Indus valley in the Great Himalayas, between Skardu and Chillas is 29 feet per mile. Lower down the course is less steep and between Chillas and Pattan the valley floor drops at the rate of 17.1 feet per mile. Between Amb and Attock the valley is old and the river has changed courses many times. The gradient is low and there is little corrosion. The valley is broad at places, more than two miles in width, and a huge load of gravels and sands is deposited, covering the flood-plain to its rim. The valley floor between Amb and Attock descends at the rate of 6 feet per mile. Downstreem from Attock, during its course through the Outer Himalayas, the Indus again flows through a narrow gorge with precipitous walls rising for 1,000 - 1,500 feet. Between Attock and Kalabagh, the valley floor has a gradient of 2.7 feet per mile.

DESCRIPTION OF ALLUVIALS

The alluvial deposits of the sector of river Indus studied in this investigation are essentially sands and gravels. On the basis of composition and mode of occurrence, two main categories can be distinguished, One of these is a dominantly sandy deposit which occupies extensive patches mantling the valley floor and the high flood marks. The other is an assortment of closely-packed pebbles, cobbles and boulders with sand in the interstices. The first sediment is referred to as mantle sand and the second as gravel deposit. Mantle sand is widespread downstream from Attock. At Khushalgarh, most of the alluvials of the valley floor are of homogenous nature, with only a few erratic thin patches of closely packed gravel deposit. Upstream of Attock rather less than one third of the alluvials are sand deposits.

Fig: 1



MAP SHOWING LOCATION OF SAMPLES

(• LOCATION OF SAMPLE)

The gravel deposits normally contain less than one-third of sand and the remainder of course clastics. Pebble-counts reveal that 65-75% of the gravels derive from acid igneous rocks, 15-25% from intermediate-basic igneous rocks and 5-10% from metamorphic rocks. The first group includes grandoiorite, grantite, granite gneiss, pegmatite and aplite and the second diorite, dolerite, gabbro and basalt. Vein quartz, limestone and schist are most common among the metamorphic components.

Medium to very fine sand usually predominates in the mantle deposit, with angular to subangular grains common in the finer fractions (less than 0.25 mm), the grains over this size being commonly sub-rounded to rounded. Wind winnowing may give rise to patches with a dark grey tinge, enriched in black micas. Streaks of heavy mineral concentrates are conspicuous, though usually of no great size.

PROCEDURES

For size analysis the samples were collected from the freshly deposited alluvium in the valley floor upto one foot depth. Between Kalabagh and Kabulgram, samples were selected from six localities, including both the above sites. Samples from Hunza, Gilgith and,Shigar tributaries and from the Indus alluvium at Skardu were also studied.

The analysis were restricted to sand-sized material between 2 mm and. 065 mm grade, In the laboratory the test samples were obtained from the field samples by cone-and - quartering- Nearly equal amounts of test samples were taken in each case and sieved by manual shaking. The sieve analysis was done with test sieve screen fitted with mesh of British Standard system 410, made by Endcloth (Filter) Ltd., London. Five sieve screens of 16, 30, 60, 120, and 200 mesh were used according to Wentworth's grade scale these represent the following intervals.

1.	+ 16	mesh	2 mm.	very coarse sand.
2.	− 16 / + 30	mesh	1 mm.	coarse sand-
3.	− 30 / + 60	mesh	½ mm.	medium sand.
4.	− 60 / +120	mesh	¼ mm.	fine sand.
5.	−120 / +200	mesh	1/8 mm.	very fine sand.
6.	−200	mesh	1/16mm.	silt.

The samples from sand and gravel deposite were treated separately. The sample retained in the pan below 200 mesh screen was taken as silt, and no further division was attempted to evaluate the clay fraction, which forms an insignificant part in the samples. The amount of material retained on each sieve was weighed, and proportional parts of the whole sample determined. From the weight percentage of the fractions, cumulative percentages were calculated; and with these data cumulative curves were constructed (Table. 2)

The most widely used statistical devices for comparing and describing sediments are quartile measures, median sorting coefficient, quartile skewness, and quartile kurtosis. These measures are obtained from median, 1st and 2nd quartiles, and 90 and 10 percentiles, derived from a cumulative curve. A short description of these is given below:—

Md is the median parameter or a measure of the average size ; 40 percent of the meterial is lager and 50 percent smaller than the median. Q3 and Q1 are the quartiles - that is, the size value associsted with the intersection of 25 and 75 percent lines with the cumlative curves. P90 and P10 are the 90 and 10 percetiles, i.e., the size associated with the percent values respectively. The first quartile, by convention, refers to the diameter value which has 75 percent of the larger and 25 percent smaller. The third quartile diameter has 25 percent coarser and 75 percent finer grade.

RESULTS

Size distribution

The grade of the meterial treated to size analysis ranges between 2 mm and .065 mm. The maximum accumulation of the material falls in three classes between 0.5 mm and 0.125 mm. which accommodate over three fourth of the material in the bulk. The remaining portion is divided among 0.065 mm, 1 mm and 2 mm classes, as arranged according to their order of abundance The samples from mantle deposit yielded only four classes between 1 mm and 0.065 mm, whereas those from the gravel deposit are coarser in size and contain a varying amount of material in th- 2 mm class (Table 1).

Unimodal disбribution is recorded in almost all th samples from the mantle deposit, whereas grave deposit yielded both unimodal and bimodal distribution. In the 16 samples from mantle deposits (Table 1,) 11 samples have their chief modes in 0.25 mm class, 3 in 0.065 mm and 1 each in 0.f 0.125 mm classes. As shown in Table ' modes in 7 samples contain over 50 material, in 6 samples over 40 pescent and in the remaining 3 samples between 30 and 39 percent.

In the gravel deposit, out of 32 samples (Table 1) only 9 yielded bimodal distribution. The chief modes in 20 samples lie in the 0.5 mm class, 7 in 0.25 mm, 4 in 0.125 mm, and 1 in 1 mm class. Out of 9 samples, 6 have a secondary mode in 0.065 mm class and 3 in 2 mm class. The material retained in the chief modes is over 50 percent in 8 samples, 40 to 50 percent in 9 samples and 25 to 40 percent in 15 samples. The scondary modes retain a lesser amount of material, varying between 3 and 15 percent; a large accumlation is in those secondary modes which lie in 0.065 mm class. In the bimodal distribution, the maximum values are 2 classes apart in 6 samples and 1 class apart in 3 samples.

Average size.

The average size of the sands is worked out by measuring the median diameters from various cumulative curves. The median diameter of over 60 percent of the samples from the mantle deposits falls between 0.22 mm and 0.35 mm range, 25 percent between 0.4 mm and 0.6 mm and 15 percent between 0.12 mm and 0.22 mm. In the gravel deposit the median diameter in nearly 65 percent of the samples lie in 0.35 mm and 0.55 mm range; and the rest between 0.55 mm and 0.9 mm. These data reveal a conspicuous coarser average size for the material collected from the gravel than mantle deposit (Table 2).

So far as the three major tributaries of the Indus namely the Gilgit, Hunza, and Shigar are concerned, the sands of the latter two are of a relatively higher average size (0.63 mm and 0.8 mm respectively). than the former one. The average size of the material of the Gilgit tributary is 0.44 mm, which is lower than the sample collected from Indus at Skardu (0.58), The transportation and depositional environment of the sands of the afore mentioned rivers is identical in this part of the area. The alluvium of the Shigar and Hunza tributaries are of coarser grade, because they are smaller streams than the Gilgit, and their material has not undergone the process of long transportation which gives textural maturity to the alluvium of the rivers Gilgit and Indus.

The average size of material from the gravel deposits at Skardu and Kabulgram is 0.58 mm and 0.54 mm respectively. In other words, there is a fall of 0.04 mm in a stretch of about 100 miles. In this part the Indus flows through a steep and narrow valley and the alluvium is transported under alpine conditions. The influx of the material from the side tributaries is also high. Downstream between Kalabagh and Kabulgram in a distance of about 200 miles the difference in grain size widens, with a net fall of 1.7 mm. The average grain size in the samples from gravel deposits between the two extreme sampling-sites, i.e., Skardu and Kalabagh, a stretch of about 500 miles, is 2.1 mm.

The average grain size of mantle deposit between Kalabagh and Kabulgram has also been studied. Between Kabulgram and Amb, a distance of about 35 miles, the average size decreases from 3.3 mm to 2.8 mm i.e. a net fall of 4.5 mm. But between Amb and Attock there is a progressive increase in the average grain size of the samples, both from mantle and gravel deposits. In this region the river Indus debouches on to a valley plain, and the valley gradient is nearly levelled. This, change in gradient has retarded the velocity of the current, with the result that most of the load is deposited on the valley floor. The increase in average size, of the alluvial material, here may be attributed to the sluggish behaviour of the stream, which is capable of removing the finer sediments only, resulting in the dominance of coarser grade material.

Downstream from Attock selective sorting and selective transportation again play a greater role and cause abrupt changes in the grain size of the alluvials, and thus formed mainly of sandsized material. This has resulted in a steep fall in grain size, and in a distance of about 150 miles between Attock and Kalabagh a net decrease of .16 mm in the samples from gravel and mantle deposits are recorded respectively. Between Kalabagh and Kabulgram the difference in average size is much the same in samples of mantle sand as it is in those of gravel deposits.

Sorting

The geometrical quartile measure of sorting adopted by the author was first proposed by Trask (1) and eliminates the size factor and the unit of measuremens. According to Trask if the coefficient of sorting is less than 2.5 the sample is well sorted, if it is greater than 4.5 the sample is poorly sorted and if it is about 3.0 the sediment has normal sorting. These values are based on the analyses of 190 samples of recent marine sediments, and according to some writers they appear to be too high. Krumbein and Trisdal (2) experimented on the size analyses of crystalline rocks disintegrated *in situ*. and found that these have coefficients of sorting which place them within the range of Trask's well-sorted sediments. Hough and Stetson (3), quoted by Hough (4) conducted size analysis of several marine sediments of sand grade and have reported sorting coefficient of between 1 and 2. stetson gives 1.45 as the average (Table 2).

In the samples under exemination the coefficient of sorting varies between .85 and 2.3; the average of 17 and 32 samples from mantle and gravel deposits is 1.4 and 1.5 respectively. There is apparently no marked down-current increase or decrease in the sorting values. The sorting values in the mantle deposits are lower than those for gravel deposit, indicating that the degree of sorting is relatively higher in most of the mantle sands. The overall result obtained from the material places the coefficient of sorting close to the average value of 1.45 obtained by Stetson.

Size-sorting relationship

Hough (5) studied the beach and near-shore sands of Cape Cod Bay and concluded, "silt and clay with diameter under 0.1 mm are less well sorted. The sediments with diamerer neer 0.2 mm are best sorted and those both coarser and finer showed less perfect sorting." Similar observation were reported by Krumbein and Aberdeen (6) in the sediments of Bataria Bay.

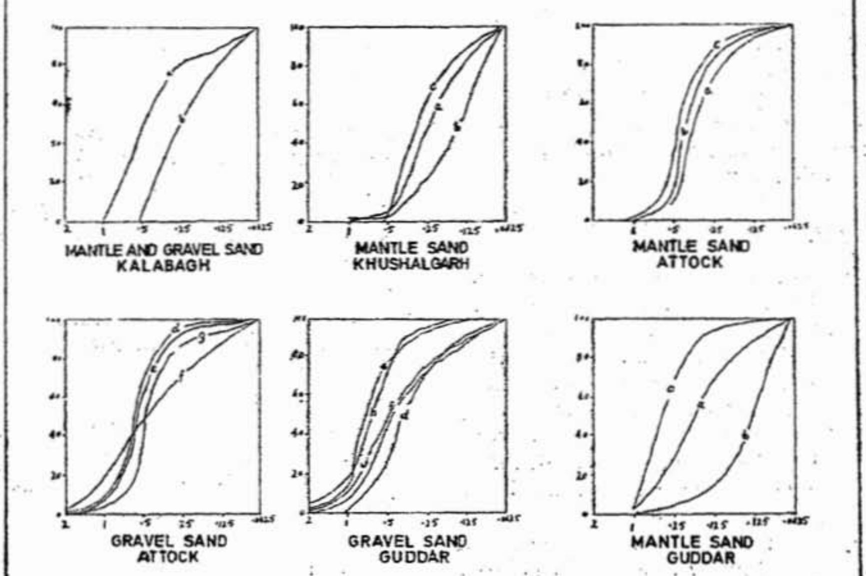


FIG. 2

CHART SHOWING CUMULATIVE CURVES OF SAMPLES FROM DIFFERENT LOCALITIES.

Inman (7), working on the size-sorting relationship, has concluded "the general relationship of sorting coefficient to median diameters appears to be similar for all water-worn environments, the difference being mainly in the degree of sorting. Sediments with median diameters near the grade of fine sand are the best sorted, sediments coarser and finer are more poorly sorted". These observations of Inman and earlier workers were further confirmed by the studies made by Griffith (8), who examined the grain size-sorting relathionship in over 1200 Tertiary sediments and attempted to express this relationship in mathematical terms.

The size-sorting relationship of the sands has been studied under the light of above mentioned observations made by the previous workers. In 44 samples studied, three yielded their median diamter close to 0.2 mm, two less than 0.2 mm and the rest over 0.2 mm. It is apparent from the above data that the samples under examination are not well sorted, and with the departure of average size from the expected norm (median 0.2) of well sorted sands, the sorting becomes progressively poorer.

Symmetry

The coefficient of geometrical quartile skewness indicates the degree of symmetry of the size distribution with respect to the median. If the skewness is unity the mode coincides with the median diameter and the distribution is symmetrical. If the skewness is greater than unity the maximum sorting of the sediments lies on the fine side of the median, and the distribution is skewed twards the coarser grade size; if it is less than unity the distribution is skewed towards the fine grade size.

The skewness value determined for the sands under examination reveal that nearly 11 samples with values between 0.98 and 1.1 have skewness close to unity. Six of these samples are from gravel and five from mantle depósits. All the rest have assymmetrical size distribution, skewed either towards the fine or towards the coarser grade sizes.

Only three samples have their skewness values more than unity (1.17 to 1.4). The maximum sorting of these lies on the fine side of the median or in other words the distribution is skewed towards the coarser grade sizes. Two of the three samples are from mantle sands and one from a gravel deposit.

The rest of the 30 samples studied have their skewness values less than unity, ranging between 0.32 and 0.97. This suggests that the distribution is skewed towards the finer grade size, the median parameter being finer than the mode. From these 30 samples, nine are from mantle deposit, and their skewness values range from 0.71 to 0.88. The remaining 21 are from gravel deposit and their skewness values range from 0.32 to 0.97.

Out of 17 samples from mantle deposits, six have relatively symmetrical distribution, two are skewed towards the coarser and nine are skewed toward finer grade size. In the gravel deposits, out of 32 samples, six have relatively symmetrical distribution, one is skewed toward coarser sizes, and the remaining 25 are skewed toward finer grade sizes.

Size-skewness relationships

The correlation between size and skewness has been investigated by some previous workers. Plumby (9), on the size analysis of the material of Black Hills terrace gravels, reported that skewness is the function of mean size. He plotted median against skewness in a scatter diagram and found that the samples having the largest mean size also have highly skewed distribution. That fine grained sediments have a different relation between size and skewness was pointed out by Hough, who observed that the finer the sediment the more skewed it is. Inman has also observed the relationship between size and skewness and has shown that the finest sediments should normally be highly skewed towards the fine fraction.

In the case of the material under examination, the size-skewness relation is not very clear. There is no marked downcurrent increase or decrease in skewness. In the following table, A and B are the figures for the smallest and largest average size shown against their skewness reproduced from table comparing the size-skewness relationship.

	A		B	
	Median	*Skewness*	*Median*	*Skewness*
1.	.13	1.08	.96	.08
2.	.13	1.01	.81	.72
3.	.19	1.4	.81	.74
4.	.24	.88	.81	.73
5.	.24	1.06	.76	.89
6.	.28	.71	.73	.74
7.	.03	.77	.06	1.1

Of the seven samples under A, showing the smallest median diameters, three have symmetrical distribution, two are skewed toward the finer and one towards the coarser grade size. Under B, the largest median diameters, all the samples except one (no.7) are skewed toward the finer grade size. The skewness in these samples varies from medium to high. One sample with a skewness of 1.1 has relatively symmetrical distribution. These results do not suggest any sympathetic relationship between size and skewness in the samples under examination. To establish any relationship between size and skewness in the Indus alluvium the author is busy in collecting more data on close spaced samples.

"Kurtosis"

The importance of the kurtosis measure for sediments is not thoroughly understood, and it has not been extensively investigated. According to Tickell (10), in normal curves kurtosis with a numerical value of 0.263 or less is quite common, A kurtosis greater than 0.263 signifies a steep curve. The kurtosis determined in this way is independent of the coarseness of the samples and tne unit of measurement used. In certain practices the standard values for the kurtosis is 3.0. so that distribution curves less than 3 are flat-topped or broad while distribution curves greater than 3.0 are sharply peaked or narrow.

The kurtosis values calculated for the Indus sands are comparable to Tickell's observation; kurtosis values of 3.0 appear to be too high and also uncommon. Out of 49 samples studied, only one yielded a kurtosis value of 3.0.

In 31 out of 49 samples the kurtosis value is over 0.2, and in the other 13 samples it is between 1.1 and 1.9. In the mantle deposit out of 17 samples, 12 have a kurtosis value over 0.2, mostly between 0.23 and 0.27. In the gravel deposits, out of 33 samples 19 gave a kurtosis value of over 0.2.

From the above data it is apparent that steep and sharply peaked curves are fairly common in the diagrammatic representations of the Indus Sands. The samples from mantle deposits have given a greater number of such curves than the gravel deposits.

REFERENCES

1. Trask, P.D., 1932 Origin and environment of source sediments of Petroleum, *Houston, Gulf Publication Co,*. PP. 7 ff,

2. Krumbien, F. W. and Tisdal 1940. Size distributions of source rocks of sediments. *Am. J. Sci.* vol. 238, PP. 296-305

3. Hough, J.L., 1942 Sediments of Cape Cod Bay, Massachusetts. *J. Sed. Pet.* Vol. 12, P P. 10-30.

4. Pettijohn, F. J., 1956, Sedimentary rocks, Second edition, *Harper & Bros.*, New Year, PP. 37.

5. Krumbien W. C., 1937. and Aberdeen Sediments of Barataria Bay. *J. Sed. Pet.* Vol. 17, PP. 3 - 17.

6. Inman, D.L., 1949 Sorting of Sediments in the light of fluid mechanics. *J. Sed Pet.* Vol. 19, PP. 51-70.

7. Griffiths, J.C., 1951 Size versus sorting in some Caribbean sediments *J. Geol.*, Vol. 59, PP. 211-243.

8. Plumley, W. J., 1948, Black Hills terraee gravles: A study in sediment transportation. *J. Geol.*, Vol. 56, PP. 526-577,

9. Tickell, F.G., 1939. The examination of fragmental rocks. *McGraw Hill Book Co. Inc.*, London.

TABLE 1. SIZE ANALYSES OF ALLUVIALS

Sieve analyses, with cumulative percentages shown in brackets, chief and secondary modes shown in bold letters.

+ 16 mesh	− 16 + 30 mesh	− 30 + 60 mesh	− 60 + 120 mesh	−120 +200 mesh	− 200 mesh	CURVE	LOCALITIES (G. gravel sand, M. mantle sand)	
—	8.8 (0.8)	**45.1** (45.9	35.1 (81.0)	7.5 (88.5)	**11.5** (100)	a	Kalabagh	(G)
		3.5 (3.5)	**44.6** (48.1)	33.1 (81.2)	18.8 (100)	b	,,	(M)
—	0.3 (0.3)	0.9 (1.2)	21.3 (22.5)	33.9 (56.4)	**43.6** (100)	b	Khushalgarh	(M)
—	0.2 (0.2)	4.4 (4.6)	**41.6** (46.2)	36.2 (82.4)	17.6 (100)	a	,,	(M)
—	—	1.2 (1.2)	**59.9** (61.1)	22.2 (83.3)	16.7 (100)	c	,,	(M)
—	0.4 (0.4)	10.2 (10.6)	**71.9** (82.3)	14.9 (97.0)	3.0 (100)	c	Attock	(M)
—	1.3 (1 8)	26.2 (21.0)	**59.6** (87.6)	10.2 (97.8)	2.2 (100)	b	,,	(M)
—	—	8.1 (8.1)	**66.6** (74.7)	20.1 (94.8)	5.2 (100)	a		(M)
1.6 (1.6)	5.7 (7.3)	**50.9** (68.2)	27.1 (95.3)	3.0 (98.3)	**11.7** (100)	d		(G)
0.3 (0.3)	6.5 (6.8)	**54.4** (61.2)	31.4 (92 6)	5.6 (98.2)	1.8 (100)	e		(G)
0.8 (0 8)	**14.3** (18.1)	**31.0** (49.1)	22.4 (71 5)	15.3 (86.8)	13.2 (100)	f		(G)
0.3 (0.3)	3.9 (4.2)	36.9 (41.1)	**47.0** (88.1)	6.2 (94.3)	5.7 (100)	g		(G)
—	1.3 (1.3)	**2.7** (4.0)	8.5 (12.5)	37.8 (50.3)	**49.7** (100)	b	Guddar	(M)
—	1.8 (1.8)	23.7 (25.3)	**46.8** (72.3)	17.8 (90.1)	10.9 (100)	d		(G)
3.4 (3.4)	11.6 (15.0)	**62.4** (77.4)	16.7 (94 1)	5.1 (99.2)	0.8 (100)	e		(G)
5.0 (5.0)	13.1 (18.1)	**55.0** (73.1)	23.0 (96.1)	2.3 (68.4)	1.6 (100)	h		(G)
1.7 (1.7)	5.9 (7.6)	**38.5** (46.1)	37.6 (76.1)	12.2 (88.3)	4.0 (100)	f		(G)
2.1 (2.1)	10.1 (12.2)	**35.9** (48.1)	26.3 (74.4)	12.3 (86.7)	**13.3** (100)	g		(G)
—	3.2 (3.2)	25.1 (28.3)	**39.9** (68 2)	20.4 (88.6)	14.4 (100)	a		(M)
—	3.2 (3.2)	**63.9** (67.1)	27.9 (95 0)	4.1 (99.1)	1.9 (100)	c		(M)
—	4.1 (4.1)	10.1 (14.2)	**74.0** (61.2)	30.6 (91.8)	8.2 (100)	a	Amb	(M)
—	1.2 (1.2)	2.7 (3.9)	24.5 (28.4)	32.7 (61.3)	**38.7** (100)	b		(M)
—	1.3 (1.3)	3.5 (4.8)	**40.2** (45.0)	38.4 (83.4)	16.6 (100)	c		(M)
0.2 (0.2)	4.9 (5.1)	**34.1** (39.2)	32.0 (71.2)	14.9 (86.1)	13.9 (190)	f		(G)
1.8 (1.8)	7.3 (9.1)	**44.0** (53.1)	28.2 (81.3)	7.9 (89.2)	**10.8** (100)	d		(G)
6.7 (6.7)	6.9 (13.6)	**39.8** (53.4)	27.7 (81.3)	9.8 (91.1)	10.1 (100)	e		(G)
1.5 (1.5)	4.9 (6.4)	14.8 (11.2)	27.9 (49.1)	**30.0** (79.1)	20.9 (100)	b	Kabulgram	(M)
0.9 (0.9)	2.2 (3.1)	3.7 (6.8)	**62.2** (69.0)	21.2 (90.2)	9.8 (100)	a		(M)
1.1 (1.1)	3.3 (4.4)	30.0 (34.4)	**54.8** (89.2)	8.3 (97.5)	2.5 (100)	c		(M)
3.1 (3.1)	3.0 (6.1)	20.0 (26.1)	**41.4** (67.5)	20.0 (87.5)	12.5 (100)	d		(G)
4.8 (4.8)	3.3 (8.1)	**34.4** (42.5)	29.3 (71.8)	**17.1** (88.9)	10.9 (100)	e		(G)
7.1 (7.1)	5.1 (12.2)	**38.0** (50.2)	21.9 (72.1)	22.1 (94.2)	5.8 (100)	f		(G)
8.6 (8.6)	9.6 (13.2)	**52.7** (70.9)	21.7 (92.6)	4.8 (97.4)	2.6 (100)	g		(G)
6.1 (6.1)	22.1 (28.2)	**43.4** (71.6)	17.0 (88.6)	4.8)93.4)	**6.6** (100)	a	Skardu	(G)
—	1.8 (1.8)	6.7 (8.5)	**74.0** (82.5)	15.6 (98.1)	1.9 (100)	b		
6.4 (6.4)	21.7 (28.1)	**46.0** (74.1)	15.9 (90.0)	0.7 (97.0)	3.0 (100)	a	Hunza Tributary	(G)
3.5 (3.5)	18.1 (21.6)	**29.6** (51.2)	20.6 (71.8)	15.6 (87.5)	12.6 (100)	b		(G)
1.9 (1.9)	11.2 (13.1)	40.9 (52.1)	30.8 (82.9)	5.0 (87.9)	12.1 (100)	c		(G)
—	**0.6** (0.6)	23.5 (24.1)	**67.2** (91.3)	5.3 (96.6)	3.4 (100)	a	Gilgit Tributary	(G)
1.1 (1.1)	13.1 (14.2)	26.2 (40.4)	**34.0** (74.4)	15.4 (89.8)	10.2 (100)	b		(G)
.9 (.9)	10.8 (11.7)	28.3 (40.0)	**30.4** (70.4)	14.6 (85.0)	**15.0** (100)	c		(G)
8.1 (8.1)	**38.2** (46.3)	31.8 (78.1)	10.7 (88.8)	9.3 (98.1)	1.9 (100)	c	Shigar Tributary	(G)
1.9 (1.9)	18.1 (20.0)	**40.0** (60.0)	23.7 (83.7)	9.7 (93.4)	7.6 (100)	d		(G)
4.1 (4.1)	28.0 (32.1)	**47.9** (70.0)	18.7 (88.7)	**6.4** (95.1)	4.9 (100)	e		(G)

TABLE 2. SIGNIFICANT VALUES DERIVED FROM CUMULATIVE CURVES.

Locality	Median (Md)	Third Quartile Q_3	First Quartile Q_1	90 — Percentile P_{90}	10 — Percentile P_{10}	"Sorting" $SO=\frac{Q_3}{Q_1}$	"Symmetry" $SK=\frac{Q_3Q_1}{(Md)^2}$	"Peakedness" $=\frac{Q_3-Q_1}{2(P_{90}-P_{10})}$	Type of sample G (gravel sand) M (mantle sand)
Kalabagh	0.38	0.62	0.27	0.87	0.12	1.5	1.1	0.23	G
	.19	0.34	0.15	0.44	0.095	1.5	1.4	0.27	M
Khushalgarh	0.23	0.34	0.16	0.43	0.11	1.4	1.04	0.3	M
	0.18	0.23	0.08	0.37	0.08	1.7	1.08	0.26	M
	0.31	0.4	0.19	0.46	0.11	1.4	0.8	0.0	M
Attock	0.35	0.42	0.24	0.45	0.15	1.32	0.85	0.3	M
	0.48	0.51	0.04	0.63	0.23	1.18	0.87	0.13	M
	0.41	0.43	0.31	0.52	0.18	1.2	0.79	0.17	M
	0.60	0.75	0.45	0.88	0.35	1.2	0.92	0.29	G
	0.59	0.73	0.33	0.93	0.29	1.3	0.91	0.28	G
	0.48	0.89	0.21	0 98	0.10	1.1	0.80	0.38	G
	0.49	0.55	0.38	0.75	0.21	1.2	0.87	0.15	G
Guddar	0.37	0.52	0.21	0.82	0.12	1.3	0.79	0.22	M
	0.13	0.19	0.09	0.31	0.071	1.4	1.01	0.20	M
	0.62	0.81	0.46	0.93	0.34	1.3	1.2	0.29	M
	0.48	0.49	0.23	0.80	0.12	1.4	0.68	0.19	G
	0.81	0.93	0.51	0.25	0.3	1.4	0.72	0.22	G
	0.48	0.81	0.28	0.92	0.12	1.7	0.98	0.33	G
	0.60	0.80	0.50	0.05	0.37	1.85	1.10	0.13	G
	0.49	0.83	0.23	0.01	0.10	1.9	0.79	0.3	G
Amb	0.37	0.86	0.13	0.87	0.08	2.3	0.64	0.31	G
Amb	0.37	0.6	0.17	0.87	0.09	1.8	0.73	0.26	G
	0.46	0.66	0.32	1.2	0.16	1.4	0.93	0.19	G
	0.41	0.67	0.15	0.39	0.09	2.1	0.58	0.80	G
	0.52	0.78	0.31	1.3	0.12	1.6	0.80	0.19	G
	0.28	0.37	0.15	0.45	0.095	1.5	0.71	0.30	M
	0.34	0.43	0.23	0.51	0.15	1.4	0.85	0.27	M
	0.24	0.34	0.15	0.44	0.095	1.5	0.88	0.27	M
Kabulgram	0.34	0.41	0.37	0.41	0.12	1.06	1.3	0.26	M
	0.24	0.44	0.14	0.87	0.90	1.7	1.06	0.16	M
	0.46	0.56	0.37	0.85	0.23	1.1	0.98	0.15	M
	0.30	0.39	0.18	0.42	0.097	1.47	0.77	0.31	M
	0.37	0.48	0.21	0.81	0.11	1.5	0.72	0.19	G
	0.43	0.63	0.22	0.39	0.12	1.7	0.74	0.25	G
	0.50	0.82	0.34	1.1	0.16	1.5	1.1	0.25	G
	0.37	0.88	0.45	1.4	0.28	1.3	0.74	0.19	G
	0.55	0.49	0.2	0.74	0.10	1.66	0.32	0.19	G
	0.50	0.75	0.39	0.47	0.11	1.38	1.17	0.64	G
Skardu	0.81	1.08	0.45	1.6	0.19	1.5	0.74	0.22	G
	0.35	0.41	0.28	0.46	0.19	1.2	0.93	0.26	G
Hunza Tributary	0.76	1.08	0.48	1.8	0.15	1.5	0.89	0.18	G
	0.75	0.93	0.23	2.5	0.09	2.0	0.68	0.14	G
Hunza Tributary	0.56	0.86	0.43	1.5	0.15	1.4	1.1	0.19	G
Gilgit	0.45	0.49	0.39	0.63	0.18	1.1	0.94	0.11	G
	0.43	0.75	0.24	1.37	0.09	1.7	0.97	0.19	G
	0.43	0.73	0.21	1.25	0.07	1.8	0.83	0.22	G
Shigar	0.96	1.32	0.56	1.9	0.28	1.5	0.80	0.23	G
	0.63	0.93	0.85	1.3	0.16	1.6	0.82	0.25	G
	0.81	0.12	0.43	1.6	0.23	1.6	0.73	0.74	G