GRAIN SIZE ANALYSIS & RADIOMETRIC STUDIES OF THE SANDS OF SOLANI RIVER SYSTEM

DISSERTATION
IN PART FULFILMENT OF THE REQUIREMENTS
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C E R T I F I C A T E

Certified that the dissertation entitled GRAIN SIZE ANALYSIS AND RADIOMETRIC STUDIES OF THE SANDS OF SOLANI RIVER SYSTEM being submitted by Sri ARUN KUMAR AWASTHI in part fulfilment for the award of the Degree of M.Sc.Tech in Applied Geology of University of Roorkee, is a record of student's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other Degree or Diploma.

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"To reason without data is nothing but delusion."

— A. Holmes

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CHAPTER - I

INTRODUCTION.

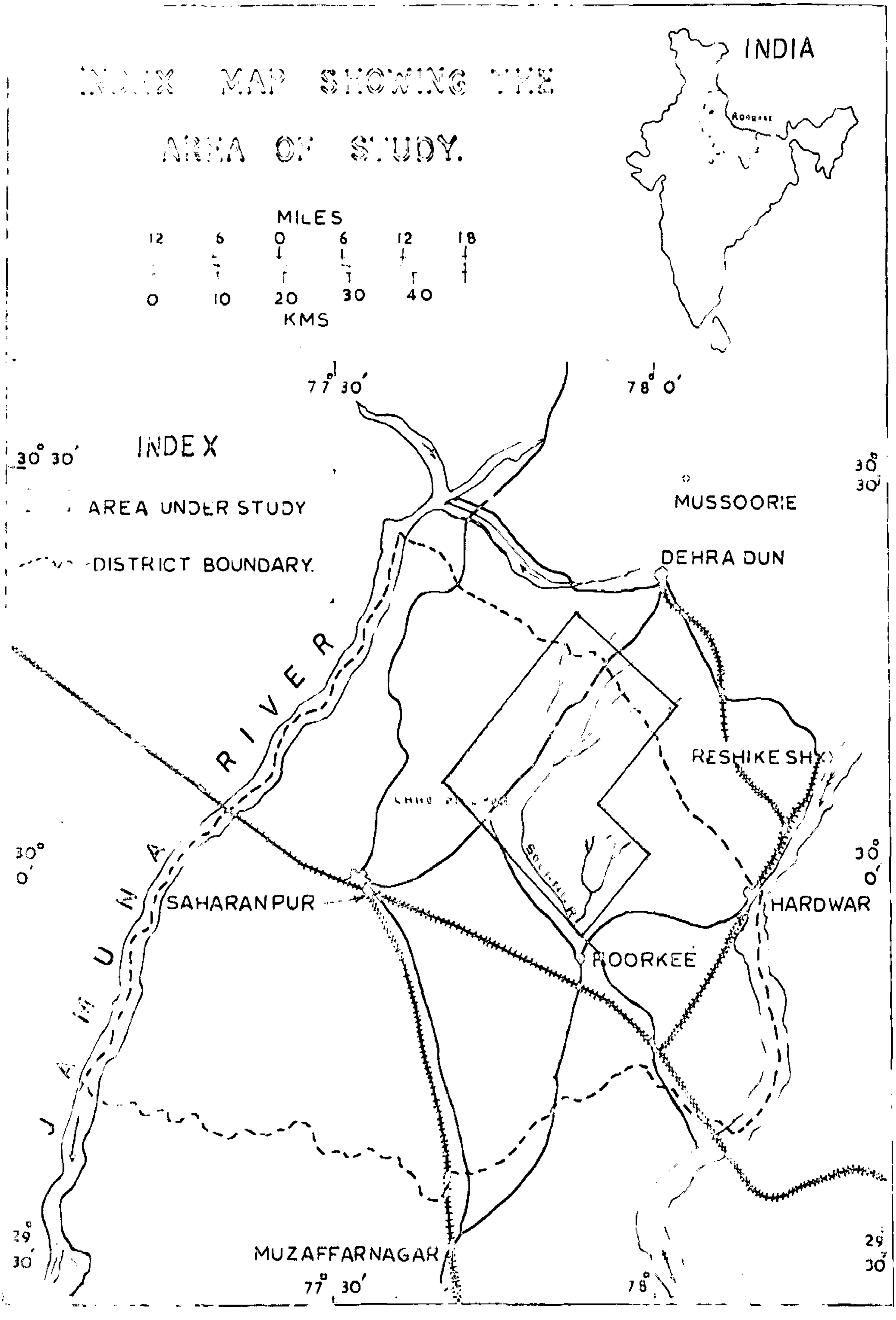
Aims and Objects:

While installing the γ-ray Spectrometer in the Radio Chemistry laboratory of this University, Prof. G.L.Christie and Sri I.P.Saraswat found unusual high background radioactive count rate in some buildings of the University. In quest of the source of this radioactivity, the sands of River Solani caught their attention. A few samples of the river sands were then studied and it was found that these sands do have an abnormal radioactive count rates. Chtistie and Saraswat (1965) reported that the Uranium is one of the most probable element causing the high count rate, rather than Thorium.

It was, in this context that the present work was taken up. The aim of this investigation was, therefore, to study the distribution of the radioactivity in the sands of R. Solani from the source onwards and the effects of grain size on it. It was thought proper to study the grain size distribution of these sands, so that some idea might be derived about the general sorting and the local variations affected by the provenence, geology and other factors, if any.

Location:

Originating in the regions south of Dehra Dun from the foothills of Siwaliks, the Solani river system merges into the



INDEX MAP SHOWING THE AREA OF STUDY.
INDIA
MILES
12 6 0 6 12 18
0 10 20 30 40
KMS
INDEX
AREA UNDER STUDY
DISTRICT BOUNDARY.
77° 30′
78° 0′
30° 30′
30° 0′
29° 30′
MUSSOORIE
DEHRA DUN
RESHIKESH
HARDWAR
ROORKEE
SAHARANPUR
MUZAFFARNAGAR
JAMUNA RIVER

river Ganga at a place 25 miles south - south-east of Roorkee; and it is the part of this river system, falling between the latitude 29° 53'N : 30° 13'N and longitude 77° 46'E : 77° 58'E that forms the locale of the present investigations. Its southern most limit is marked by the Ganga canal-crossing the river in the city of Roorkee. The northern most boundary can be drawn by a line passing through Mohand and running parallel to the foothills.

Physiography:

Physiographically, the region can be classified into three distinct units, viz.

1. Foothill Zone of Siwaliks in the north which ranges upto an elevation of 3000 ft.

2. The Sub-montane tract just south of foothill zone of Siwaliks. With a general slope towards south, it is made up of Bhabar having an elevation of 1100 - 1300 ft. and Tarai belt with an elevation of 1000 - 1100 ft. above M.S.L. The Tarai belt is separated from the Bhabar by the Spring Line, which runs roughly parallel to the Himalayan foothills.

3. Gangetic Plains: The southerly sloping sub-montane tract when becomes almost flat, marks the beginning of the Gangetic plains which have an elevation of the order of 900 - 950 ft. near Tarai belt and 850 - 900 ft. further 10 to 15 miles south

Drainage:

Intermittent in its nature, the Solani river system is the only source of natural drainage in the area. It remains, for most of the part of an year, dry; but in the rainy season (June to September), it is capable of causing great havocks in the nearby areas.

The obstructing higher lands, east of the river near Chhutmalpur, have probably forced the river to meander - thereby changing its flow vector from N-S to NW - SE.

Fed by very many tributaries and streamlets, the Solani river system has chiefly the following two drainage patterns:-

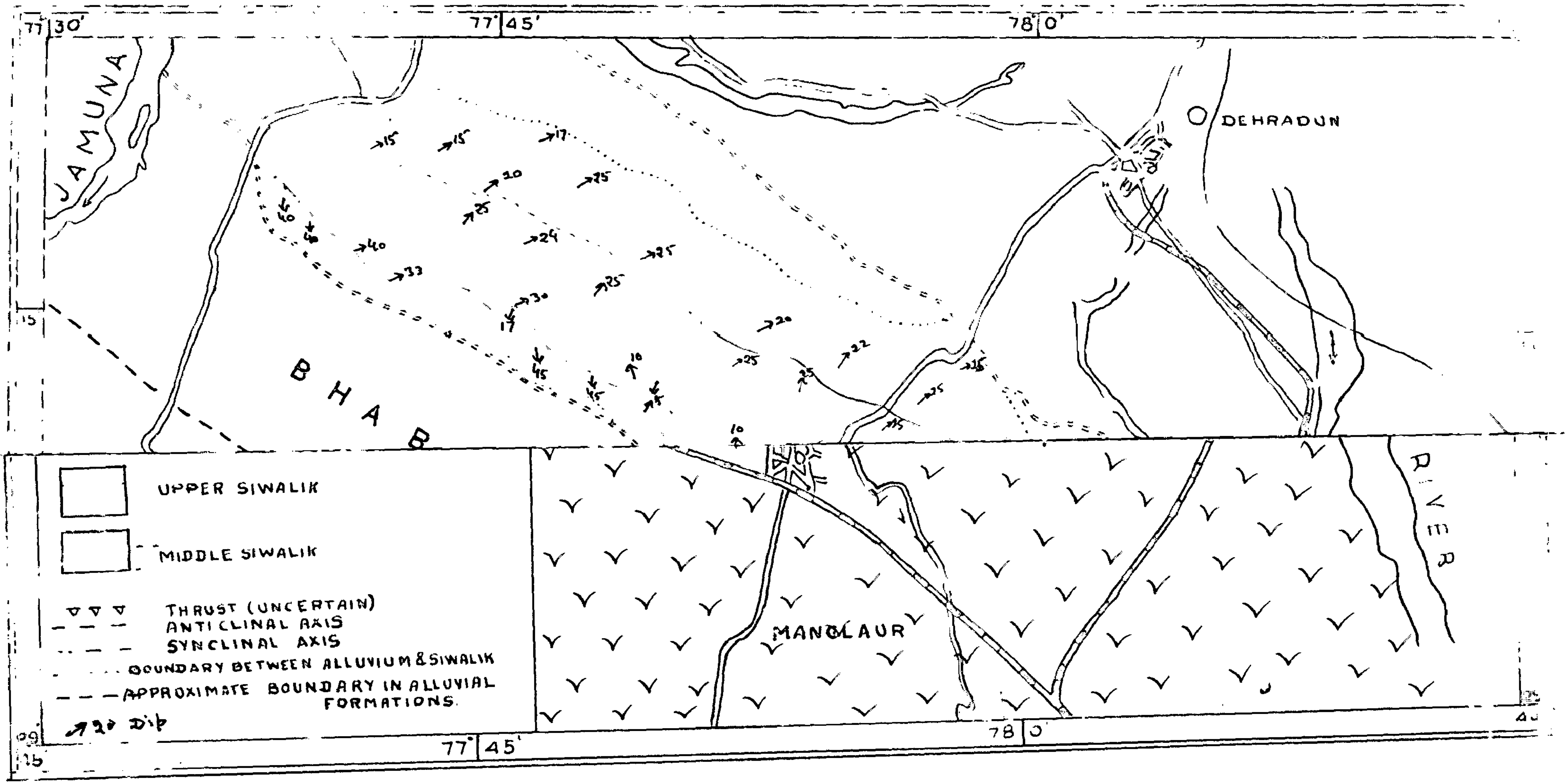
1. Braided pattern which is characterised by various tributaries such as Mohand rao, Sukh rao, Shahjahanpur rao etc., which run, except for a short distance, parallel to each other.

2. Dendritic Pattern Branching like dendrites, this pattern is exhibited by various streamlets of a tributary, east of the main Solani River near the Ganga canal crossing in the township of Roorkee. Such pattern is restricted to the Gangetic plains north-east of Roorkee.

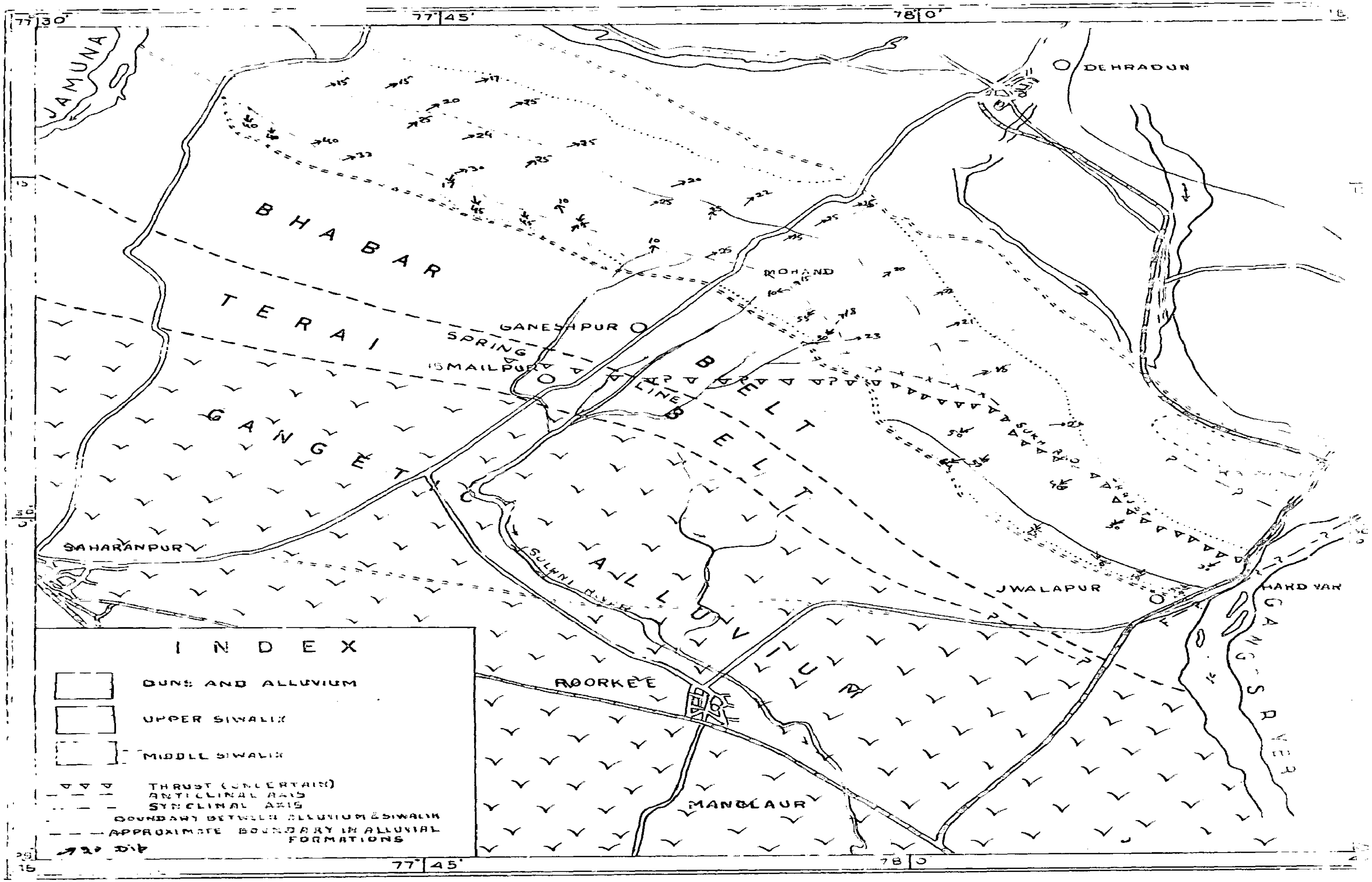
General Geology of the Area:

The northern fringes of the area is occupied by the Siwalik rocks of Mio-Pliocene age. The rest of the area is covered by the Pleistocene and Recent alluvial deposits. According to Raghava Rao (1965) the general succession of formations is as follows:-

GENERALISED GEOLOGICAL MAP OF THE AREA
(AFTER K V RAGHAVA RAO)



GENERALISED GEOLOGICAL MAP OF THE AREA
(AFTER K V RAGHAVA RAO)



AGE	FORMATION		LITHOLOGY
RECENT	Bhabar Deposits		Alluvial fan deposits, essentially constituted of sand boulders, clay-boulder beds with gravel.
	Tarai Deposits		Clay, sandy clay, sands with gravels and pebbles.
	Gangetic Alluvium		Sands, silts, clays and kankars with occasional gravel beds.
MIO-PLIOCENE	Siwalik	Upper	Pebbles, boulders, conglomerates sand rock, green and maroon clay
		Middle	Massive sand rocks, light-grey sandstone associated with clay and calcareous beds.
		Lower	Hard massive grey to brown sandstones, grey to maroon clays and shale beds.

The Siwaliks display a great sequence of fresh water deposits.

The Bhabar formation lying south of Siwalik hills, constitute the alluvial fan deposits. Its southern most limit is marked by the sping line running almost 10 miles south of and parallel to the foothill zone of Siwaliks.

It would be difficult to define Tarai formations strictly in a geological sense, but roughly, however, this belt extents about 6 miles south of spring line. They are also the alluvial fan deposits

The region south of Tarai zone is occupied by the Gangetic alluvium, which forms the greater part of the North Indian Plains. These are strictly the river terrace and flood plain deposits.

Method of Approach to the Present Investigation:

Based on the above mentioned characteristics of the area, the problem was attacked according to a plan which consisted of two phases - (1) Field Work and (2) Laboratory Work.

Field Work: The field work was primarily consisted of collecting the samples according to a programme based on sound statistical footings (Chapter II). Besides the sample collection, the relative radioactive radiations were also noted with the help of a Geiger - Muller Counter in the upper reaches of the river system, but no significant data could be obtained due to comparatively low sensitivity of the instrument.

Laboratory Work: The laboratory work was confined to the mechanical analyses of appropriate samples for the grain size studies (Chapter III and IV) and Gamma ray Spectrometry for the radioactivity studies (Chapter V). Based on the radiometric analyses, the interesting samples were further analysed for their heavy fractions (Chapter VI).

The results obtained by all these studies were correlated to get answer to various problems which prompted the present investigation (Chapter VII).

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CHAPTER - II

SAMPLING

Introduction:

Realising that it is insufficient to measure any set of samples selected indescriminately without any thought of experimental design, many investigaters have pondered the problem of how to sample geological deposits. This problem does not matter much so long as the material from which sampling is done, is uniform so that any kind of sample gives almost the same results. But, when the material is heterogeneous, the method of sampling becomes critical and then it becomes necessary to design the sampling method according to their variability to ensure statistically sound answers.

Statistical Design of Sampling:

The three statistical designs of sampling that are currently in use in geologic problems, are given below along with their geologic equivalents:

a. Stratified Random Sampling: (Sedimentation Unit Sampling) The samples are drawn from a population (the outcrop) where the sub-populations (strata - used geologically and statistically)are non-overlapping and comprise whole population (outcrop). A set of random samples are then drawn independently from each stratum. It is adopted in the stratified rock population.

b. <u>Systematic Sampling</u> (Grid Spot Sampling): It has the first spot of sampling chosen randomly and the position of all subsequent samples is determined automatically by a pre-conceived plan. It is adopted for the sampling of Fluviatile deposits.

c. <u>Random Sampling</u> (Channel Sampling): It is one that ensures every individual of population (outcrop) equal likelihood of being included in the sampling. It is mostly used in homogeneous formations such as glacial tills.

<u>Criterian to adopt a Sampling Design</u>:

The sampling should be such that the mean and variance of some characteristics (say quartz pebbles size) as calculated from sample should truly represent the mean and variance of the population (outcrop of quartz pebbles).

Mathematically, if $\bar{x}$ and S^2 and μ, σ^2 are mean and vaariance of some characteristics say the length of the quartz pebbles from samples and population respectively, then the design of sampling should be such that

$$\bar{x} = \mu$$

and

$$S^2 = \sigma^2$$

<u>Sampling Design for the present Problem</u>:

By studying the lengths of pebbles in New Jersey, Richard Steinmetz (1962) concludes that if a fluvial type of deposit is sampled by all the above mentioned programmes, and if $\bar{x}_a$, $\bar{x}_b$, $\bar{x}_c$ and S_a^2, S_b^2, S_c^2 be the mean and variances calculated from the stratified, systematic and random sampling respectively, then

(i) $\bar{x}_a = \mu$; but $S_a^2 < \sigma^2$ i.e., S_a^2 is an underestimate of ^{2}, the population variance. Hence, stratified sampling programme is not suitable.

(ii) $\bar{x}_c \neq \mu$ and $S_c^2 < \sigma^2$ i.e. neither sample mean nor the variance are the proper estimates of population parameter and hence random sampling design is to be totally rejected.

(iii) $\bar{x}_b = \mu$; and $S_b^2 = \sigma^2$ i.e. both the sample mean as well as the variance are the true estimates of population parameters. In the present investigation, therefore the systematic or Grid Spot Sampling was considered to be the best sampling design.

The Sampling Programme for Solani River:

The systematic sampling in the present study consists of two parts, (a) Fixation of interval between the samples along the river and (b) Selection of a spot randomly.

A previous knowledge of non-variability between the samples collected preliminarily at intervals of about 500 yards appealed the author to choose arbitrarily, a distance interval between the successive samples of about 3/4th of a mile. Having chosen randomly, a spot on the right bank of the river, 200 yards up-stream (sample No.1c on the map) from the canal aqueduct the positions of other sopts to be sampled, were automatically fixed at a pre-planned regular interval of about 3/4th of a mile up-stream along the river.

Besides the systematic sampling special sample spots were also fixed at places where the river showed some peculiarities such as meandering or where the confluences of various tributaries.

Depth Control:

Assuming that the radioactive radiations falling from atmosphere will not penetrate the surface sands to a depth of 6 inches from the surface, it was decided to take the samples of the sand layer lying between 6" to 8" depth from the surface at the spots fixed by previous planning.

Since the sediments were deposited in the very recent years it can safely be assumed that the nature and conditions of deposition had remained same throughout the sedimentation period of the upper 6 to 8 inch layer. It appears safe therefore to presume that the same sedimentational unit has been sampled according to the plan and that the samples collected from this unit can, then, be compared.

Thus the depth restriction on sampling programme, will give the following advantages over surface sampling:-

i. The atmospheric radiations would be filtered off

ii. The decayed organic matter that might have been present on the surface would be removed effectively.

iii. The same sedimentalogical unit would be sampled to remove sampling errors.

Precautions against the Contamination of Samples from Terrace Soil:

The river is, in general, shifting its course more towards western bank and thereby engulfing the old river terraces. Hence any sample taken from the shifting bank will be contaminated by the terrace soil. It was, therefore, decided to take the samples at a distance of 8 to 10 feet away from the non-shifting bank of the river. By this method the contamination due to terrace soil would be avoided.

Method of Sample Collection:

A pit of about 8 x 8x 6 inches dimensions was dug at each pre-fixed spot. A sand layer of about 2" thickness and weighing about 500 gms. was collected from the bottom of each pit. The samples thus collected were numbered and their locations were plotted on the topographical map. (Map No. III)

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CHAPTER - III

GRAIN SIZE ANALYSIS OF SANDS AND GRAPHIC PRESENTATION OF DATA

Introduction:

Of the various properties of sediments, the grain size attributes have one of the wide, if not the widest, applications in the field of Sedimentology and Stratigraphy. The grain size analysis of sediments has, however, been used.

i. As one of the methods of correlation of various formations;

ii. To determine the ability and capacity of sand and sandstones to contain oil, water and gas;

iii. To determine the direction of transport of sediments;

and iv. To classify the sedimentary rocks.

Moreover, an identification of the constituent mineral grains can give a clue as to the location of source rocks from which they have been derived. Furthermore, many physical properties of sediments such as porosity, permeability and compactness are depended on the grain size. An intensive study of the recent sediments is being made to determine if characteristic grain size distributions are associated with certain modern environmental conditions under which the deposition took or is taking place. It may, then, be possible to discover the influence of different components of the environment on the formation of various features of the sediments and determine which factors are responsible for a particular feature. The study of recent sediments permits, thus the determination of effects of environment.

Grain Size Grade Scale:

Quantitative measurement of grain size parameters such as size and sorting is required for precise work. To measure grain size one must first choose a grade scale. Out of the various proposed scales the following two scales have been used exclusively in the sedimentary studies:-

i. Wentworth's Scale - It is a geometric scale based on a constant ratio of 2 between the successive classes.

ii. Phi (ϕ) Scale - It is an arithmetic scale in which all the divisions are equal in range.

Wentworth's geometric scale has been converted by Krumbein into an equivalent arithmetic scale by the following relation:

$$\phi = -\log_2 n$$

where n is the diameter of grains in millimeters

Modern data is nearly always stated in ϕ terms because the mathematically computations are much simplified, and has therefore, been used in the present study.

A. Mechanical Analysis:

Mechanical analysis of sediments requires the preparation into fractions or grades according to some size ratio. Out of the various methods of doing this, the sieve analysis has remained the most popular method for sand range particles and has been employed in the present work.

Preparation of Samples:

The purpose of grain size analysis is to obtain the grain size of the clastic particles as they were deposited. This is often difficult because -

i. the clastic sand grains may acquire overgrowth or may be cemented into hard tough aggregates,

ii. chemically precipitated materials might be introduced into the sediments or rocks if not removed, give erronous size values.,

iii. clay minerals because of their flaky character and surface electrical charges tend to cluster in lumps.

The grain size, therefore, should be disaggregated and dispersed by physical or chemical means. For this purpose each of the 38 preliminary samples out of a total of 102, of Solani sands were dried after being boiled with very dilute Hydrochloric acid and were dispersed one by one by fingures till they were ready for sieve analysis. The disaggregated sand samples were then coned and quartered till 50 gms. of relatively homogeneous fraction of sample remained.

Sieving:

The B.S. Sieves with mesh numbers 25, 36, 52, 72, 100, 150, 170, 200 and 240 were used for the sieving. An automatic sieve shaker was utilised for the purpose, the duration of shaking being 10 minutes. The retained mass of sand for each sample in each sieve was recorded and the loss in weight was equally adjusted for each fraction of sand samples. The results of sieve analyses are given in the Tables presented herewith (in the Appendix)

B. Graphic Representation of Data:

One of the first steps in the grain size analysis is the graphic presentation of the data in the form of cummulative curves - the abscissa being represented by grain size and the ordinate by cummulative weight percentage of retained sand.

Using the grain size in ϕ scale, the arithmetic base paper have been employed to draw the cummulative curves of all the 38 samples (Graph Nos. 1 to 13). They all have similar shapes in the form of letter 'S'. However, three types in shapes can be recognised:-

i. Type A. In this type of curve the lower tail of it, is much larger and extends more, almost parallel to abscissa. This is exemplified by the cummulative curves of samples such as 1c, 3a, 64, 84 etc. This extended tail represents that sediments have much coarser grains than the average size.

ii. Type B. In this, the upper tail of the curve is much larger and extends almost parallel to the abscissa - indicating thereby that the sediments have larger amounts of finer fraction than average size. The examples of such samples are 38, 61, 48, 58.

iii. Type C. In these types of cummulative curves both the tails are symmetrical to each other. Here most of the grains are of average size of the sample. The examples are 7b, 13, 31.

CHAPTER - IV

STATISTICAL PARAMETERS OF GRAIN SIZE AND THEIR SIGNIFICANCE

Introduction:

Although much can be done by purely graphic methods in the interpretation of cummulative curves, it is more convenient to have the characteristics of the curves expressed as numbers. Statisticians have developed analytical devices so that the numbers themselves, instead of pictures of the curves, may be used to describe and define them.

In order to describe and compare these wide ranges of curves, the following statistical parameters are to be described and discussed herewith.

GRAIN SIZE PARAMETERS

A. Parameters of Average Grain Size:

There are many diverse parameters given by statisticians, but the following two are more important and have been used in the present study

1. ϕ - Median Size (ϕ 50)

It is the middle point in the size distribution (in ϕ scale) of sediments of which one half of the weight is composed of particles larger than the median diameter and the rest are smaller than this size.

The median diameter ϕ 50 is read directly from the cummulative curves by noting the diameter value at the point of intersection of the 50% line on the curve.

It is by far the most commonly used method and easiest to determine. But it does not reflect the overall size of the sediments (especially skewed ones) - because it is not affected by the extremes of the curves.

2. ϕ Graphic Mean:

Best by far, yet the easiest to compute, this measure gives the overall picture of size of sediments. It is found by dividing the sum of observation of size by total number of observations considered.

It has been shown by Mecamman (1962) that Folk and Ward's formula for graphic mean - $\left(\frac{\phi_{84} + \phi_{50} + \phi_{16}}{3} \right)$ has an efficiency of 88%, and in which only three size grades are used with such a high efficiency and has therefore been employed as average grain size parameter, in the present study.

The Concept of Efficiency:

If a set of values observed for a measure (such as that given by Folk and Ward's mean size formula) shows less fluctuations than a set of values observed for another (such as Inman's Mean size formula $\frac{\phi_{16} + \phi_{84}}{2}$ with efficiency of 74%.), and if both the measures are unbiased estimates of same parameters (i.e. average size of the sediments), then, Folk and Ward's mean size measure is a more desirable estimate and is statistically said to be more efficient than Inman's measure. It is more effective because it has lower variance as shown by Mccammon (1962). Higher the efficiency, better the estimate and it is because of higher efficiency that the Mean Size Formula given by Folk and Ward has been used.

Comments on the Average Size:

The mean size of sediment is a function of -

i. the size range of available materials,

ii. the amount of energy imparted to the sediments which depends on the current velocity or the turbulence of the transporting medium,

andiii. actions and interactions between the various grains before being deposited.

Thus any average value of grain size is a net reflection of these factors. But how much is the contribution of each factor is yet uncertain.

B. Measures of Sorting:

Sorting of grains according to their sizes is one of the most useful textural attributes in characterising the sedimentary masses that must be studied quantitatively. Sorting is most commonly determined by a measure given below:-

Standard Deviation of Grain Size: It is a measure of sedimentary grains which indicates the fluctuation in the kinetic energy (velocity) of the depositing agent about its average velocity. When a sedimentary deposit is produced by two different modes of deposition such as the combination of bed load and the suspended load, the standard deviation indicates the difference in the kinetic energies (velocities) associated with these modes of deposition.

The following measures of sorting are currently used but the Inclusive Graphic Standard Deviation as given by Folk and Ward has been used exclusively, as it has maximum efficiency of 79%:

TABLE - II

Name of the Authors	Sorting Measures		Efficiency %
Krumbein	$(\phi_{75} - \phi_{25})/1.35$	-	37
Inman	$(\phi_{84} - \phi_{16})/2$	-	54
	$(\phi_{95} - \phi_{5})/3.3$	-	64
Folk and Ward	$\frac{(\phi_{84} - \phi_{16})}{4} + \frac{(\phi_{95} - \phi_{5})}{6.6}$		79

Using Inclusive Graphic Standard Deviation, Folk and Ward has classified sorting as given in the Table - III.

TABLE - III

Inclusive Graphic Standard Deviation Interval	Sorting Designation
< 0.35	Very well sorted
0.35 - 0.50	Well sorted
0.50 - 1.00	Moderately sorted
1.00 - 2.00	Poorly sorted
2.00 - 4.00	Very poorly sorted
> 4.00	Extremely poorly sorted

Comments on Sorting:

Sorting has an inverse relationship with the Standard Deviation i.e., the greater the standard deviation, the poorer is the sorting and vice versa.

The sorting depends upon atleast the following factors:-

i. Size range of source material supplied to the environment - If sufficient quantities of material of different sizes are not available, all the fluctuations in the velocity cannot be recorded geologically. Thus, the size destribution of source material, to a certain extent controls the sorting of the sediments.

ii. Current Characteristics and type of the deposition - Currents of relatively constant strength whether low or high, will give better sorting than the currents which fluctuate rapidly from almost slack to violent.

Also, very weak currents do not sort grains well, neither do very strong currents. There is an optimum current velocity or degree of turbulence which produces best sorting. For best sorting then the currents must be of intermediate strength and constant strength.

The type of deposition is associated with a characteristic current conditions and thus it also to some extent governs the sorting of sediments.

iii. Number of Provinces: If an environment is getting contributions from two or more sources say,(clay and gravel), then the pure end members will be better sorted than the bimodal mixture (clay – gravel).

C. <u>Skewness:</u>

Skewness is defined as the symmetry of the curve and can be described as the tendency of a curve (here grain size distribution curve) to depart from a symmetrical form and marks the position of Mean with respect to the median. If the skewness is negative, the sample is coarsely skewed i.e., the mean is towards the coarser side of the median and when skewness is positive, the sample is finely skewed. It has been measured by the following formula:–

$$\text{Skewness} = \frac{1}{2}\left\{ \frac{\phi_{84} + \phi_{16} - 2\phi_{50}}{\phi_{84} - \phi_{16}} + \frac{\phi_{95} + \phi_{5} - 2\phi_{50}}{\phi_{95} - \phi_{5}} \right\}$$

<u>Comments:</u> This is the best ~~method~~ measure of skewness available to use because it determines the skewness of the 'tails' of the curve rather than the central portion. The most critical difference lie in the 'tail' parts of the curve and hence these have to be given due recognition. Furthermore this measure is geometrically independent of sorting of the samples.

TABLE – IV

CLASSIFICATION OF SKEWNESS AS PROPOSED BY FOLK AND WARD

Skewness Value	Designation
0	Symmetrical Curves
+1 to 0.3	Strongly fine skewed
+.3 to +0.1	Fine skewed
+0.1 to –0.1	Near symmetrical
–0.1 to –0.3	Coarse skewed
–0.3 to –1.0	Strongly coarse skewed

Physical Concept of skewness: Assuming sufficient quantities of material of different sizes are available, a coarsely skewed sample implies that the velocity of the depositing agent operated at a higher value than the average velocity for a greater length of time than normal under normal conditions of deposition or the velocity fluctuations towards the higher values occurred more often than normal. Reverse will be the case for finely skewed sediments.

D. Kurtosis:

Kurtosis is conventionally considered as measure of peakedness of a frequency curve. However, Kendall and Stuart(1958) state that it is not necessarily so, and the Kurtosis should not be interpreted as describing the shape (flatness and peakedness) of frequency curve. It is really a ratio of sorting within central 90% of the distribution to the sorting of central 50% of the distribution. Therefore Kurtosis measures the sorting ratio rather than peakedness of the curve.

The formula for Kurtosis is given as

$$\text{Kurtosis } (K_G) = \frac{\phi_{95} - \phi_5}{2.44\,(\phi_{75} - \phi_{25})}$$

Physical Meaning of Kurtosis: When K_G IS GREATER THAN ONE, it indicates that the velocity fluctuations were restricted within the central 50% of the average velocity for greater length of time than normal. When K_G is less than one, the reverse is the case. When K_G is equal to one, the distribution is normal i.e., the sorting throughout the central 90% of the distribution was same and the velocity of the stream was steady and operated for long time.

COMPUTATION OF GRAIN SIZE PARAMETERS

The various statistical parameters are the absolute numerical statements of grain size and are estimated from one or the other formulae. From the cummulative curves of samples, the values of ϕ_5, ϕ_{25}, ϕ_{16}, ϕ_{50} ‡ ϕ_{75}, ϕ_{84} and ϕ_{95} were obtained as given in the table No.5. Since the samples are large in number, it was decided to use the high speed IBM electronic computer installed in the C.B.R.I., Roorkee, which respons to a special command codes called machine language. This language is also known as FORTRAN System originating from the FORmula TRANslating system.

<u>Programme for Calculations of Parameters:</u> A series of instructions to the computer is called a programme and it is according to the following programme that the computer worked:–

```
       C       PARA    CALCULATION      -  A.K.A.
     161   =   READ 1, FY 5, FY 16, FY 25, FY 50, FY 75, FY 84, FY95
       1       F φ RMAT   (7F 10.0)
      A1   =   FY 84 + FY 16
      B1   =   FY 95 - FY 16
      C1   =   FY 84 - FY 16
      GM   =   (A1 + FY 50)/3
   SIGMA   =   (C1  0.25 + (B1/6.6))
    SKEW   =   ((A1 - 2  FY 50)  0.5/C1) + (FY 95 + FY 5 - 2  FY 50)
                                               0.5/B1)
   KURTO   =   B1/(2.44  (FY 75 - FY 25))
   PUNCH   =   6, GM, SIGM A, SKEW, KURTO
     6 Fφ RMAT (4E 16.8)
     GφTφ  161
     END
```

Ø – Kurtosis
KB= α – α
0.13683138E+01
0.10465002E+01
0.10270591E+01
0.11186114E+01
0.11462802E+01
0.11942535E+01
0.15589842E+01
0.10711624E+01
0.11105235E+01
0.80104322

ION OF VARIOUS STATISTICAL PARAMETERS OF GRAIN SIZE

IVE CURVES			STATISTICAL PARAMETERS			
ϕ_{75}	ϕ_{84}	ϕ_{95}	Graphic Mean (GM) $= \frac{\phi_{16}+\phi_{50}+\phi_{84}}{3}$	Inclusive Graphic Standard Deviation (Sigma) $= \frac{\phi_{84}-\phi_{16}}{4} + \frac{\phi_{95}-\phi_{5}}{6.6}$	'Ø' Skewness $SK_1 = \frac{1}{2}\left(\frac{\phi_{84}+\phi_{16}-2\phi_{50}}{\phi_{84}-\phi_{16}} + \frac{\phi_{95}+\phi_{15}-2\phi_{50}}{\phi_{95}-\phi_{16}}\right)$	Ø – Kurtosis $KR = \frac{\phi_{95}-\phi_{5}}{2.44(\phi_{75}-\phi_{25})}$
2.94	3.08	3.55	0.25966667E+01	0.51219697	0.28553226E-01	0.10728062E+01
3.03	3.16	3.56	0.27466667E+01	0.43878788	0.59918005E-02	0.10669870E+01
2.62	2.80	3.20	0.22733333E+01	0.50204545	0.18524531	0.96975294
2.77	2.89	3.25	0.24733333E+01	0.42113636	0.59215585E-01	0.99632561
2.78	2.96	3.32	0.23833333E+01	0.54265152	0.11856856	0.90786470
2.81	3.02	3.49	0.25100000E+01	0.49204545	0.23562632	0.10928962E+01
3.06	3.20	3.68	0.28333333E+01	0.40924248	0.54054060E-01	0.12636612E+01
2.35	2.60	3.17	0.20466667E+01	0.56704545	0.16801706	0.12481371E+01
2.38	2.54	2.99	0.21360000E+01	0.43280303	0.90886935E-01	0.11763789E+01
2.20	2.36	2.78	0.18633333E+01	0.54742424	-0.78075790E+01	0.12167979E+01
2.30	2.50	2.96	0.19900000E+01	0.52734848	0.11987278	0.12427287E+01
1.92	2.06	2.58	0.16766667E+01	0.46666667	-0.68181815E-01	0.17174093E+01
2.47	2.68	3.11	0.21766667E+01	0.61780303	-0.32457120	0.13960041E+01
2.20	2.44	2.92	0.19100000E+01	0.54590909	0.10569853	0.12490242E+01
2.20	2.38	2.78	0.19333333E+01	0.48069606	0.22727273E-01	0.12816692E+01
2.17	2.28	2.65	0.18866667E+01	0.42674242	-0.42209877E-01	0.11028316E+01
2.20	2.36	2.84	0.18800000E+01	0.53893939	-0.46076163E-01	0.12823903E+01
2.60	2.84	3.26	0.22400000E+01	0.56484848	0.19224924	0.10138050E+01
2.30	2.46	2.96	0.20100000E+01	0.50219697	-0.31533165E-01	0.11959151E+01
2.28	2.54	3.06	0.19100000E+01	0.67916667	-0.86611570E-02	0.13050043E+01
2.70	2.93	3.44	0.22633333E+01	0.66492424	0.90210600E-01	0.10770111E+01
2.28	2.58	3.26	0.19000000E+01	0.72750000	0.91242815E-01	0.12871276E+01
2.67	2.96	3.62	0.21500000E+01	0.82280303	0.82981970E-01	0011Y56913E+01
2.60	2.88	[illegible].58	0.21166667E+01	0.78212121	0.80385535E-01	0.11612022E+01
3.10	3.31	4.00	0.26666667E+01	0.69515152	0.15402990E-02	0.11223920E+01
2.46	2.[illegible]0	3.24	0.21566667E+01	0.53984848	0.20974136	0.11674118E+01
2.45	2.64	3.10	0.21633333E+01	0.49613636	0.89358545E-01	0.12295082E+01
2.56	2.77	3.19	0.22166667E+01	0.52871212	0.19824267	0.10332487E+01
2.12	2.36	2.96	0.17666667E+01	0.64651515	0.25715956E-01	0.13583138E+01
3.12	3.38	4.02	0.26500000E+01	0.7[illegible]88	0.62344825E-01	0.10455002E+01
2.90	3.07	3.64	0.24900000E+01	0.60765152	0.35256410E-01	0.10270591E+01
3.00	3.20	4.00	0.25733333E+01	0.65651515	0.17029395	0.11186114E+01
2.46	2.68	3.14	0.21566667E+01	0.51871212	0.16686417	0.11462902E+01
2.82	3.08	3.98	0.22700000E+01	0.77060606	0.38491698	0.11942535E+01
3.05	3.20	3.84	0.28033333E+01	0.51643939	0.17838527	0.15589842E+01
3.00	3.28	4.12	0.23100000E+01	0.10127273	0.35344570E-02	0.10711624E+01
3.17	3.39	4.18	0.27166667E+01	0.71931818	0.75661380E-01	0.11105235E+01
2.83	2.98	3.13	0.25100000E+01	0.42795455	0.45011255E-02	0.80104322

ns multiplication by 10^{-1}

TABLESSHOWING CALCULA

Sl. No.	Sample No.	ø VALUES DRAWN FROM CUMMULA			
		$ø_5$	$ø_{16}$	$ø_{25}$	$ø_{50}$
1.	1c	1.77	2.11	2.26	2.60
2.	3a	2.05	2.32	2.45	2.76
3.	7b	1.62	1.81	1.91	2.21
4.	13	1.84	2.06	2.19	2.47
5.	31	1.57	1.85	1.99	2.34
6.	27	1.81	2107	2.18	2.44
7.	24	2.20	2.46	2.58	2.84
8.	19a	1.16	1.56	1.69	1.99
9.	34	1.47	1.73	1.86	2.12
10.	38	0.85	1.34	1.55	1.89
11.	74	1.08	1.53	1.68	1.94
12.	42a	0.82	1.26	1.50	1.71
13.	51	0.93	1.53	1.83	2.32
14.	53	1.00	1.42	1.57	1.87
15.	60	1.06	1.50	1.65	1.92
16.	87	1.17	1.47	1.62	1.91
17.	90	0.90	1.38	1.58	1.90
18.	89	1.38	1.72	1.84	2.17
19.	58	1.18	1.53	1.69	2.04
20.	48	0.64	1.29	1.52	1.90
21.	64	1.18	1.64	1.84	2.22
22.	84	0.62	1.27	1.50	1.85
23.	61	0.78	1.39	1.68	2.10
24.	93	0.80	1.40	1.64	2.07
25.	92	1.59	1.99	2.22	2.70
26.	46a+b	1.36	1.68	1.80	2.09
27.	82	1.36	1.71	1.87	2.14
28.	80	1.40	1.74	1.85	2.14
29.	102	0.64	1.18	1.42	1.76
30.	100	1.62	1.93	2.14	2.64
31.	99	1.56	1.90	2.07	2.50
32.	77	1.68	1.98	2.15	2.54
33.	98	1.35	1.69	1.82	2.10
34.	97	1.27	1.64	1.89	2.09
35.	67	1.90	2.31	2.54	2.90
36.	70(a+b+c)	0.67	1.32	1.68	2.33
37.	71	1.66	2.04	2.24	2.72
38.	73	1.84	2.05	2.17	2.50

Where E + 01 means multiplication by 10; E — 0

Sequence of Operation: The data was fed into the computer through punched cards according to a format – which specified how the data was to be transmitted to the computing system. After doing its work according to the above programme, the computer produced the following results: given in the table No. 5.

INTERPRETATION OF GRAIN SIZE PARAMETERS

A. Average Grain Size:

About 75% of the samples with their average size values lying between 2.00ɸ to 2.8ɸ, fall under the fine sand class of sediments while the rest of 25% of samples, by virtue of their mean size ranging from 1.6ɸ to 1.9ɸ , can be termed as coarse grained samples. It should therefore be mentioned at the very outset, that the present investigation is confined to the fine and medium sized sands.

Observations and Inferences: The medium grained sands are characteristically found to occur at the confluences of rivers and tributaries, which can be explained by the fact that – at the confluence, the water velocities of two rivers are checked by each other – thereby the coarser material is easily deposited and the finer materials are swept away by the stream.

The fact that the transportation of these grains is not much and that the velocity of water is not much variable, render one to infer that the grains of these fine to medium sands must not have their original sizes more than that of the coarse grained sands. Further, these grains in the source area must be loosely cemented, otherwise it would not have been possible to obtain fine to medium disaggregated sands in the Solani river for such a short transportation of 15 to 20 miles. Summing up therefore, these inferences, it can be concluded that the parentage of these sands lie in the loose sand rock which can at the most have its grain size that of the coarse grained sands.

B. Graphic Standard Deviation as a measure of Sorting:

84% of the samples have their values lying between 0.5 to 1 and hence fall under medium sorted class while the rest of the 16% samples with their values ranging between 0.4 to 0.5 can be placed in the well sorted class of Sorting Classification. It can be said that Solani sands are medium to well sorted.

Sorting as mentioned in Chapter III depends upon the nature of source rocks, nature of transporting agency and the distance of transport of sediments. For Solani river the transport is less and the velocity variation of water for most of the part of an year, is not much. These agents, have, therefore, played little role in the sorting of Solani sands. Thus the remaining third factor i.e., the nature of source rock may be attributed as the cause of moderate to well sorted sands. In other words, the source material itself was atleast moderately well sorted.

The logical inference, therefore, from the study of average grain size and graphic standard deviation is that the parent rock of these sands are coarse to medium grained loosely cemented and moderately well sorted sand rock.

C. Skewness (SK_1):

Based on the results given in the table, 5, about 70% of the samples have their skewness values lying between 0.1 to -0.1 - thereby falling in the nearly symmetrical class of skewness. The rest of the 30% of the samples have their skewness, falling in the finely skewed class (+3.0 to 0.1).

The samples in the nearly symmetrical class are themselves, although very slightly, skewed both positively or finely skewed and negatively i.e. coarsely skewed.

Observations and Explanations: The negatively skewed samples i.e. having excess coarser material than average are found to occur at the confluences of various rivers and tributaries. This fact can be explained as follows:-

Two rivers or tributaries coming from different directions, when meet each other, their velocities are suddenly changed - producing thereby eddy currents. And under these conditions the coarser material can easily settle down in comparison to the finer ones which undergo whirling movement along with the downslope moving eddies. Thus coarsely or negatively skewed sediments are produced at the confluences. As the eddies begin to die while moving down the stream, the associated finer sediments settle down - producing thereby positively or finely skewed sediments..

<u>Inference</u>: Observation of negative skewness in the sediments coming from a single source, might be helpful in predecting the conditions of deposition i.e. it may, in a geological formation deposited by rivers, indicate the confluences or some obstruction to the flowing water. In otherwords, a sudden change in velocity may be inferred by a negative skewness. The positively skewed sediments will them indicate that the most of the coarse material which was originally present with these sediments, have been deposited upstream and the finer ones are left over by them.

D. <u>Kurtosis (KG)</u>:

The samples, in general, have their kurtosis values nearly equal to one, i.e.

Sorting in the central 90% of size distribution = Sorting in the central 50% of the size distribution.

Hence the velocity fluctuations were not rapid and that the velocity of water was steady for long time and it is under these conditions that the present sediments were deposited.

Scrutinising strictly the Kurtosis data, it is observed that most of the samples have their values slightly more than one. This means that - Sorting in the central 90% of size distribution is greater than sorting in central 50% of size distribution. Translating this statement in terms of velocity conditions, it can be inferred that - whatever be the velocity fluctuations from average velocity, they were restricted to the central 50% of the grain size distribution and operated for greater length of time than normal.

EFFECT OF TRANSPORT ON GRAIN SIZE AND SORTING

A. Transport Versus Grain Size:

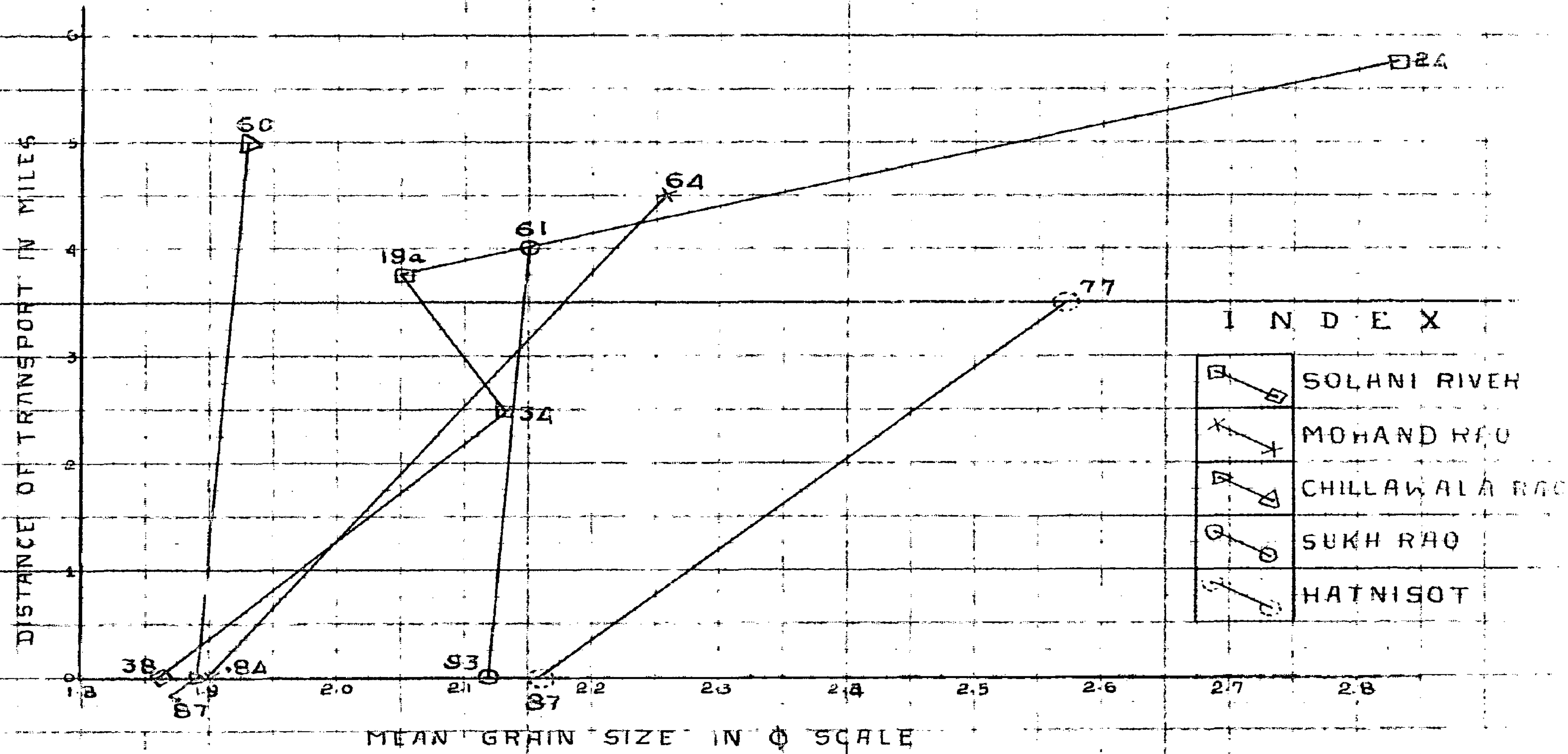
In order to see the effect of transport on the grain size various samples were selected in various tributaries. For each tributary, two samples, with known distances of transport, were plotted in the graph No. 14 . From the graph, it can be inferred that the for all tributaries and for most of the part of the plotted Solani river, the grain size in ϕ units increases with transport, or in other words - it can be said that with increase in transport of sediments, the grain size in millimetor scales decreases.

However, during the transport from sample 34 to 19a of Solani river, the grain size in millimeter has increased. This is because of the fact that the sample 19a was taken from the concave (towards river) side of the meandered part of the river, where the sediments were deposited due to obstruction or the change in the velocity of the stream.

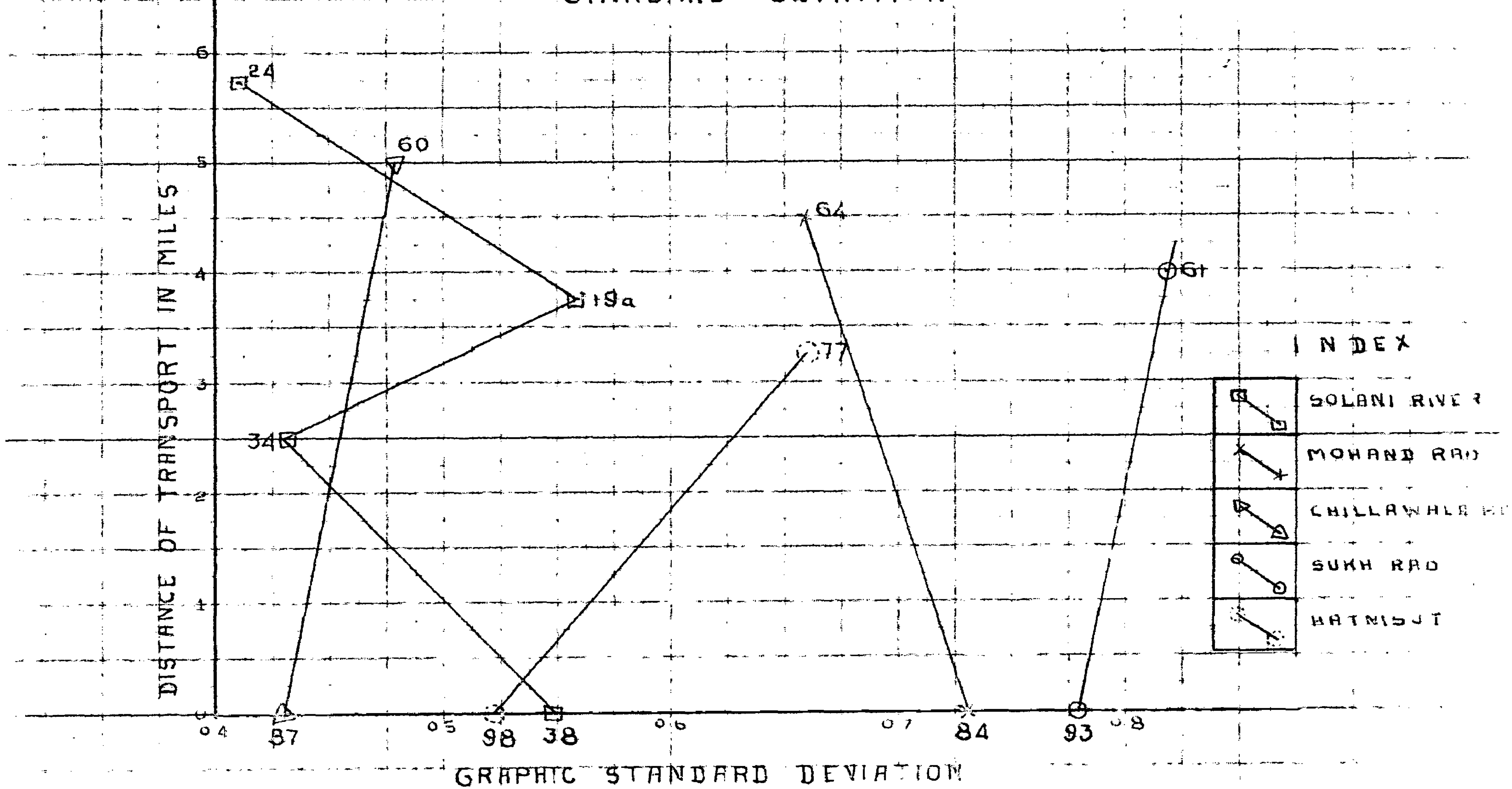
B. Transport Versus Sorting:

Graphically, for the tributaries Sukhrao, Chillawala and Hatnisot, as the distance of transport increases, the σ_1 also increases i.e. with the transport, the sorting of sediments become poorer in these tributaries. Besides these tributaries the sorting has also become poorer in the meandered portion of Solani from where the sample No. 19a was taken. This decrease in sorting is due to various obstructions offered to the river water by meanders and topographical features. In the parts of Solani river between sample

GRAPH BETWEEN DISTANCE OF TRANSPORT & MEAN GRAIN SIZE



GRAPH 15 BETWEEN DISTANCE OF TRANSPORT AND GRAPHIC STANDARD DEVIATION



38 to 34 and then between 19a to 24 where no obstruction was offered t it, the corting increased with the transport. The same is the story with the Mohanrao.

<u>Inference:</u> The facts that the various tributaries in the northern parts of the area of present study, tend to decrease the sorting of the sediments with the transport and that the samples from these rivers are themselves well to moderately well sorted, force the author to infer that the source rock of these sands must be well to very well sorted sediments.

RELATIONSHIPS BETWEEN VARIOUS PARAMETERS

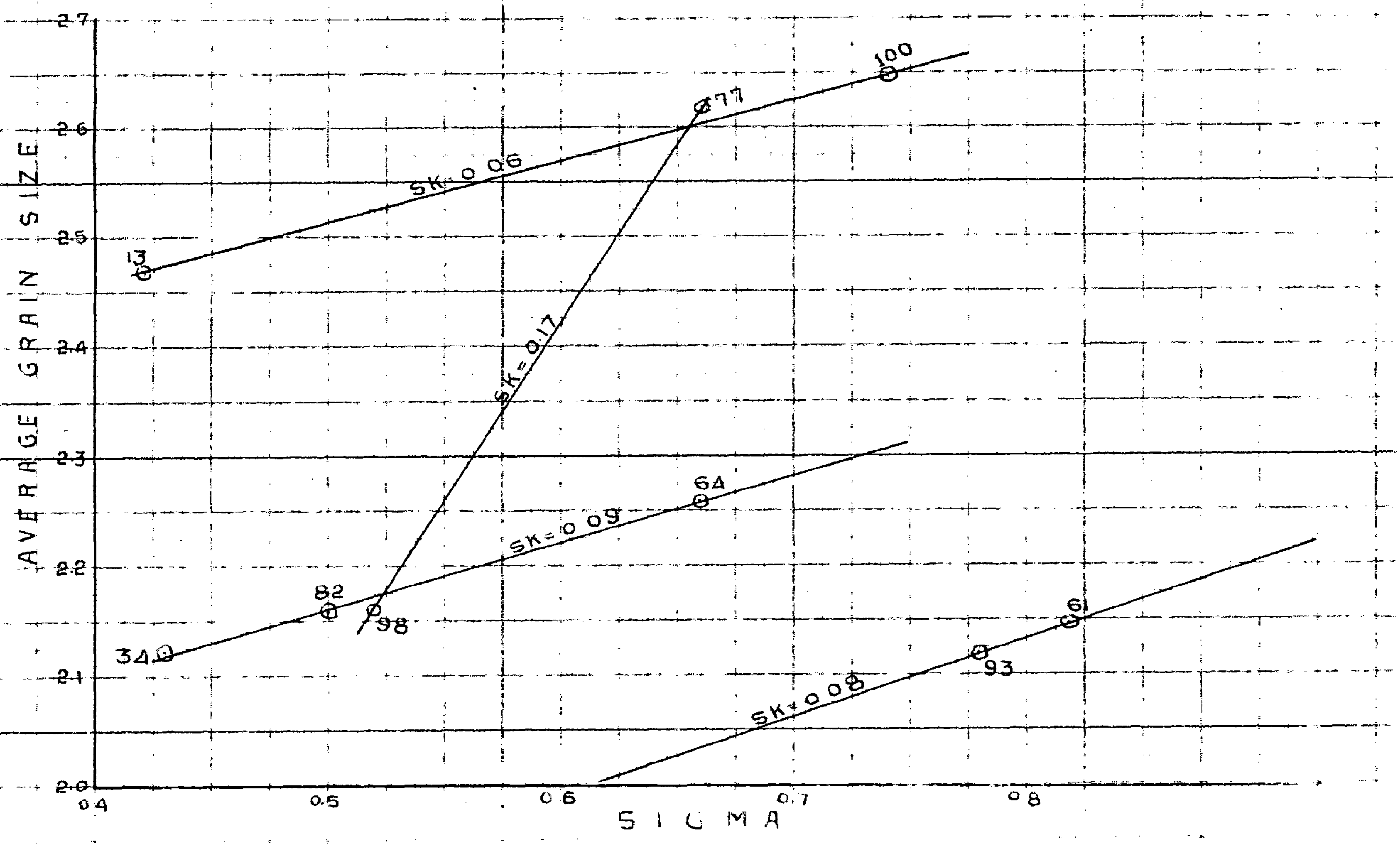
The Kurtosis values of samples are almost constant and are nearly equal to 1. The relationship between the rest of the three parameters is, therefore discussed as follows:-

A. Relation of Mean Grain Size and Graphic Standard Deviation when Skewness is kept constant:

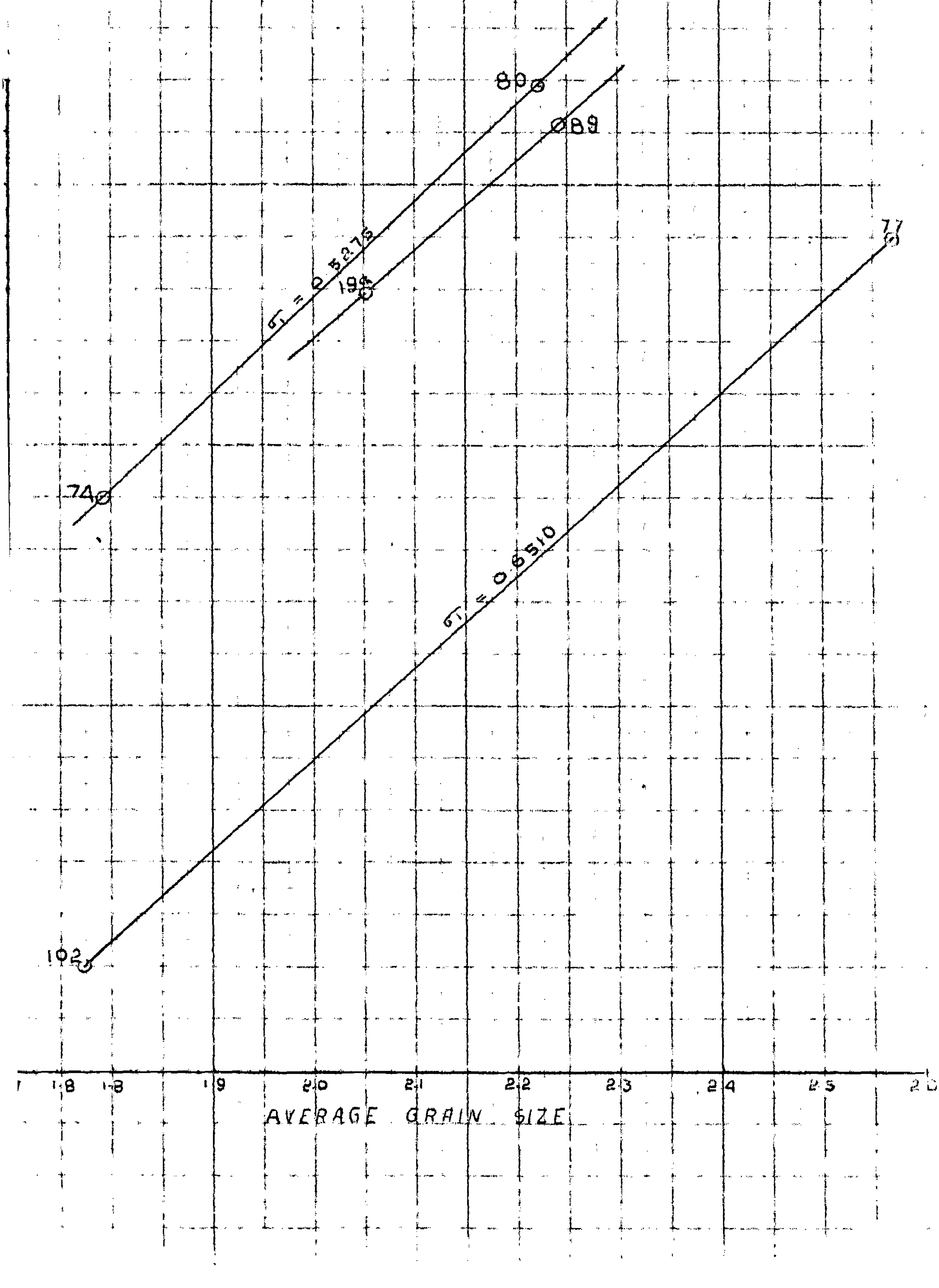
For a constant value of skewness, the graph No. 16 between mean grain size and sigma has been plotted. From the graph it is clear that as the average grain size of sands increase, the sigma also increase. Since sigma has inverse relation with sorting of grains, it is apparent that as skewness remains constant the coarser the sediments the poorer will be the sorting.

For same skewness values, the slopes of the graph are same, but as skewness increases, the slope also increases.

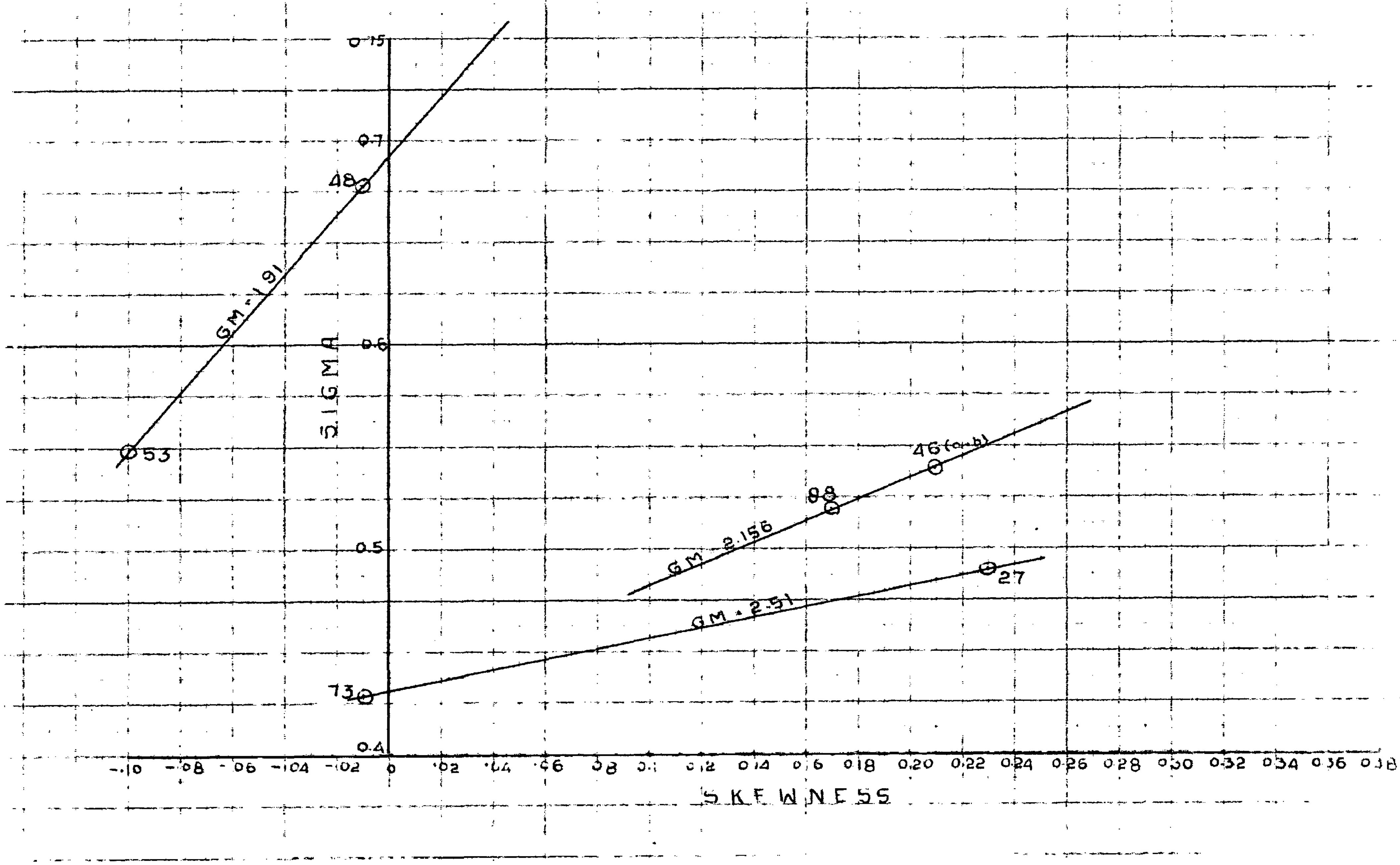
GRAPH 6 BETWEEN AVERAGE GRAIN SIZE &
GRAPHIC STANDARD DEVIATION (SIGMA) (σ I)



GRAPH 17 - BETWEEN AVERAGE GRAIN SIZE & SKEWNESS



GRAPHS BETWEEN GRAPHIC STANDARD DEVIATION (SIGMA) & SKEWNESS



B. Relationship between average grain size and skewness:

Keeping sigma constant, the graph No. 17 between skewness and average grain size, shows that as the grain size increases, skewness also increases. Again, for almost same values of σ_I the graphs are almost parallel indicating thereby a functional relationship between these three parameter.

C. Relationship bbetween skewness and graphic standard deviation when mean grain size is kept constant:

The graph No. 18 shows that - as the skewness increases the sigma also increases for a fixed average grain size. In other words, the greater the skewness the poorer will be the sorting of sediments if the average grain size is kept constant.

It is clear from the graph - that as the grain size increas the slope of the lines also increase. It again shows a functional relationship between the parameters and it is from this graph that the following mathematical relationship has been derived. Table VI has been constructed from the graph No. 18

TABLE - VI

Number of observations	Average grain Size (GM)	Slope of the curves ($\frac{\Delta \sigma_I}{\Delta Sk_I}$)
1	1.910	1.300
2	2.156	0.425
3	2.510	0.200

L Let the following relation exists between the variables GM and the slope

$$y = a_0 + a_1 x + a_2 x^2 \quad \ldots\ldots\ldots\ldots \quad (1)$$

where a_0, a_1 a_2 are some constants and $y = \frac{\Delta \sigma_1}{\Delta SK_1}$, $x =$ GM

Applying the principles of least squares, the above mentioned second degree polynomial has been fitted to the data given in the table VI . The values of constants a_0, a_1 and a_2 have been found after tedious mathematical computations, as

$$a_0 = -33.12185382$$
$$a_1 = 32.42466190$$
$$a_2 = -7.668814415$$

Hence the relationship between the various grain size parameters have been derived as -

$$\frac{\Delta \sigma_1}{\Delta SK_1} = -33.12185382 + 32.4246619\ (GM) - 7.668814415(GM)^2$$

<u>Significance:</u> From this relation it is clear that if two samples have same size and same skewness then their sortings will be equal. Again, if two samples having same size, then the sample which has greater skewness will be poorer in sorting and the magnitude of this poorness in sorting can be calculated from the above relation.

<u>DISCRIMINATION OF ENVIRONMENT OF DEPOSITION BY GRAIN SIZE PARAMETERS</u>

Every environment of deposition can be assumed to have its characteristic energy conditions and energy fluctuation in space and time. The preservation of these fluctuations is the subject to the availability of sufficient amounts of source material of all sizes. If so, then size distribution would indicate the environment of deposition. In the present problem, the aim is to discriminate between the two types of environments of deposition by means of a suitable statistics.

Discrimination: - Based strictly on the statistical theory of discrimination, B.K.Sahu (1964) has worked out the following discriminatary function to differentiate between the fluviatile and turbidity current deposition.

$$Y_{FLUV:TURB} = 0.7216\ GM - 0.4030\ \sigma_I^2 + 6.7322\ SK_1 + 5.2927\ K_G$$

Thus to distinguish between fluviatile and turbidity current deposits, the above equation can be used. For various samples Y is calculated and from it mean $\bar{Y}$ is obtained.

Now if

$\bar{Y}$ < 9.8433, the environment is turbidity current type

and if $\bar{Y}$ > 9.8433, it would indicate fluviatile deposits.

A. Application of Discriminant Function Y in the present study:

The river Solani and its tributaries have their deposits of fluviatile nature. The velocity in the river is almost steady every except at the places where tributaries meet each other or at places where some obstruction is offered to the river. At the confluence eddies are formed and the deposition takes place there under somewhat turbulent conditions.

Therefore applying the discriminant function Y in the data of Solani river system , following results were obtained.

$\bar{Y} < 7.5$ indicated deposition at the river confluence or under somewhat turbulent condition.

and $\bar{Y} > 7.5$ < 9.8 indicates somewhat steady conditions of fluviatile deposition.

B. Modification of Sahhi's Discriminant Formula:

Under Sahu's inferences the present samples must have come from turbid conditions of deposition (since $\bar{Y}$ is always less than 9.8433). But this is definitely not the case. Hence ~~the~~ his formula has to be reviewed in the light of the present results. It is to be remembered that his samples were taken from deltaic conditions. His formula may be true for coastal areas but the present samples were taken from definitely inland river deposits. Hence for inland river deposits, Sahu's formula has to be modified as –

For inland deposits

$\bar{Y} < 7.5$ indicates deposition under eddy current conditions

$\bar{Y} > 7.5$ indicates deposition under somewhat uniform veloci conditions.

This tentative modification is however, based on only 28 samples and is therefore subject to varification when more samples from different areas are available for analysis.

CHAPTER - V

RADIOMETRIC STUDIES OF SOLANI SAND

A. Fundamental Principles of Radioactivity:

Radioactivity of a substance is the property by virtue of which its atomic nuclei disintegrate spontaneously by the emission of energy and particles.

Probably tremendous energies were required to build up and hold these nuclei together in the very early stages of the earth's history. Since these conditions no longer prevail, these high energy radioactive nuclei have become unstable and are now, therefore, in a process of spontaneous decomposition to attain a low energy stable state. This process of decomposition through disintigration is unaffected by ordinary physical and chemical changes such as electric, magnetic fields, heat radiations and mechanical pressures etc.

All elements having their atomic Number more than 83 are unstable and are therefore, radioactive. But there are a few radioactive elements such as C^{14}, Rb, K^{40} WHICH have their atomic N lesser than 83. However any radioactive element can be mode radioactive artificially by bombarding its nucleus with particles such as nuetrons, protons, etc.

Nuclear Radiations: The nuclear transformations in the radioactive substances are accompanied by a release of energy in the following forms:

1. Alpha particles
2. Beta particles
3. Gamma rays

Alpha particles: It is an electrically positive corpuscle emitted by a radioactive substance. Its atomic number is 2 and mass number is 4. Thus it can be considered as a helium nucleus. Alpha rays are emitted by a radioactive nuclei of the heavier elements when two protons and two neutrons in the nucleus combine and break off. Thus the parent nucleus's charge is reduced by two and its mass number by 4; it has become another and slightly lighter element. The emission velocity (about one fifteenth to one twenth that of light) of nearly all alpha particle from any particular alpha active isotope is a constant.

Because of their relatively large charge and size, alpha particles readily strip electrons from atoms of the surrounding matter (i.e. they are strongly ionising) and soon come to a halt as neutral helium atoms; they are thus able to penetrate only a few centimeters of air and are stopped by a sheet of paper.

Beta Particles: It is an electrically negative corpuscle emitted by a radioactive substance. Its charge is (-1). A beta particle may be considered as an electron. Beta rays are emitted by some nuclei of both the lighter and heavier radioactive elements when one of the neutrons in the nucleus breaks up into a proton, which remains in the nucleus, and a beta particle, which leaves it. Thus the parents nucleus's charge is increased by one, but its mass number remains the same. The daughter is another element with nearly the same atomic mass as the parent.

Unlike those of alpha particles, the emission velocity of beta particles, for any particular radioactive isotope, is extremely variable, ranging from relatively low speeds to speeds approaching that of light. On the average, they are about ten times as high as alpha velocities. Because of their high velocities, small size and less charge, beta particles are much less interacting than alphas and hence their range of penetration is larger. In fact they are only about a hundredth as ionising as alphas and are therefore about a hundred times more penetrating; although all but most energetic of them, will be stopped by about 4-5 millimeters of Aluminium or a few millimeters of rocks.

<u>Gamma Rays</u>: Gamma rays are the electromagnetic radiation of same nature and velocity as light, but with much greater energy and hence with higher frequencies. They are usually but not always observed along with alpha and beta decay.

Gamma rays have about one hundredth, the ionising ability of beta rays. Being bundles of energy (quanta) rather than massive, charged particles of comparatively slow speed, they are not so likely to collide with an electron and eject it from its atoms. Correspondingly they are 10 to 100 times more penetrating than beta rays and may pass through several centimeters of lead, upto a foot of rock and several hundred feet of air. Their penetration does not stop suddenly, but rather, their energy gradually declines with the depth of penetration.

<u>Statistical Nature of Radioactive disintegration</u>: All radioactive nuclei eventually disintegrate, but no one can predict the exact

instant at which any given nucleus will decay. However, for a large number of atoms, undergoing this change, a certain factors which would give the probab-ility of this change per unit time can be found. This fraction is known as decay constant (λ). It is reasonably certain that λ (Lambda) remains constant throughout geologic time for a particular type of nucleus. However a more convenient unit of decay called half life ($T_{\frac{1}{2}}$) which is defined as the time during which half the number of original radio-active atoms will disintigrate, is related to the decay constant by the following relation

$$T_{1/2} = \frac{0.693}{\lambda}$$

The random sequence of nuclei decay fluctuates about a mean value and if a radioactive source is counted n times for equal limes (but less than its half life), under identical environmental conditions, gives a series of counts $x_1, x_2, x_3 \ldots\ldots x_n$, then a deviation of each count x_i ($i = 1, 2, 3 \ldots\ldots n$) from the mean counts $\bar{x}$ will be observed. This dispersion of individual counts from the mean, is expressed by standard deviation (σ) as

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

$$\simeq \sqrt{\bar{x}}$$ (Because the radioactive disintegratio[n] follows the Poisson's distribution)

With the probability as 0.68, ($\bar{x} \pm \sigma$) is taken as the limits in which the counts will lie.

B. Detection Techniques of Radiation:

Radiations as such are not perceptible to normal human senses unless they are too high. They are then detected by their noticeable effects of interaction with certain substances. These methods can be grouped under the following heads:

1. Photographic Method: It utilises the property of a radio-active substance to make characteristic fogging on the photographic plates.

2. Fluoroscopic Method: The capaicty of radioactive substance to cause fluorensce of certain body, is used in these methods. This method is not applicable for feebly radioactive substances.

3. Electrical Method: The ionisation of air by radioactive radiations, is the principle behind the electrical method of detection. The electric current thus produced by ionisation is a measure of radioactivity.

4. Chemical Methods: The chemical effects produced by any radio-active substance can be used to detect radioactivity.

C. Measurement of Radioactivity in Solani Sands:

Of the various instruments designed to measure and detect alpha, beta and gamma radiations, the Geiger Muller Counter and Scintellation Counters grouped under electrical methods are most commonly used. The detection of γ radiations and not the α & β radiations, in the present study by Gamma Ray Spectrometer, has been chosen after considering the following facts:

1. From the previous work, it has been found that the sands of Solani, are feably radioactive and hence to measure its radioactivity, a large volume of sand will be required.

2. Alpha and beta radiations have low penetration power in comparison to gamma radiations, and they will therefore, be easily absorbed in the volumunous sand samples. Hence it will be easier to detect gamma radiations by Gamma Ray Spectrometer which is based on the principles of Scintellation Counter and will therefore, be discussed in brief here.

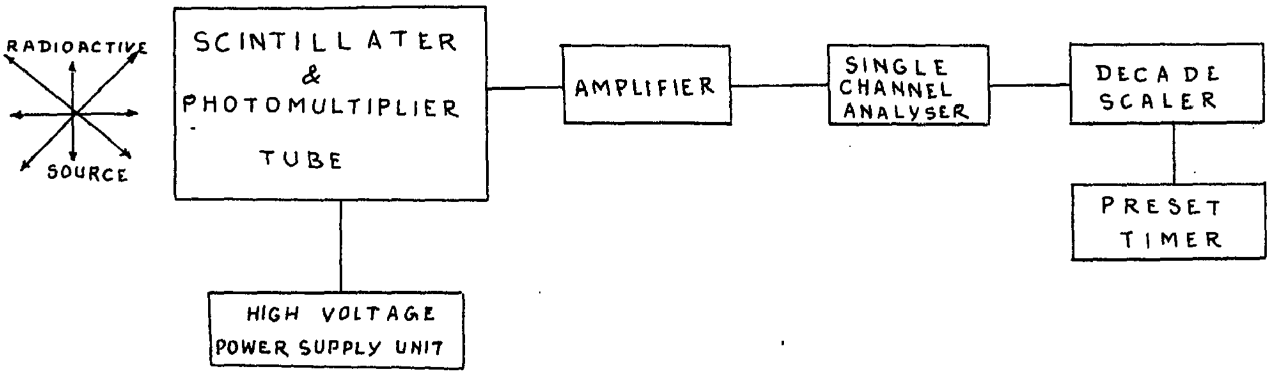
<u>Gamma Ray Spectrometer:</u>

<u>Principle:</u> The operation of this instrument is based on the fact that "a flash or burst of light is produced is produced when gamma ray strikes the atoms of certain substances, called 'phosphors' (because of this property) such as thallium activated sodium iodide crystal. The flash occurs when the excited electrons, which have received some or all of an impinging ray's energy, as it collides with their atoms, loose their excitation energy and fall back into a 'ground state'. As they fall from one descrete energy level to a lower one, they emit electromagnetic radiations, which for phosphers, is in the frequency range of visible and ultraviolet light. This light pulse from the crystal, is proportional to the energy of the gamma ray.

<u>Basic components of Gamma Ray Spectrometer and their working:</u>

The Gamma Ray Spectrometer, has essentially the following components:-

<u>Schematic Representation of Gamma Ray Spectrometer</u>



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1. <u>Scintillator:</u> It is in fact, the most crucial element of a spectrometer. A transparent crystal of sodium iodide which gives off a very minute burst of light when struck by gamma rays, is the most adopted scintillator.

2. <u>Photomultiplier tube and High Voltage Power Supply Unit:</u> The photomultiplier tube produces an electrical pulse when the burst of light impinges on it. This photomultiplior becomes effective when high voltage is supplied to it.

3. <u>Amplifier:</u> The electric pulse produced by photomultiplier tube is too small in amplitude to be easily and correctly recorded. Hence it is amplified by an amplifier.

4. <u>Single Channel Analyser:</u> Various radioactive substances emitt energy radiations of characteristic peaks of count rate at characteristic wavelength. Hence to record count rates for various wave lengths, a unit in the name of Single Channel Analyser is provided with a spectrometer. This is done by allowing

the pulses of desired voltages, coming from the amplifier to pass through it to the recorder.

A single channel analyser consists of the following three sub-units:-

a. Discriminater Level Unit: It allows the pulses having higher voltage than that indicated by the adjustable knob of this unit, to pass through it.

b. Window Width Unit: It allows only the pulses having their voltage value lying in the interval marked by the discriminator level voltage and (window width voltage + ~~and~~ discriminater voltage) to pass through it.

c. Integral (Surplus) and Differential Switches: When the connection is made to the integral setting, it gives all the pulses having their voltage values ranging, from set descriminater voltage to the maximum possible voltage of descriminater level unit.

When the connection is made to differential setting, then and only then, the window width unit functions according to its settings.

d. Decade Counter and Preset Timer: The function of this electronic device is to count all the discrete pulses comming from single channel analyser. It is connected to a preset timer unit in which the time for which the counting is to be done, is set before the counting starts. After the lapse of this pre-set time, after it is switched on, it automatically stops the counter.

C_1. Calibration of Instrument and Counting of Samples:

In order to compare the radioactivity of samples, the instrument has to be checked for its reliability, using a standard sample. For this, a standard sample was prepared using pitchblende. Two grams of impure pitchblende ore ground to -72 to +120 mesh size w was mounted and sealed in a disc shaped container. Before counting the samples, this standard was always counted under same geometric conditions of standard with respect to the Scintillator to check the instruments' reliability.

The various samples of sands were counted at three base voltages i.e., 0, 10 and 20 for such lengths of times so that the standard deviation on each observation due to counting was less than 10%, under the following settings of the instrument:-

1. Settings in the Pre-set Timer - 300 secs.

   Settings in the Decade scales.

   (i) Select scale - 1000

   (ii) Input switch - positive

   (iii) Disc Bias - 5

2. Settings in the Single Channel Analyser.

   (i) Window width - 0

   (ii) Discriminator levels used 0, 10, 20 volts

   (iii) Surplus counting.

3. Settings in the Amplifier.

   (i) Gain =A(B + C) = 50 when A = 500, B = 0, C = 0.1

   (ii) Select input - Negative

   (iii) Decay time - 4.4 secs.

4. Settings in High Voltage Units.

(i) Voltmeter - 800 volts.

Under these settings, the number of counts per minute per hundred grains for each samples were observed and are presented in the table No. VII and shown in the map. No. III

D. Distribution of Radioactivity in the Area:

The plot of radioactivity verses samples, indicates that the 20% of the samples show count rate of more than 60, 52% between 40-60 and those giving count rates less than 40 are 28%. It was, then, decided to study the physical features of the rivers and tributaries at the places from where the samples in each class were taken. Such a study indicates that the radioactive mineral content of sands vary along the course of river and the variation does not follow any distinct pattern. However, the following facts clearly emerge out.

1. Radioactivity less than 40 counts per minute in the area where there is confluence of two o r more streams.

2. Radioactivity is between 40 to 60 counts per minute at the places situated upstream just before the confluences of stream or at the places where small tributaries or streamlets just originate or at meanders of streams.

3. Radioactivity is more than 60 counts per minute where generally only few obstructions by some barriers whether natural or artificial are met with. The tributaries east and west of Mohand have relatively higher radioactivity.

RIVER SOLANI

Counts per Minute per 100 gms. of Sand Sample

$$C = \frac{S - B \pm \sqrt{S + B}}{A \times 2 \times 5}$$

Discriminater Levels in volts		
0	10	20
140.32 ± 4.5904	119.68 ± 4.0493	94.00 ± 3.7357
40.24 ± 3.6140	36.16 ± 3.1080	30.72 ± 2.9456
51.04 ± 3.6466	36.56 ± 3.1797	34.40 ± 2.9302
70.80 ± 3.6466	61.76 ± 3.4087	46.32 ± 3.1405
69.52 ± 3.8141	51.68 ± 3.2749	42.00 ± 3.0718
49.96 ± 3.6016	38.88 ± 3.2077	34.48 ± 2.9342
51.92 ± 3.7118	43.52 ± 3.2173	36.24 ± 3.0386
36.88 ± 3.6382	30.64 ± 3.0802	23.84 ± 2.9575
52.72 ± 3.7358	48.00 ± 3.2351	34.72 ± 3.0583
47.28 ± 3.6140	37.20 ± 3.1080	31.28 ± 2.9423
45.52 ± 3.7324	43.12 ± 3.2382	33.96 ± 3.0247
49.68 ± 3.7800	51.12 ± 3.3357	38.96 ± 3.0619

TABLE VII

ADIOMETRIC ANALYSES OF SAND SAMPLES OF RIVER SOLANI

FOR FIVE (5) MINUTES

Standard Sample: Discriminator Levels in volts: 0	Standard Sample: Discriminator Levels in volts: 10	Standard Sample: Discriminator Levels in volts: 20	Sand Sample (S): Discriminator Levels in volts: 0	Sand Sample (S): Discriminator Levels in volts: 10	Sand Sample (S): Discriminator Levels in volts: 20	Counts per Minute per 100 gms. of Sand Sample, $C = S - B \pm \sqrt{S+B}$: Discriminator Levels in volts: 0	Counts per Minute per 100 gms. of Sand Sample, $C = S - B \pm \sqrt{S+B}$: Discriminator Levels in volts: 10	Counts per Minute per 100 gms. of Sand Sample, $C = S - B \pm \sqrt{S+B}$: Discriminator Levels in volts: 20
62255	51805	37838	2524	2029	1679	140.32 ± 4.5904	119.68 ± 4.0493	94.00 ± 3.7357
62950	51653	37936	1272	981	870	40.24 ± 3.6140	36.16 ± 3.1080	30.72 ± 2.9456
64437	53817	38317	1682	1294	1210	70.24 ± 3.9883	59.52 ± 3.4355	57.68 ± 3.2975
61479	51769	37113	1264	1063	863	43.52 ± 3.5627	40.16 ± 3.2240	32.56 ± 2.9053
62255	51805	37835	1244	909	815	37.92 ± 3.5917	30.08 ± 3.0373	24.88 ± 2.9053
61479	51768	37113	1637	1292	1095	73.36 ± 3.8832	58.48 ± 3.4427	52.12 ± 3.1506
61813	52508	37848	1377	1095	900	53.88 ± 3.5322	47.19 ± 3.1237	34.62 ± 2.9780
61479	51769	37113	1304	913	776	46.72 ± 3.5090	28.16 ± 3.0746	24.80 ± 2.8509
62950	51653	37936	1360	1004	905	46.48 ± 3.6861	38.00 ± 3.1318	33.52 ± 2.9833
61479	51769	37112	1453	1185	940	58.64 ± 3.7289	49.92 ± 3.3426	39.36 ± 2.9970
61813	52508	37848	1212	856	721	38.96 ± 3.5204	26.72 ± 2.9686	19.20 ± 2.7732
64437	53817	38317	1190	911	873	32.88 ± 3.5718	32.56 ± 3.0088	30.72 ± 2.9518
63925	53321	38078	1268	1002	835	40.16 ± 3.5916	36.56 ± 3.1462	24.96 ± 2.5477
64437	53817	38317	1103	886	792	23.92 ± 3.4929	30.56 ± 2.9832	24.64 ± 2.8675
63931	52366	38290	1399	1047	875	51.04 ± 3.7161	42.32 ± 3.1644	28.88 ± 2.9833
61813	52508	37848	1179	865	760	36.32 ± 3.4905	27.44 ± 2.9805	22.32 ± 2.8177
61479	51769	37113	1340	1086	919	49.60 ± 3.7107	42.00 ± 3.2463	37.04 ± 2.6436
61479	5169	37113	1283	1007	880	45.04 ± 3.5801	35.68 ± 3.1672	33.92 ± 2.9241
61813	52608	37848	1245	975	807	41.60 ± 3.5504	36.24 ± 3.0952	26.08 ± 2.8707
62294	52814	37371	1321	964	865	45.52 ± 3.6424	34.16 ± 3.1001	29.60 ± 2.9497
63931	52366	38290	1261	928	796	40.00 ± 3.5231	32.80 ± 3.0123	22.50 ± 2.8403
61813	52508	37848	1661	1476	1218	74.88 ± 3.9074	76.32 ± 3.5759	58.96 ± 3.2975
61813	52508	37848	1855	1262	1061	74.40 ± 3.9020	59.20 ± 3.3790	46.40 ± 3.1440
63328	52279	37036	1337	1087	898	50.80 ± 3.6124	46.00 ± 3.1988	33.84 ± 2.9641
63925	53321	38078	1373	1068	905	49.36 ± 3.6973	41.84 ± 3.1288	30.56 ± 3.0226
64437	53817	38317	1291	917	740	38.96 ± 3.6618	29.36 ± 3.0640	20.08 ± 2.5041
63931	52366	38290	1226	978	766	36.20 ± 3.5660	36.80 ± 3.0937	20.16 ± 2.8622
64437	53817	38317	1573	1219	1001	61.52 ± 3.9020	53.52 ± 3.3643	40.24 ± 3.0974
51479	51769	37113	1167	826	754	34.96 ± 3.4657	21.12 ± 2.9778	25.84 ± 2.7822
51479	51769	37113	1384	1098	954	53.12 ± 3.3983	42.96 ± 3.2582	39.84 ± 3.0040
51479	51769	37113	1356	1018	886	51.04 ± 3.6466	36.56 ± 3.1797	34.40 ± 2.9302
31813	52508	37848	1610	1294	1060	70.80 ± 3.6466	61.76 ± 3.4087	46.32 ± 3.1405
33328	52279	37036	1571	1161	1000	69.52 ± 3.8141	51.68 ± 3.2749	42.00 ± 3.0718
51479	51769	37113	1307	1047	887	49.96 ± 3.6016	38.88 ± 3.2077	34.48 ± 2.9342
52294	52814	37371	1401	1081	948	51.92 ± 3.7118	43.52 ± 3.2173	36.24 ± 3.0386
54437	53817	38317	1268	933	788	36.88 ± 3.6388	30.64 ± 3.0802	23.84 ± 2.9575
33931	52366	38290	1420	1188	948	52.72 ± 3.7356	48.00 ± 3.2351	34.72 ± 3.0583
31813	52508	37848	1316	987	872	47.28 ± 3.6140	37.20 ± 3.1080	31.28 ± 2.9423
54437	53817	38317	1373	1089	951	45.52 ± 3.7324	43.12 ± 3.2382	33.96 ± 3.0247
54437	53817	38317	1425	1189	976	49.68 ± 3.7800	51.12 ± 3.3357	38.96 ± 3.0619

4. Only one sample out of a total of 40, shows exceptionally high radioactivity (140 counts per minute per 100 gms of sample.

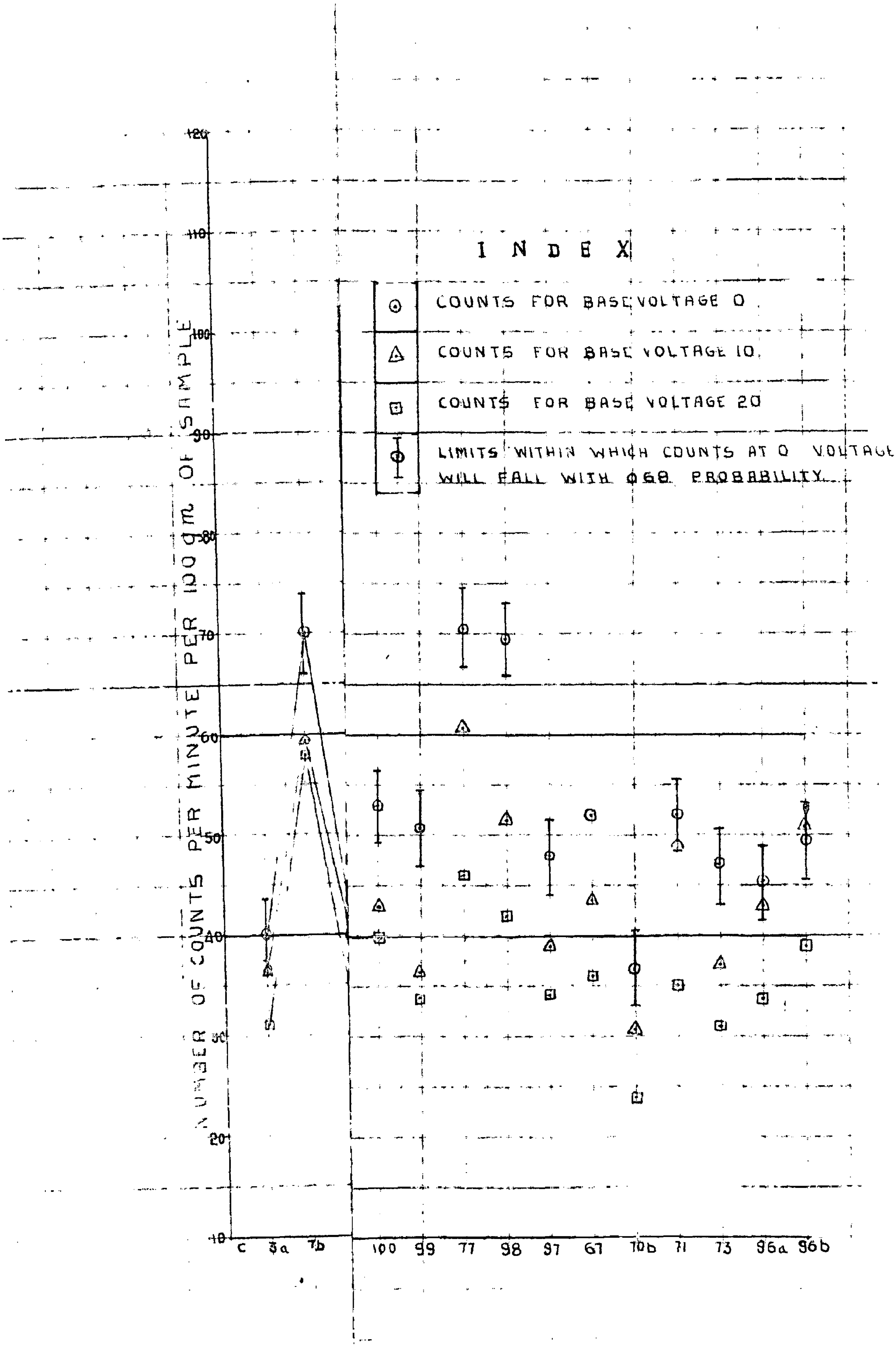
I. Radioactivity distribution in relation to grain size:

Sample 1c which gave the maximum radioactivity, was considered best for such study and it were the various sieve fractions of this samples that were counted separately. The results of such analysis is given in the table No.VIII

TABLE VIII

S.No.	Mesh No.	Counts per minute per 100 gms.
1.	52	47
2.	72	48
3.	120	72
4.	150	267
5.	170	588
66	200	830
7.	-200	1182

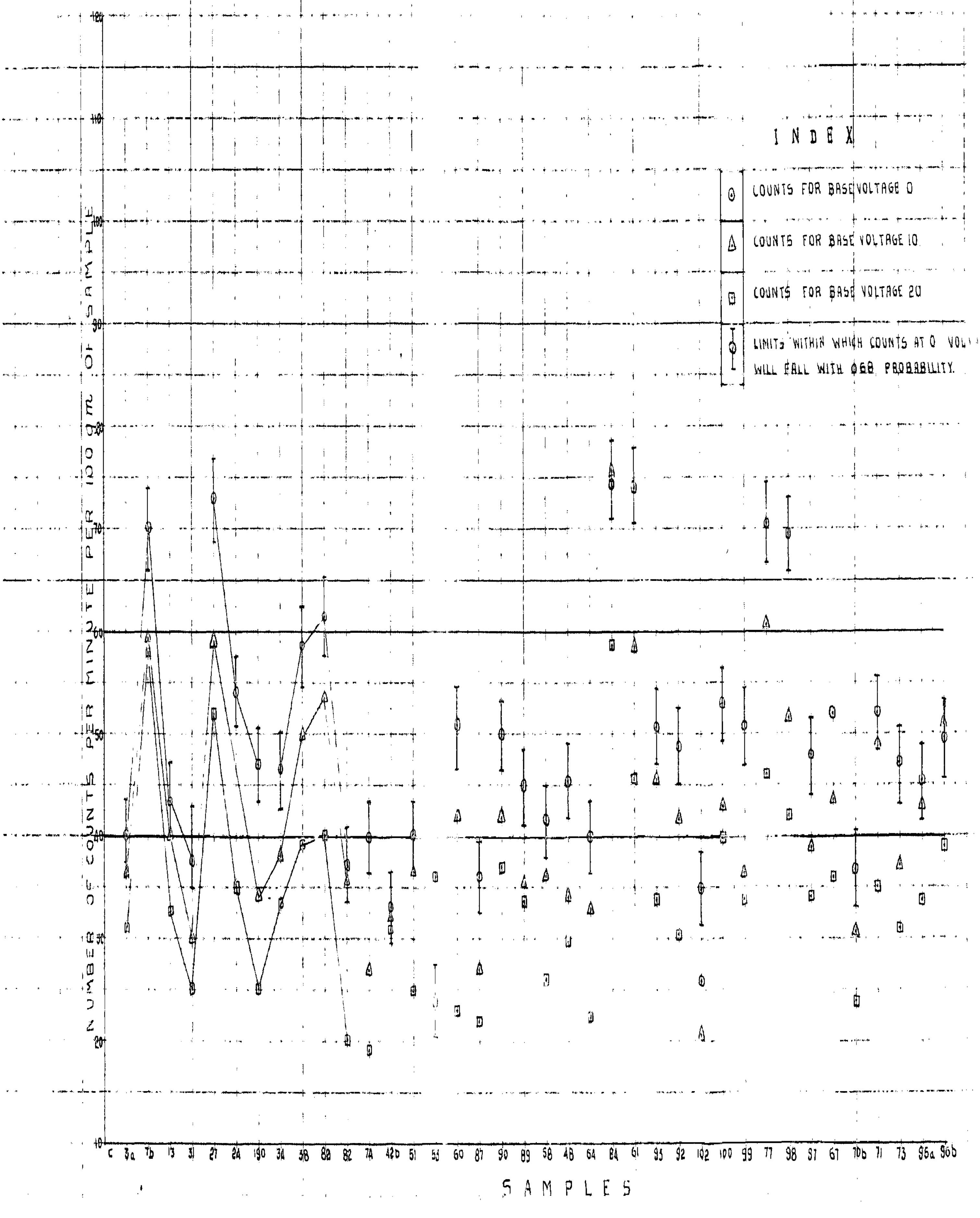
It is observed from the above table that the specific activity of fractions increase with the decrease in the particle size. This data is in agreement with the reported one. However, in this investigation particle size lesser than +300 have not been studied. The rate of increase of activity is more when the particle becomes finer than 120 mesh in comparison to particle coarser than this size.



INDEX
COUNTS FOR BASE VOLTAGE 0
COUNTS FOR BASE VOLTAGE 10.
COUNTS FOR BASE VOLTAGE 20
LIMITS WITHIN WHICH COUNTS AT 0 VOLTAGE WILL FALL WITH .68 PROBABILITY.
NUMBER OF COUNTS PER MINUTE PER 100 gm. OF SAMPLE
120
110
100
90
80
70
60
50
40
30
20
10
C
3a
7b
100
99
77
98
97
67
70b
71
73
96a
96b

Graph No. 19

RADIOACTIVITY DISTRIBUTION IN SAND SAMPLES.



F. Identification of Nature of Radioactivity:

Radioactive materials are identified from their characteristic radiations and energies given off by isotopes of elements present in a sample. Therefore, by comparing the gamma ray spectrum of unknown sand sample with that of known samples of Pitchblende and Monazite containing traces of Uranium, the nature of the r radioactivity could be predicted. Table No. IX . A perusal of the table shows that the gamma ray spectrum of heavies in the fraction + 150 - 120 mesh of sand sample lc agreed more closely in nature with that of pitchblende sample and hence it may be that the radioactivity in the sand samples is due to the presence of uranium and its daughter products. This result is in conformity with that of reported by Christie and Sarswat (1966). However, when samples in general were considered, the radioactive element is not so very close. It may be due to partial separation of various sub-species.

Table - IX
Compasison of Gamma ray spectrum of Pitchblende, Monazite and the sand sample No. lc/150

Sample	Counts per minute at Base voltages			Gamma Ray Spectrum (Ratio of Base Voltages)	
	0	10	20	0/20	10/20
Pitchblende	60192	53780	38421	1.56	1.39
Monazite	36843	32960	27068	1.36	1.21
Sample lc/150	43	35.5	27.5	1.56	1.3

CHAPTER – VI

HEAVY MINERALS AND THEIR SIGNIFICANCE

Introduction:

Despite their small amounts in sands, the heavy minerals have been studied with two views in mind – firstly as indicators of provenence and secondly as evidences of radioactivity.

The sand samples that gave significant radioactive counts were selected for heavy mineral studies. Each of the selected samples were analysed for +120 + 150 fraction through B.S sieves. Using bromoform, the heavy minerals from each fractions of samples were then separated and mounted on slides for microscopic examination. The minerals identified are giveni in Table No. X . The various rough estimates for each sample are also indicated in the same Table.

Table X

Heavy minerals	Samples with their estimates of Heavy mineral													
	1c/72	1c/120	1c/150	7b/120	27/120	38/120	61/120	80/120	77/120	98/120	84/120	67/120	71/120	73/12
1. Garnet	C	C	C	C	C	C	C	c	C	C	C	c	c	c
2. Kyanite	c	c	c	c	c	c	c	c	c	c	c	c	c	c
3. Opaque minerals	C	C	C	C	C	c	c	C	C	c	c	C	C	C
4. Tourmaline	s	s	r	s	s	s	s	s	s	S	S	s	s	s
5. Staurolite	s	s	s	S	s	s	s	S	S	s	s	S	s	s
6. Topaz	r	r	r	R	r	r	r	R	r	R	r	r	r	r
7. Rutile	R	S	s	R	R	r	S	R	R	r	R	R	R	R
8. Hornblende	R	R	R	r	r	R	R	r	r	R	r	R	R	R
9. Epidote	R	R	R	r	r	r	r	R	R	R	r	R	R	R
10. Zircon	r	r	c	r	R	r	r	r	R	R	r	r	r	r
11. Chlorite	–	–	–	–	–	–	–	R	–	–	–	R	R	R
12. Sphene	–	–	–	R	–	–	–	–	–	–	–	R	–	–

Where C – very common; c – Common; R – very rare; r – Rare
S – very sparse; s – Sparse.

General Characters of the Heavy Minerals:

1. Garnet: Mostly pinkish and occasionally colourless, garnet occurs in irregular subrounded form with high relief. But a few grains show perfect crystalline form. The inclusions of quartz are common. The surface is pitted with very manyf fractures.

Possible sources of derivation: The garnet might have come from the pegmatites or high rank metamorphic rock.

2. Kyanite: Colourless with high relief, the Kyanite occurs in bladed to somewhat tabular forms. The edges are sharp. The prismatic forms are sometimes very much deformed. The cross cleavages are most predominent. The grains are subangular prismatic.

Possible sources of derivation: The kyanite is essentially a high grade metamorphic mineral associated specially with mica schists and gneisses and might have been derived from these rocks.

3. Opaque Minerals: The opaque minerals are irregular in form but are subrounded in nature. Black to brownish grey in colour, the blackish variety shows some alteration, observed as a white mineral under cross nicols. This white mineral may be leucoxene and hence the black mineral can be named as Ilmenite. The opaque minerals ~~which~~ appearing somewhat brownish chocolate coloured, may be hematite or limonite. Ilmenite can be derived from Igneous rocks specially basic and ultrabasics.

4. Tourmaline: It is brown coloured, With variedterminations. PRISMATIC FORM is predominent. The pleochroism is characteristic.

Striations parallel to length of prism is also sometimes marked The inclusion in the form of needles are also met with. These inclusions may be of zircon and rutile. Rarely blue tourmalines are found.

Tourmaline might have come from Pneumatolitic rocks, acid igneous rocks, pegmatites, schists and phyllites. But according to Krynine, the brown tourmaline characterises low rank metamorphism. The blue tourmaline might have come from pegmatite.

5. Staurolite: Irregular in shape and sub-angular to angular at termination, the staurolite has brownish yellow to straw yellow colour. It shows characteristic pleochroism with varying intensities. Sometimes inclusions of quartz are metm with.

The staurolite has been probably derived from schists or contact metamorphic rocks. In any case it belongs to high rank metamorphic rocks.

6. Topaz: Colourless, very much irregular forms are observed. It occurs as angular to sub-angular grains with high relief. It shows somewhat pitted appearance. Under cross nicols topaz gives mostly grey yellow to high second order blue, gree n colours. Some of the grains of topaz show pleochroic halos.

Topaz can be derived from Granite gneisses and other contact metamorphic rocks.

7. Rutile: It occurs in irregular form. The grains are angular to sub-angular at terminations. The colour of rutile

grains is dark pinkish red and under cross nicols its interference colours are masked by the body colour. The pleochroic halos are also observed in some grains.

Rutile is commonly found in Acid Igneous rocks, crystalline metamorphic rocks. Frequently it can be derived in situ from decomposition of ilmenite.

8. Hornblende: Dark green coloured hornblende has its colour density greatest at the centre of grains which occur in sub-rounded tabular form. The pleochroism (from pale to dark green) is only noticeable near the boundaries of grains. Some grains show prismatic cleavage, the extinction angle by which come out to be near 16^{o}. The interference colours are second order green, blue, red, yellow. Some of the grains show alteration probably into chlorite.

The hornblende could be derived from Igneous and Metamorphic rocks - specially from granites, syenite, diorites and volcanic equivalents and Hornbelnde schists.

9. Epidote: Irregular rather angular to subangular dark green coloured grains of epidote show brilliant high order interference colours such as green, purple red.

It can be derived from crystalline metamorphics, especially altered impure limestone. Also, it can come from altered igneous rocks originally rich in ferro-magnesium minerals.

10. Zircon: It occurs in small colourless, subrounded grains. A few grains show perfect crystalline forms. The relief

of these grains is very characteristically high. The fractures are also common. It occurs both as independent grains as well as inclusion in some other minerals.

It can be derived from acid and intermediate igneois rocks. Less commonly it occurs in schists and limestones.

11. Sphene: Brownish in colour, it occurs in lozenge shape. It is very much pitted. Its interference colours are masked by its body colour.

It can be derived from granites, intermediate igneous rocks, metamorphic rocks such as gneisseses, schists and altered limestones.

12. Chlorite: Few green coloured grains are found in the form of flaky minorals. Its grey interference colour of the first order is very characteristic.

It can be derived from igneous as well as metamorphic rocks. It can also come as alteration product of hornblende and biotite.

Provenence of Solani Sands:

The source rocks of Solani sands as inferred from the grain size studies in the Chapter IV, must be loosely cemented, medium grained well sorted sand rocks. The heavy minerals of Solani sands are comparable to those found in the sand rocks of Siwaliks. According to Raju (1963), the presence of garnet and tourmaline marks the Lower Siwaliks, while kyanite is very characteristic of

Middle Siwaliks. The sillimanite and andalusite along with Hornblende and heavies of Lower and Middle Siwaliks mark the Upper Siwaliks. All these minerals are present almost in the same shape and form in the sands of Solani river system. Hence it can be concluded that the source rocks of these sands may belong to Middle and Lower Siwaliks. The Upper Siwaliks have very little contribution because, the heavy minerals of it with the exception of hornblende are all together absent in the sands and even the hornblende has very little percentage in comparison to other minerals. But the facts that the rocks of lower Siwaliks are not exposed near Mohand, and that the tributaries of Solani river system are mostly confined to the Middle Siwaliks, appeal the author to conclude that the source rocks of these sands belong almost entirely to Middle Siwaliks and to a lesser extent to the upper Siwaliks.

Heavy Minerals and Radioactivity:

Radioactive minerals are generally the heavy minerals. Hence the heavies of +120 - 72 fractions of sand samples were separated and were put to microscopic examination. The radioactivity was evidenced under microscope by the presence of zircon in almost all the slides. Besides this, the pleochroic halos in Rutile (or Baddeleyite), Topaz and Tourmaline are also observed. In some of the prismatic brown tourmalines, peobably zircon appears as needle. One grain of staurolite (Plate No.) was also found to contain pleochroic halos. The percentage of zircon in most of the slides is not more than 0.5 to 1% of the total heavy minerals present. It can, thus, be concluded that although the radioactivity is largely due to the uranium content in certain heavy minerals, but the possibilities of the occurrence of thorium or any other radioactive element cannot be ruled out at this stage. There certainly exist a relation between the amount of heavy minerals and the radioactive counts. Samples with high count rate have a higher percentage of heavy minerals. However, exact correlation between the heavy minerals and radioactivity can be made only after a careful separation of individual heavy minerals and their chemical and radiometric analyses.

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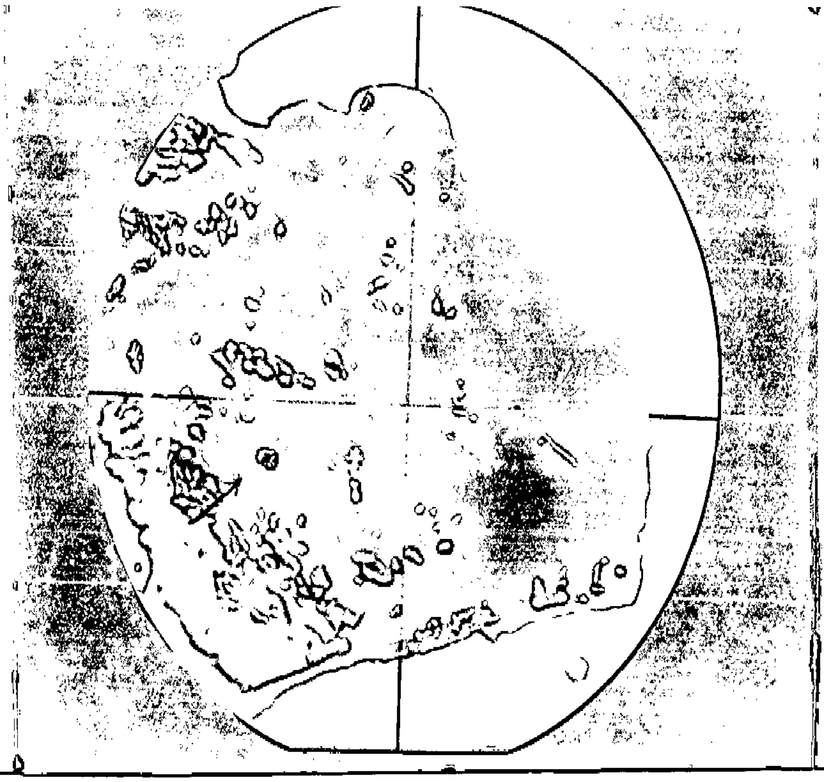

PHOTOMICROGRAPH - 1. Pleochroic Halo in Staurolite grain

PHOTOMICROGRAPH - 2. A Crystal of Zircon

PHOTOMICROGRAPH - 3. Kyanite grain showing inclusions of Rutile

PHOTOMICROGRAPH - 4. Heavy minerals: G - Garnet ; K - Kyanite ; O - Opaque minerals ; Z - Zircon.

CHAPTER - VII

SUMMARY AND CONCLUSIONS

The present work was taken up to investigate the radio activity of the sands of River Solani from the source upto Roorkee and the effect of grain size on the radioactivity. The heavy mineral suits of the sand were also examined to find the minerals in which uranimum has been capured. The regions through which Solani river system pass are occupied by Siwalik rocks, Bhabar, Tarai and Gangetic alluvium. The lithology of the rocks is clay, sandy clay, gravels, silts, sands. The origin of R. Solani and its tributaries is in Siwalik hills of the Saharanpur and Dehra Dun districts.

Various methods of sampling techniques were analysed and it was found that for the present study the method of systematic Grid Sampling would be most suitable. The samples were collected at the intervals of 3/4th to a mile's distance. Proper care was taken to avoid any contamination either due to the terrace soil or due to the cosmic ray activities. The method employed to collect the samples was so designed that the same sedimentological unit would be sampled throughout the length of the river system.

Mechanical analyses of samples, thus collected were done in the laboratory using B.S.S 25, 36, 52, 72, 120, 150, 170, 200 and 240 mesh sieves. The cummulative curves were drawn on the basis of data collected in this manner.

On the basis of cummulative curves, various grain size parameters were calculated. A discussion on these parameters and their significance has already been done in Chapter - IV. The main findings were that the

(1) The sands of the river are fine to medium grained size and their sorting well to moderately well. Since the transportation of these sands was small, it was concluded that the source rocks of these sands must be fine grained, well sorted loosely cemented sand rocks.

(2) The confluences of various tributaries can be predicted wherever, negative skewness values are observed in the area. Most of the material at the confluences are coarser than the average grain size.

(3) Based on the Kurtosis values, it was inferred that velocity fluctuations of streams operate for very short period of time.

(4) With the transport, the grain size in general, decreas in the river system. The sorting becomes poorer in the northern most tributaries due to unsteady flow of the water near the foothill zone. This again confirms, the conclusions derived in (1).

(5) Variońs relations between the grains size parameters that have been derived are given below:

(a) $SK_1 = F\left(\frac{\Delta GM}{\Delta \sigma_1}\right)$

(b) $\sigma_1 = F\left(\frac{\Delta GM}{\Delta SK_1}\right)$

(c) $GM = F\left(\frac{\Delta \sigma_1}{\Delta SK_1}\right)$

Where SK = Skewness

GM = Mean Grain Size

= Measure of sorting

Δ = Difference operater

F = Function

The last relation has been fully worked out as -

$$\frac{\Delta\sigma_1}{\Delta SK_1} = -33\text{-}12185382 + 32.4246619(GM) + 7.668814415(GM)^2$$

The significance of this relation has been briefly dealt in the chapter No. IV.

(6) Deposit of different environmental conditions can be discriminated using the following equation originally given by Sahu (1964) but modified in the light of present data.

$$Y = 0.7215 GM - 0.4030\sigma_1^2 + 6.7322\ SK_1$$

if $\bar{Y} < 7.5$, the deposition at the river confluence is predicted.

and if $\bar{Y} > 7.5$, the deposition under uniform velocity conditions is indicated.

The radiometric analysis of Solani sands have given the following results:

1. The Solani sands do have radioactivity higher than that of background but its estimate due to non availability of a standard sample could not be made.

2. Radioactivity is minimum at the confluences of various tributaries.

3. Radioactivity of intermediate strength is observed at places just before the confluences or at meanders or at places near foothills where they originate.

4. Radioactivity is maximum at places where some natural or

artificial bariersto the flow of water occur.

5. The grain size has been shown to have an inverse relation with the radioactivity i.e. the finer the size of the particles, the greater will be the radioactivity. This relation is further confirmed by the low level radioactivity present at the confluences of tributaries where most of the material is coarser.

6. Based on the gamma ray spectrum it has been concluded that the cause of the radioactivity in the sands is a radioactive mineral which has more affinity towards uranium rather than thorium.

7. The heavy minerals present in the sands are Garnet, Kyanite, opaque minerals (Ilmenite, hematite, limonite), Staurolite, Tourmaline Topaz, Rutile, Epidote, Hornblende, Zircon, Chlorite and Sphene. Based on these minerals and their characters under microscope, it is concluded that the source of these sands are the Siwalik rocks.

8. The Finer the sieve fraction, the greater was the amount of heavy minerals and the higher was the radioactivity. This is confirmed by the greater percentages of radioactive minerals in the finer fractions.

9. The evidences of radioactivity in the heavy minerals are the presence of Zircon, the pleochroic haloes in Staurolite, Topaz Rutile and probably Baddeyelite. However, the possibility of monazite cannot be ruled out.

Based on the radioactivity distribution in the area and the heavy minerals, it is concluded that the source of the radioactivity of sands lies in the Siwalik rocks near Mohand and it is this region that has to be further investigated.

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REPORTS OF SIEVE ANALYSES

A.K. Awasthi

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 1c

Locality – Main Solani River

Name of the Sieve – B.S.Sieve

Mass of the sample – 50 gms.

Method of shaking – Automatic shaker

Time of shaking – 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ϕ scale				
18	0.85344	0.2286	0.220	0.221	0.442	0.442
25	0.59944	0.7418	0.074	0.074	0.148	0.590
52	0.29464	1.7630	1.840	1.849	3.698	4.770
72	0.21082	2.2460	9.645	9.694	19.388	24.158
120	0.12446	3.0066	27.275	27.414	54.828	78.986
150	0.10414	3.2642	5.620	5.649	11.298	90.286
170	0.08890	3.4916	1.540	1.548	3.096	93.380
200	0.07620	3.7140	1.752	1.761	3.522	96.902
240	0.06350	3.9775	0.700	0.703	1.406	98.308
Pan	<.06350	<3.9775	0.840	0.844	1.688	99.996
TOTAL			49.746	49.998		
LOSS IN WEIGHT			0.254			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 3a

Locality - Main Solani River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening: Millimeter	Screen Opening: In Φ scale	Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% Wt. ingms.	Cummulative retained Wt.% in gms.
25	0.59944	0.7418	0.010	0.010	0.020	0.020
36	0.42164	1.2460	0.050	0.050	0.100	0.120
52	0.29464	1.7630	0.547	0.548	1.096	1.216
72	0.21082	2.2460	5.595	5.603	11.206	12.422
120	0.12446	3.0066	30.290	30.331	60.662	73.084
150	0.10414	3.2642	7.975	7.986	15.972	89.056
170	0.08890	3.4916	1.880	1.882	3.764	92.820
200	0.07620	3.7140	2.005	2.008	4.016	96.836
240	0.06350	3.9775	0.655	0.656	1.312	98.148
Pan			0.925	0.926	1.852	100.000
T O T A L			49.932	50.000		
LOSS IN WEIGHT			0.068			

(ANALYST)

REPORT ON SIEVE ANALYSIS

Sample No. 7b

Locality - Main Solani River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale.				
25	0.59944	0.7418	0.080	0.080	0.160	0.160
36	0.42164	1.2460	0.582	0.583	1.166	1.326
52	0.29464	1.7630	5.560	5.565	11.130	12.456
72	0.21082	2.2460	20.290	20.311	40.622	53.078
120	0.12446	3.0066	18.990	19.007	38.014	91.092
150	0.10414	3.2642	2.425	2.427	4.854	95.956
170	0.08890	3.4916	0.542	0.542	1.084	97.030
200	0.07620	3.7140	0.718	0.719	1.438	98.468
240	0.06350	3.9775	0.300	0.300	0.600	99.068
Pan			0.465	0.465	0.930	99.998
T O T A L			49.954	49.999		
LOSS IN WEIGHT			0.046			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.13

Locality - Main Solani River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr.Wt. % retained in gms.	Cummulative retained Wt.% in gms
	Millimeter	In ϕ scale				
25	0.59944	0.7418	0.027	0.027	0.054	0.054
36	0.42164	1.2460	0.155	0.158	0.316	0.370
52	0.29464	1.7630	1.432	1.440	2.880	3.250
72	0.21082	2.2460	13.487	13.567	27.134	30.384
120	0.12446	3.0066	29.532	29.708	59.416	89.800
150	0.10414	3.2642	3.137	3.155	6.310	96.110
170	0.08890	3.4916	0.662	0.666	1.332	97.442
200	0.07620	3.7140	0.637	0.641	1.282	98.724
240	0.06350	3.9775	0.327	0.329	0.658	99.382
Pan			0.307	0.309	0.618	100.000
	T O T A L		49.703	50.000		
	LOSS IN WEIGHT		0.297			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 31

Locality - Main Solani River

Name of the Sieve - B.S. Sieve

Mass of the sample - 50 gms.

Method of Shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen opening: Millimeter	Screen opening: In φ scale	Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt. % retained in gms.	Cummulative retained Wt.% in gms.
25	0.59944	0.7418	0.110	0.110	0.220	0.220
36	0.42164	1.2460	0.537	0.537	1.074	1.294
52	0.29464	1.7630	4.595	4.599	9.198	10.492
72	0.21082	2.2460	16.712	16.728	33.456	43.948
120	0.12446	3.0066	21.206	21.226	42.452	86.400
150	0.10414	3.2642	3.979	3.983	7.966	94.366
170	0.08890	3.4916	0.871	0.872	1.744	96.110
200	0.07620	3.7140	0.972	0.973	1.946	98.056
240	0.06350	3.9775	0.380	0.380	0.760	98.816
Pan			0.590	0.590	1.180	99.996
TOTAL			49.951	49.998		
LOSS IN WEIGHT			0.049			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.27

Locality - Main Solani River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of Shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained q in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ɸ scale				
25	0.59944	0.7418	0.040	0.040	0.080	0.080
36	0.42164	1.2460	0.165	0.166	0.332	0.412
52	0.29464	1.7630	1.875	1.886	3.772	4.184
72	0.21082	2.2460	14.480	14.564	29.128	33.312
120	0.12446	3.0066	24.730	24.874	49.748	83.060
150	0.10414	3.2642	5.050	5.079	10.158	93.218
170	0.08890	3.4916	0.850	0.855	1.710	94.928
200	0.07620	3.7140	1.270	1.277	2.554	97.482
240	0.06350	3.9775	1.250	1.257	2.514	99.996
Pan						
T O T A L			49.710	49.998		
LOSS IN WEIGHT			0.290			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.24

Locality - Main Solani River

Name of the Sieve - B.S.Sieve

Mass of the Sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Φ scale				
25	0.59944	0.7413	0.002	0.002	0.004	0.004
36	0.42164	1.2460	0.027	0.027	0.054	0.058
52	0.29464	1.7630	0.200	0.201	0.402	0.460
72.	0.21082	2.2460	2.870	2.885	5.770	6.230
120	0.12446	3.0066	30.737	30.904	61.808	68.038
150	0.10414	3.2642	9.272	9.322	18.644	86.682
170	0.08890	3.4916	1.860	1.870	3.740	90.422
200	0.07620	3.7140	2.450	2.466	4.926	95.348
240	0.06350	3.9775	0.962	0.967	1.934	97.282
Pan			1.250	1.357	2.714	99.996
T O T A L			49.730	49.998		
LOSS IN WEIGHT			0.270			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.19a

Locality - Main Soleni River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø Scale				
25	0.59944	0.7418	0.627	0.629	1.258	1.258
36	0.42164	1.2460	2.558	2.565	5.130	6.388
52	0.29464	1.7630	12.130	12.163	24.326	30.714
72	0.21082	2.2460	19.475	19.528	39.056	69.770
120	0.12446	3.0066	11.675	11.707	23.414	93.184
150	0.10414	3.2642	1.385	1.389	2.778	95.962
170	0.08890	3.4916	0.387	0.388	0.776	96.738
200	0.07620	3.7140	0.567	0.568	1.136	97.874
240	0.06350	3.9775	0.300	0.301	0.602	98.476
Pan			0.760	0.762	1.524	100.000
T O T A L			49.864	50.000		
LOSS IN WEIGHT			0.136			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.34

Locality - Main Solani River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic Shaker

Time of shakingm - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Coorrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ϕ scale				
25	0.59944	0.7418	0.060	0.060	0.120	0.120
36	0.42164	1.2460	0.780	0.780	1.560	1.680
52	0.29464	1.7630	8.507	8.508	17.016	18.696
72	0.21082	2.2460	22.137	22.190	44.380	63.076
120	0.12446	3.0066	16.040	16.042	32.084	95.160
150	0.10414	3.2642	1.012	1.012	2.024	97.184
170	0.08890	3.4016	0.355	0.355	0.710	97.894
200	0.07620	3.7140	0.440	0.440	0.830	98.774
240	0.06350	3.9775	0.187	0.137	0.374	99.148
Pan			0.425	0.425	0.850	99.998
T O T A L			49.993	49.999		
LOSS IN WEIGHT			0.007			

(ANALYST)

REPORT ON SIEVE ANALYSIS

Sample No. 38

Locality - Main Solani

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	2.072	2.083	4.166	4.166
36	0.42164	1.2460	4.382	4.405	8.810	12.976
52	0.29464	1.7630	13.267	13.338	26.676	39.652
72	0.21082	2.2460	19.547	19.651	39.302	78.954
120	0.12446	3.0066	9.332	9.382	18.764	97.718
150	0.10414	3.2642	0.750	0.754	1.508	99.226
170	0.08890	3.4916	0.115	0.116	0.232	99.458
200	0.07620	3.7140	0.115	0.116	0.232	99.690
240	0.06350	3.9775	0.055	0.055	0.110	99.800
Pan			1.000	0.100	0.200	100.000
T O T A L			49.735	50.000		
LOSS IN WEIGHT			0.265			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 42a

Locality – Rivers East of Lalakhala   Name of the Sieve – B.S.Sieve

Mass of the sample – 50 gms.   Method of shaking – Automatic shaker

Time of shaking – 10 minutes   Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Commulative retained Wt.% in gms.
	Millimeter	In ϕ scale.				
25	0.59944	0.7418	1.730	1.738	3.476	3.476
36	0.42164	1.2460	6.112	6.140	12.280	15.756
52	0.29464	1.7630	21.580	21.678	43.356	59.112
72	0.21082	2.2460	15.787	15.859	31.718	90.830
120	0.12446	3.0066	3.126	3.139	6.278	97.108
150	0.10414	3.2642	0.527	0.529	1.058	98.166
170	0.08890	3.4916	0.205	0.206	0.412	98.578
200	0.07620	3.7140	0.250	0.251	0.502	99.080
240	0.06350	3.9775	0.088	0.088	0.176	99.256
Pan			0.370	0.372	0.744	100.000
T O T A L			49.774	50.000		
LOSS IN WEIGHT			0.226			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 51

Locality - Rivers East of Lalo-Khala

Name of the Sieve - B.S. Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Commulative retained Wt.% in gms.
	Millimeter	In φ scale				
25	0.59944	0.7418	1.760	1.766	3.532	3.532
36	0.42164	1.2460	2.5[illegible]	2.569	5.138	8.670
52	0.29464	1.7630	6.560	6.583	13.166	21.836
72	0.21082	2.2460	19.586	19.653	39.306	61.142
120	0.12446	3.0066	16.015	16.071	32.142	93.284
150	0.10414	3.2642	1.810	1.816	3.632	96.916
170	0.08890	3.4916	0.422	0.423	0.846	97.762
200	0.07620	3.7140	0.472	0.474	0.948	98.710
240	0.06350	3.9775	0.213	0.214	0.428	99.138
Pan			0.430	0.431	0.862	100.000
T O T A L			49.827	50,000		
LOSS IN WEIGHT			0.173			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.46(a+b)

Locality - Solani Extended

Mass of the sample - 50 gms.

Time of shaking - 10 minutes

Name of the Sieve - B.S.Sieve

Method of shaking - Automatic shaker

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms
	Millimeter	In Ø scale				
25	0.59944	0.7418	0.385	0.385	0.770	0.770
36	0.4216 4	1.2460	1.362	1.362	2.724	3.494
52	0.29464	1.7630	8.995	8.999	17.998	21.492
72	0.21082	2.2460	20.710	20.719	41.438	62.930
120	0.12446	3.0066	14.445	14.451	28.902	91.832
150	0.10414	3.2642	1.830	1.831	3.662	95.494
170	0.08890	3.4916	0.522	0.522	1.044	96.538
200	0.07620	3.7140	0.580	0.580	1.160	97.698
240	0.06350	3.9775	0.252	0.252	0.504	98.202
Pan			0.897	0.897	1.794	99.996
	T O T A L		49.978	49.998		
	LOSS IN WEIGHT		0.022			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 82

Locality – Solani Extended

Name of the Sieve – B.S. Sieve

Mass of the sample – 50 gms.

Method of shaking – Automatic shaker

Time of shaking – 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulativ retained Wt.%in gms
	Millimeter	In Ø scale				
25	0.59944	0.7418	0.355	0.355	0.710	0.710
36	0.42164	1.2460	1.245	2.246	2.492	3.202
52	0.29464	1.7630	7.660	7.669	15.338	18.540
72	0.21082	2.2460	22.052	22.077	44.154	62.694
120	0.12446	3.0066	15.635	15.653	31.306	94.000
150	0.10414	3.2642	1.500	1.502	3.004	97.004
170	0.08890	3.4916	0.362	0.362	0.724	97.728
200	0.07620	3.7140	0.382	0.382	0.764	98.492
240	0.06350	3.9775	0.200	0.200	0.400	98.892
Pan			0.552	0.553	1.106	99.998
	TOTAL		49.943	49.999		
	LOSS IN WEIGHT		0.057			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.80

Locality - Solani Extended

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ø scale				
25	0.59944	0.7418	0.240	0.241	0.482	0.482
36	0.42164	1.2460	1.050	1.056	2.112	2.594
52	0.29464	1.7630	7.620	7.661	15.322	17.916
72	0.21082	2.2460	19.457	19.562	39.124	57.040
120	0.12446	3.0066	17.100	17.192	34.384	91.424
150	0.10414	3.2642	2.305	2.317	4.634	96.058
170	0.08890	3.4916	0.670	0.674	1.348	97.406
200	0.07620	3.7140	0.635	0.638	1.276	98.682
240	0.06350	3.9775	0.255	0.256	0.512	99.194
Pan			0.400	0.402	0.804	99.998
T O T A L			49.732	49.999		
LOSS IN WEIGHT			0.268			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.102

Locality - Shahjahanpur Rao

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ∅ scale				
25	0.59944	0.7418	3.490	3.510	7.020	7.020
36	0.42164	1.2460	5.720	5.753	11.506	18.526
52	0.29464	1.7630	15.861	15.952	31.904	50.430
72	0.21082	2.2460	15.087	15.174	30.348	80.778
120	0.12446	3.0066	7.405	7.447	14.894	95.672
150	0.10414	3.2642	0.895	0.900	1.800	97.472
170	0.08890	3.4916	0.250	0.251	0.502	97.974
200	0.07620	3.7140	0.300	0.302	0.604	98.578
240	0.06350	3.9775	0.190	0.191	0.382	98.960
Pan			0.515	0.518	1.036	99.996
TOTAL			49.703	49.998		
LOSS IN WEIGHT			0.287			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.100

Locality - NW Tributary to Shahjanpur Rao

Name of the Sieve - B.S.Sieve

Mass of the samole - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7413	0.330	0.331	0.662	0.662
36	0.42164	1.2460	0.935	0.938	1.876	2.538
52	0.29464	1.7630	3.672	3.684	7.368	9.906
72	0.21082	2.2460	10.207	10.241	20.482	30.388
120	0.12446	3.0066	19.225	19.289	38.578	68.966
150	0.10414	3.2642	6.040	6.060	12.120	81.086
170	0.08890	3.4916	1.805	1.811	3.622	84.708
200	0.07620	3.7140	2.700	2.709	5.418	90.126
240	0.06350	3.9775	2.140	2.147	4.294	94.420
Pan			2.780	2.789	5.578	99.998
T O T A L			49.834	49.999		
LOSS IN WEIGHT			0.166			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.99

Locality - NE Tributary to Shahjahanpur Rao

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt. % retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	0.270	0.270	0.540	0.542
36	0.42164	1.2460	0.720	0.721	1.442	1.982
52	0.29464	1.7630	3.855	3.859	7.718	9.700
72	0.21082	2.2460	13.185	13.200	26.400	36.100
120	0.12446	3.0066	22.125	22.151	44.302	80.402
150	0.10414	3.2642	4.480	4.485	8.970	89.372
170	0.08890	3.4916	1.400	1. 402	2.804	92.176
200	0.07620	3.7140	1.862	1.864	3.728	95.904
240	0.06350	3.9775	1.025	1.026	2.052	97.956
Pan			1.020	1.021	2.042	99.998
T O T A L			49.942	49.999		
LOSS IN WEIGHT			0.058			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 77

Locality - Sots Combined

Name of the Sieve - B.S. Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ϕ scale				
25	0.59944	0.7418	0.147	0.148	0.296	0.296
36	0.42164	1.2460	0.405	0.407	0.814	1.110
52	0.29464	1.7630	2.705	2.721	5.442	6.552
72	0.21082	2.2460	12.510	12.586	25.172	31.724
120	0.12446	3.0066	21.480	21.610	43.220	74.944
150	0.10414	3.2642	5.212	5.244	10.488	85.432
170	0.08890	3.4916	1.677	1. 687	3.374	88.806
200	0.07620	3.7140	1.800	1.811	3.622	92.428
240	0.06350	3.9775	1.130	1.137	2.274	94.702
Pan			2.632	2.648	5.296	99.998
T O T A L			49.698	49.999		
LOSS IN WEIGHT			0.302			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.98

Locality - Hatni Sot

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In φ scale				
25	0.59944	0.7418	0.300	0.301	0.602	0.602
36	0.42164	1.2460	1.470	1.473	2.946	3.548
52	0.29464	1.7630	8.480	8.497	16.994	20.542
72	0.21082	2.2460	21.1[illegible]	21.162	42.324	62.866
120	0.13446	3.0066	15.160	15.180	30.360	93.226
150	0.10414	3.2642	1.485	1.488	2.976	96.202
170	0.08890	2.4916	0.380	0.381	0.762	96.964
200	0.07620	3.7140	0.515	0.516	1.032	97.996
240	0.06350	3.9775	0.225	0.225	0.450	98.446
Pan			0.775	0.776	1.552	99.998
TOTAL			49.900	49.999		
LOSS IN WEIGHT			0.100			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.97

Locality - Khanjwa Sot

Name of the sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms
	Millimeter	In ϕ Scale				
25	0.59944	0.7418	0.662	0.667	1.334	1.334
36	0.42164	1.2460	1.752	1.764	3.528	4.862
52	0.29464	1.7630	5.987	6.029	12.058	16.920
72	0.21082	2.2460	15.397	15.505	31.010	47.940
120	0.12446	3.0066	16.825	16.943	33.886	81.826
150	0.10414	3.2642	3.175	3.1977	6.394	88.210
170	0.08890	3.4916	1.005	1.012	2.024	90.234
200	0.07620	3.7140	1.507	1.517	3.034	93.268
240	0.06350	3.9775	0.897	0.903	1.806	95.074
Pan			2.445	2.462	4.924	99.998
TOTAL			49.652	49.999		
LOSS IN WEIGHT			0.348			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.48

Locality - Mohand Rao - Sukrao   Name of the Sieve - B.S.Sieve

Mass of the samole - 50 gms.   Method of shaking - Automatic shaker

Time of shaking - 10 minutes   Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ø scale				
25	0.59944	0.7418	2.970	2.977	3.954	5.954
36	0.42164	1.2460	4.475	4.485	8.970	14.924
52	0.29464	1.7630	12.090	12.117	24.234	39.158
72	0.21082	2.2460	17.130	17.169	34.338	73.496
120	0.12446	3.0066	10.465	10.489	20.978	94.474
150	0.10414	3.2642	1.345	1.348	2.696	97.170
170	0.08890	3.4916	0.355	0.356	0.712	97.882
200	0.07620	3.7140	0.440	0.441	0.882	98.764
240	0.06350	3.9775	0.187	0.187	0.374	99.138
Pan			0.430	0.431	0.862	100.000
	T O T A L		49.887	60.000		
	LOSS IN WEIGHT		0.113			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 64

Locality - Main Solani River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic Shaker.

Time of shaking - 10 minutes

Date of analysis

Mesh No.	Screen opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ø scale				
25	0.59944	0.7418	0.922	0.923	1.846	1.846
36	0.42164	1.2460	2.132	2.134	4.268	6.114
52	0.29464	1.7630	7.220	7.227	14.454	20.568
72	0.21082	2.2460	15.915	15.930	31.860	52.428
120	0.12446	3.0066	16.840	16.856	33.712	86.140
150	0.10414	3.2642	3.430	3.433	6.866	93.006
170	0.08890	3.4916	0.902	0.903	1.806	94.812
200	0.07620	3.7140	1.195	1.196	2.392	97.204
240	0.06350	3.9775	0.472	0.472	0.944	98.148
Pan			0.925	0.926	1.852	100.000
	T O?T A L		49.953	50.000		

LOSS IN WEIGHT 0.047

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.84

Locality - Mohand Rao

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic Shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.%in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	3.000	3.002	6.004	6.004
36	0.42164	1.2460	4.730	4.733	9.466	15.470
52	0.29464	1.7630	13.198	13.206	26.412	41.882
72	0.21082	2.2460	15.765	15.774	31.548	73.430
120	0.12446	3.0066	9.460	9.465	18.930	92.360
150	0.10414	3.2642	1.402	1.403	2.806	95.166
1170	0.08890	3.4916	0.522	0.522	1.044	96.210
200	0.07620	3.7140	0.537	0.537	1.074	97.284
240	0.06350	3.9775	0.357	0.357	0.714	97.998
Pan		1.000	10000	1.001	2.002	100.000
TOTAL			49.971	50.000		
LOSS IN WEIGHT			00.029			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 61

Locality - Sukrao

Name of the Sieve - B.S. Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms
	Millimeter	In Ø scale				
25	0.59944	0.7418	2.405	2.417	4.834	4.834
36	0.42164	1.2460	3.915	3.935	7.870	12.704
52	0.29464	1.7630	8.330	8.373	16.746	29.450
72	0.21082	2.2460	14.510	14.586	29.172	58.622
120	0.12446	3.0066	13.342	13.410	26.820	85.442
150	0.10414	3.2642	3.032	3.048	6.096	91.538
170	0.08890	3.4916	0.838	0.839	1.678	93.216
200	0.07620	3.7140	1.107	1.113	2.226	95.442
240	0.06350	3.9775	0.772	0.777	1.5524	96.996
Pan			1.492	1.500	3.000	99.996
	T O T A L		49.740	49.998		

(ANALYST)

REPORT ON SIEVE ANALYSIS

Sample No.92

Locality - Tributary to Sukrao

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	0.182	0.182	0.364	0.364
36	0.42164	1.2460	0.667	0.669	1.338	1.702
52	0.29464	1.7630	3.340	3.348	6.696	8.398
72	0.21082	2.2460	9.002	9.024	18.048	26.446
120	0.12446	3.0066	21.477	21.531	43.062	69.508
150	0.10414	3.2642	6.347	6.363	12.726	82.234
170	0.08890	3.4916	1.995	2.000	4.000	86.234
200	0.07620	3.7140	2.585	2.591	5.182	91.416
240	0.06350	3.9775	1.505	1.509	3.018	94.434
Pan		>	2.775	2.782	5.564	99.998
T O T A L			49.875	49.999		
LOSS IN WEIGHT			0.125			

(ANALYST)

REPORT ON SIEVE ANALYSIS

Sample No.93

Locality - Sukrao

Name of the Sieve - B.S.Sieve

Name of the sample - 50 gms.

Method of shaking - Automative shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr.Wt. % retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ø scale				
25	0,59944	0,7418	2,197	2,208	4,416	4.416
36	0,42164	1,2460	3,575	3,593	7,186	11,602
52	0,29464	1,7630	9,682	9,731	19,462	31,064
72	0,21082	2,2460	14,547	14,620	29,240	60,304
120	0,12446	3,0066	13,155	13,221	26,442	86,746
150	0,10414	[illegible].8642	2,722	2,735	5,470	92,216
170	0,08890	3,4916	0,725	0,729	1,458	93,674
200	0,07620	3,7140	1, 255	1,261	2,522	96,196
240	0,06350	3,9775	0.805	0,809	1,618	97,814
Pan			1,087	1,092	2,184	99,998
	T O T A L		49,750	49,999		
	LOSS IN WEIGHT		0,250			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.87

Locality - Main Chillawala

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ø scale				
25	0.59944	0.7418	0.410	0.410	0.820	0.820
36	0.43164	1.2460	2.880	2.883	5.766	6.586
52	0.29464	1.7630	15.410	15.427	30.854	37.440
72	0.21082	2.2460	22.310	22.334	44.668	82.108
120	0.12446	3.0066	8.080	8.089	16.178	98.286
150	0.10414	3.2642	0.430	0.430	0.860	99.146
170	0.08890	3.4916	0.110	0.110	0.220	99.366
200	0.07620	3.7140	0.120	0.120	0.240	99.606
240	0.06350	3.9775	0.050	0.050	0.100	99.706
Pan			0.145	0.145	0.290	99.996
T O T A L			49.945	49.998		
LOSS IN WEIGHT			0.055			

(ANALYST)

REPORT ON SIEVE ANALYSIS

Sample No. 89

Locality - Chikna River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	0.230	0.231	0.462	0.462
36	0.42164	1.2460	1.245	1.251	2.502	2.964
52	0.29464	1.7630	7.750	7.790	15.580	18.544
72	0.21082	2.2460	18.560	18.655	37.310	55.854
120	0.12446	3.0066	16.880	16.966	33.932	89.786
150	0.10414	3.2642	2.500	2.513	5.026	94.812
170	0.08890	3.4916	0.605	0.608	1.216	96.028
200	0.07620	3.7140	0.725	0.729	1.458	97.486
240	0.06350	3.9775	0.400	0.402	0.804	98.290
pan			0.850	0.854	1.708	99.998
TOTAL			49.745	49.999		
LOSS IN WEIGHT			0.255			

(ANALYST)

REPORT ON SIEVE ANALYSIS

Sample No.90

Locality - Chillawala Rao

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	1.706	1.708	3.416	3.416
36	0.42164	1.2460	4.060	4.066	8.132	11.550
52	0.29474	1.7630	13.720	13.742	27.484	39.034
72	0.21082	2.2460	19.675	19.707	39.414	78.448
120	0.12446	3.0066	9.085	9.100	18.200	96.648
150	0.10414	3.2642	0.787	0.788	1.576	98.224
170	0.08890	3.4916	0.220	0.220	0.440	98.664
200	0.07620	3.7140	0.235	0.235	0.470	99.134
240	0.06350	3.9775	0.120	0.120	0.240	99.374
Pan			0.312	0.312	0.624	99.998
	T O T A L		49.919	49.998		
	LOSS IN WEIGHT		0.081			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 53

Locality - Main Chillawala River

Name of the Sieve - B.S. Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	1.032	1.038	2.076	2.076
36	0.42164	1.2460	3.987	4.010	8.020	10.096
52	0.29464	1.7630	14.582	14.666	29.332	39.428
72	0.21082	2.2460	18.815	18.924	37.848	77.276
120	0.12446	3.0066	9.412	9.466	18.932	96.208
150	0.10414	3.2642	0.935	0.940	1.880	98.088
170	0.08890	3.4916	0.255	0.256	0.512	98.600
200	0.07620	3.7140	0.280	0.282	0.564	99.164
240	0.06350	3.9775	0.080	0.080	0.160	99.324
Pan			0.355	0.337	0.674	99.998
T O T A L			49.713	49.999		
LOSS IN WEIGHT			0.287			

(ANALYST)

REPORT ON SIEVE ANALYSIS

Sample No.58

Locality - Budhwa Silt River Name of the Sieve - B.S.Sieve

Mass of the sample - 50gms Method of shaking - Automatic shaker

Time of shaking - 10 minutes Date of analysis:

Mesh No.	Screen Opening Millimeter	Screen Opening In ø scale	Wt. retained in gms.	Corrected Wt. in gms.	Corr.Wt. % retained in gms.	Cummulative retained Wt.% in gms.
25	0.59944	0.7418	0.660	0.662	1.324	1.324
36	0.42164	1.2460	2.400	2.407	4.814	6.138
52	0.29464	1.7630	11.595	11.631	23.262	29.400
72	0.21082	2.2460	20.840	20.906	41.812	71.212
120	0.12446	3.0066	12.010	12.048	24.096	95.308
150	0.10414	3.2642	1.287	1.292	2.584	97.892
170	0.08890	3.4916	0.307	0.308	0.616	98.508
200	0.07620	3.7140	0.297	0.298	0.596	99.104
240	0.06350	3.9775	0.147	0.147	0.294	99.398
Pan			0.300	0.301	0.602	100.000
TT O T A L			49.843	50.000		
LOSS IN WEIGHT			0.157			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 60

Locality - Main Chillawala River

Name of the Sieve - B.S. Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In Ø scale				
25	0.59944	0.7418	1.095	1.096	2.192	2.192
36	0.42164	1.2460	2.970	2.974	5.948	8.140
52	0.29464	1.7630	12.475	12.470	24.980	33.120
72	0.21082	2.2460	22.207	22.234	44.468	77.588
120	0.12446	3.0066	10.222	10.234	20.468	98.056
150	0.10414	3.2642	0.620	0.621	1.242	99.298
170	0.08890	3.4916	0.070	0.070	0.140	99.438
200	0.07620	3.7140	0.130	0.130	0.260	99.698
240	0.06350	3.9776	0.050	0.050	0.100	99.798
Pan			0.100	0.100	.	.
T O T A L			49.939	49.999		
LOSS IN WEIGHT			0.061			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No.67

Locality - Tributary near Canal crossing, to Solani

Name of the sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr.Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ϕ Scale				
25	0.59944	0.7418	0.200	0.200	0.400	0.400
36	0.42164	1.2460	0.570	0.571	1.142	1.542
52	0.29464	1.7630	0.622	0.623	1.246	2.788
72	0.21082	2.2460	5.717	5.729	11.458	14.246
120	0.12446	3.0066	26.705	26.763	53.526	67.772
150	0.10414	3.2642	9.190	9.210	18.420	86.192
170	0.08890	3.4916	2.405	2.410	4.820	91.012
200	0.07620	3.7140	1.285	1.288	2.576	93.538
240	0.06350	3.9775	1.272	1.275	2.550	96.088
Pan			1.925	1.929	3.858	99.996
		T O T A L	49.891	49.998		
	LOSS IN WEIGHT		0.109			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 71

Locality – Eastern branch of the tributary to Solani near Ganges canal crossing.

Name of the sieve – B.S. Sieve

Mass of the sample – 50 gms.

Method of shaking – Automatic shaker

Time of shaking – 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ϕ scale				
25	0.59944	0.7418	0.140	0.141	0.282	0.282
36	0.42164	1.2460	0.440	0.442	0.884	1.166
52	0.29464	1.7630	2.780	2.796	5.592	6.758
72	0.21082	2.2460	9.560	9.616	19.232	25.990
120	0.12446	3.0066	20.722	20.843	41.686	67.676
150	0.10414	3.2642	6.615	6.654	13.308	80.984
170	0.08890	3.4916	2.157	2.170	4.340	85.324
200	0.07620	3.7140	2.265	2.278	4.556	89.880
240	0.06350	3.9775	1.570	1.579	3.158	93.038
Pan			3.460	3.480	6.960	99.998
TOTAL			49.709	49.999		
LOSS IN WEIGHT			0.291			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 73

Locality – Western branch of the tributary to Solani near Ganges canal crossing.

Name of the sieve – B.S. Sieve

Mass of the sample – 50 gms.

Method of shaking – Automatic shaker

Time of shaking – 10 minutes

Date of analysis:

Mesh No.	Screen Opening Millimeter	Screen Opening In ϕ scale	Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gm.
25	0.59944	0.7418	0.007	0.007	0.014	0.014
36	0.42164	1.2460	0.045	0.045	0.090	0.104
52	0.29464	1.7630	1.515	1.518	3.036	3.140
72	0.21082	2.2460	14.535	14.568	29.136	32.276
120	0.12446	3.0066	25.980	26.038	52.076	84.352
150	0.10414	3.2642	4.767	4.778	9.556	93.908
170	0.08890	3.4916	1.242	1.245	2.490	96.398
200	0.07620	3.7140	1.005	1.007	2.014	98.412
240	0.06350	3.9775	0.235	0.235	0.470	98.882
Pan			0.557	0.558	1.116	99.996
T O T A L			49.888	49.199		
LOSS IN WEIGHT						

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 70(a+b+c)

Locality - Tributary To Solani Canal Crossing

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

Method of shaking - Automatic shaker

Time of shaking - 10 minutes

Date of analysis:

Mesh No.	Screen Opening		Wt. retained in gms	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms
	Millimeter	In ϕ scale				
25	0.59944	0.7418	2.900	2.922	5.844	5.844
36	0.42164	1.2460	4.260	4.292	8.584	14.428
52	0.29464	1.7630	6.480	6.529	13.058	27.486
72.	0.21082	2.2460	9.490	9.562	19.124	46.610
120	0.12446	3.0066	14.140	14.248	28.496	75.106
150	0.10414	3.2642	4.235	4.267	8.534	83.640
170	0.08890	3.4916	1.487	1.498	2.996	86.636
200	0.07620	3.7140	2.102	2.118	4.236	90.872
240	0.06350	3.9775	0.475	0.479	0.958	91.830
Pan			4.052	4.083	8.166	99.996
T O T A L			49.621	49.998		
LOSS IN WEIGHT			0.379			

(ANALYST)

REPORT OF SIEVE ANALYSIS

Sample No. 74

Locality - Lalekuala River

Name of the Sieve - B.S.Sieve

Mass of the sample - 50 gms.

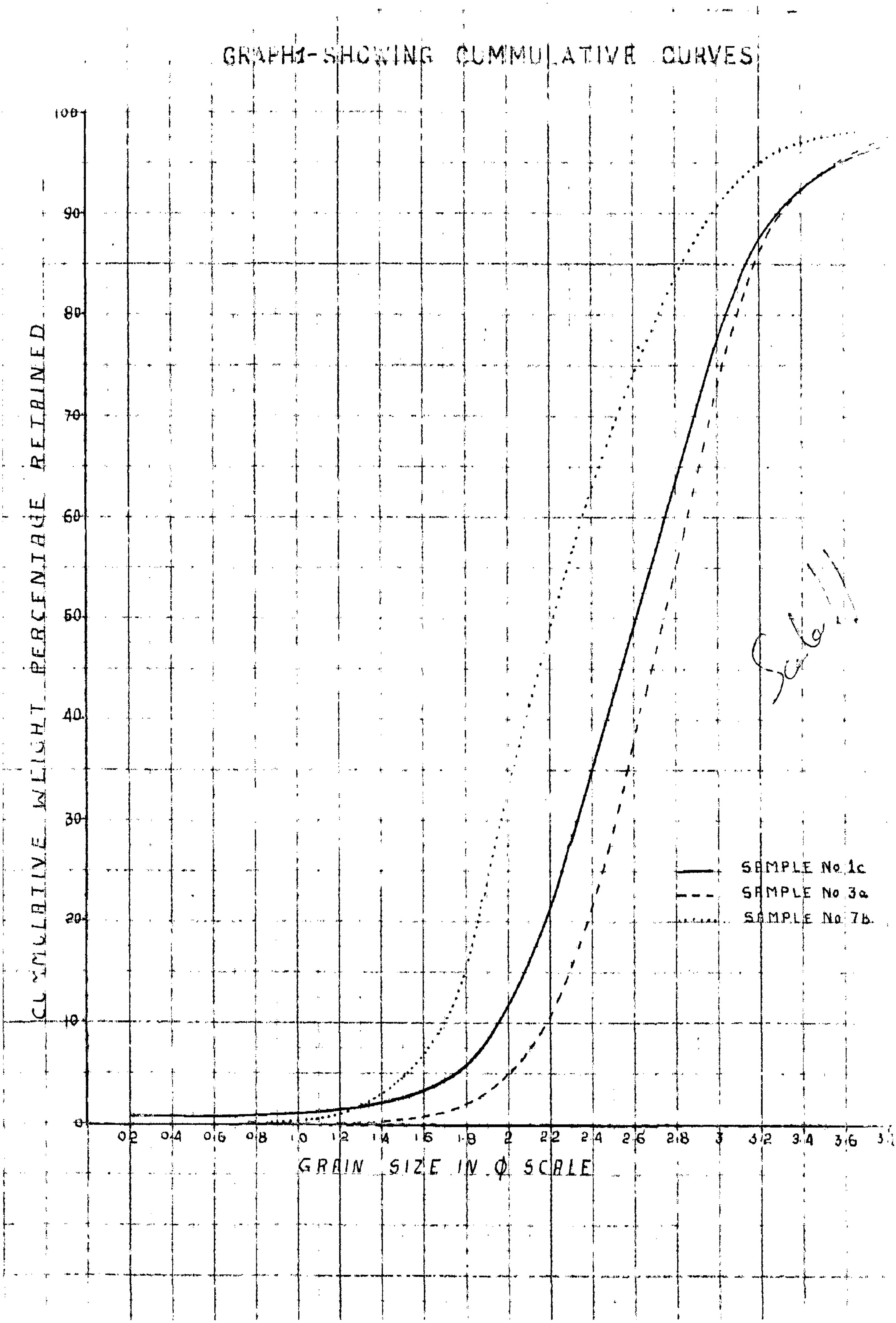
Method of shaking - Automatic shaker

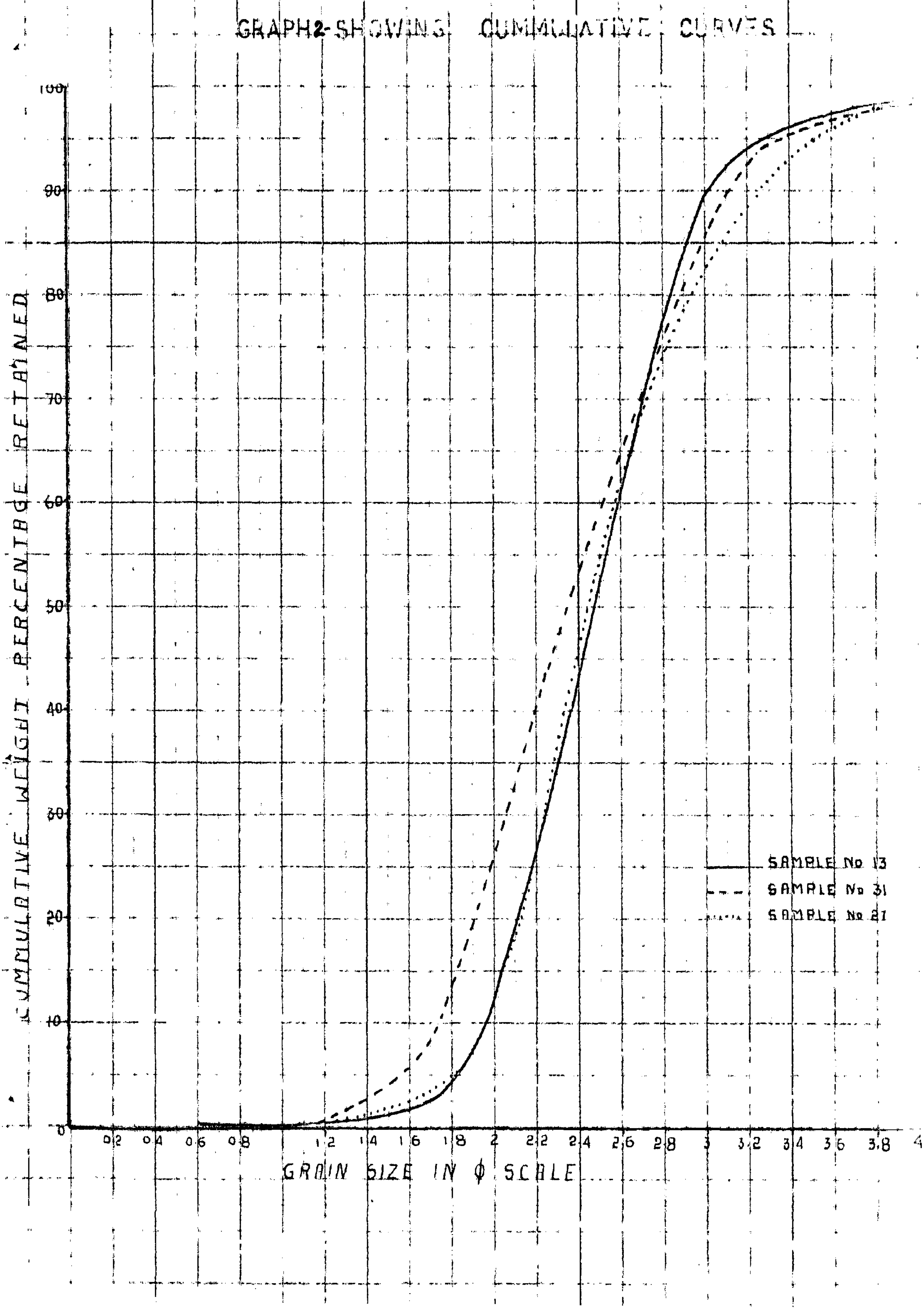
Time of shaking - 10 minutes

Date of analysis:

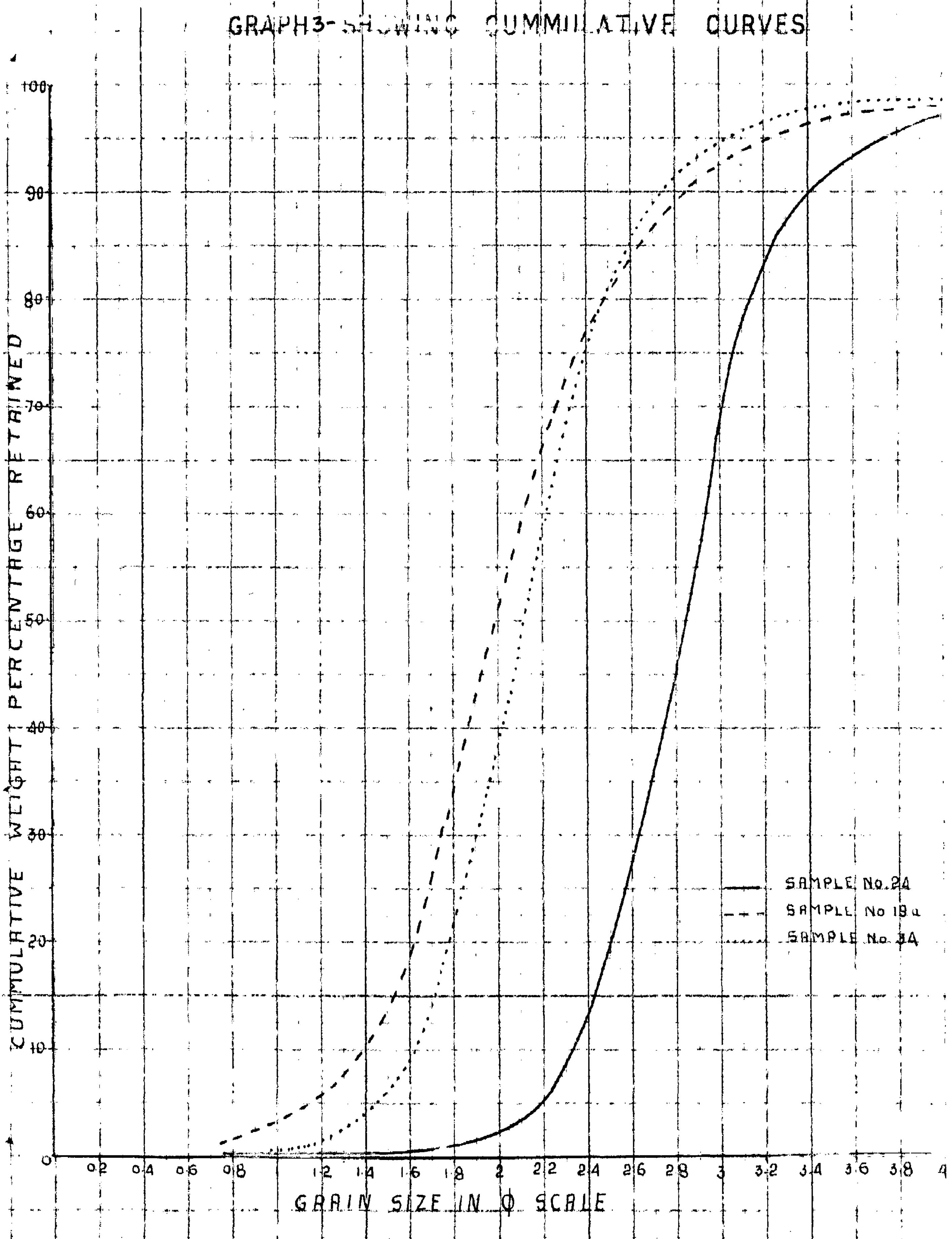
Mesh No.	Screen Opening		Wt. retained in gms.	Corrected Wt. in gms.	Corr. Wt.% retained in gms.	Cummulative retained Wt.% in gms.
	Millimeter	In ø scale				
25	0.59944	0.7418	1.160	1.165	2.330	2.330
36	0.42164	1.2460	2.600	2.612	5.224	7.554
52	0.29464	1.7630	11.520	11.574	23.148	30.702
72	0.21082	2.2460	20.870	20.969	41.938	72.640
120	0.12446	3.0066	11.555	11.610	23.220	95.860
150	0.10414	3.2642	0.930	0.934	1.868	97.728
170	0.08890	3.4916	0.235	0.236	0.472	98.200
200	0.07620	3.7140	0.310	0.311	0.622	98.822
240	0.06350	3.9775	0.105	0.105	0.210	99.032
Pan			0.480	0 .482	0.964	99.996
TOTAL			49.765	49.998		
LOSS IN WEIGHT			0.235			

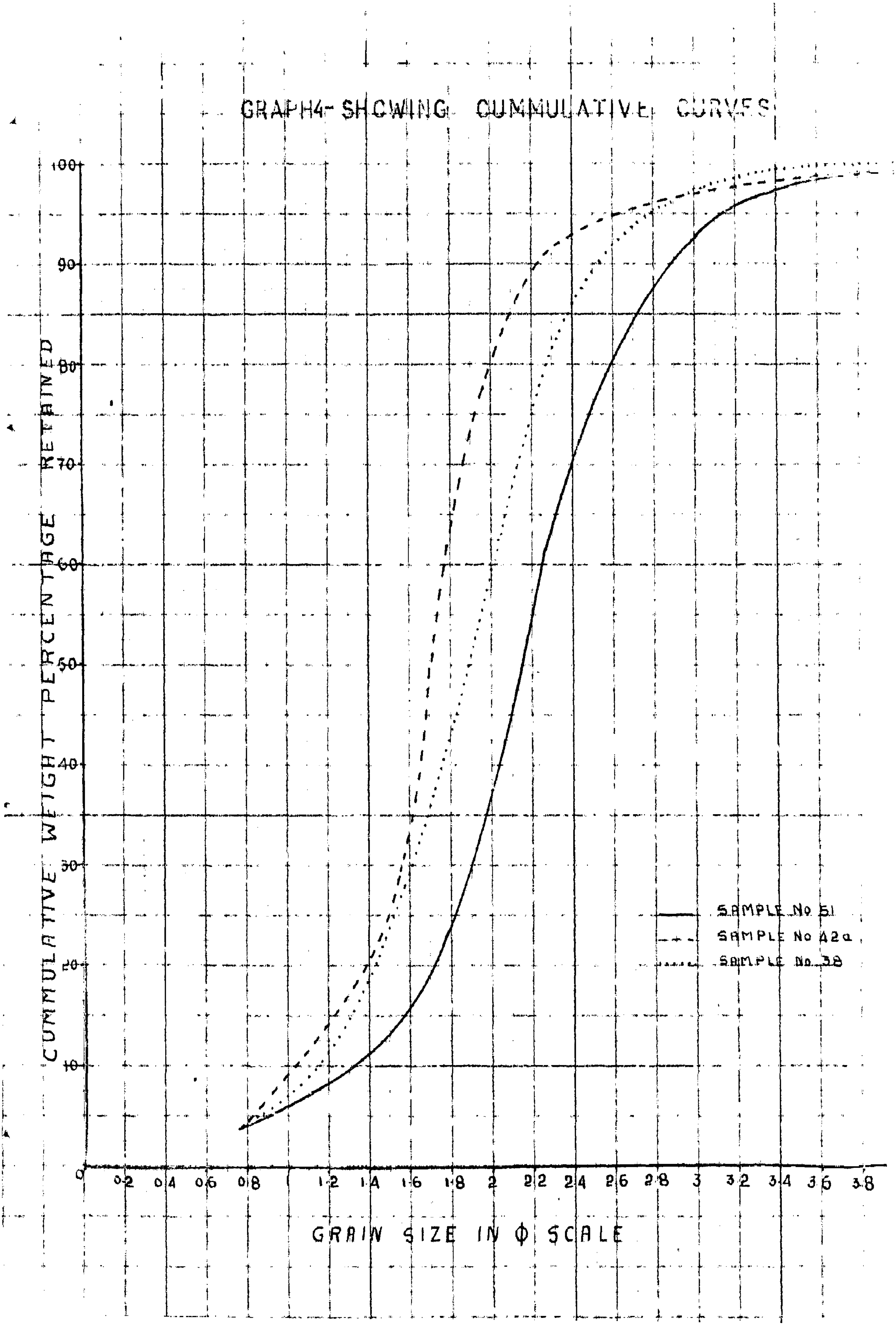
(ANALYST)

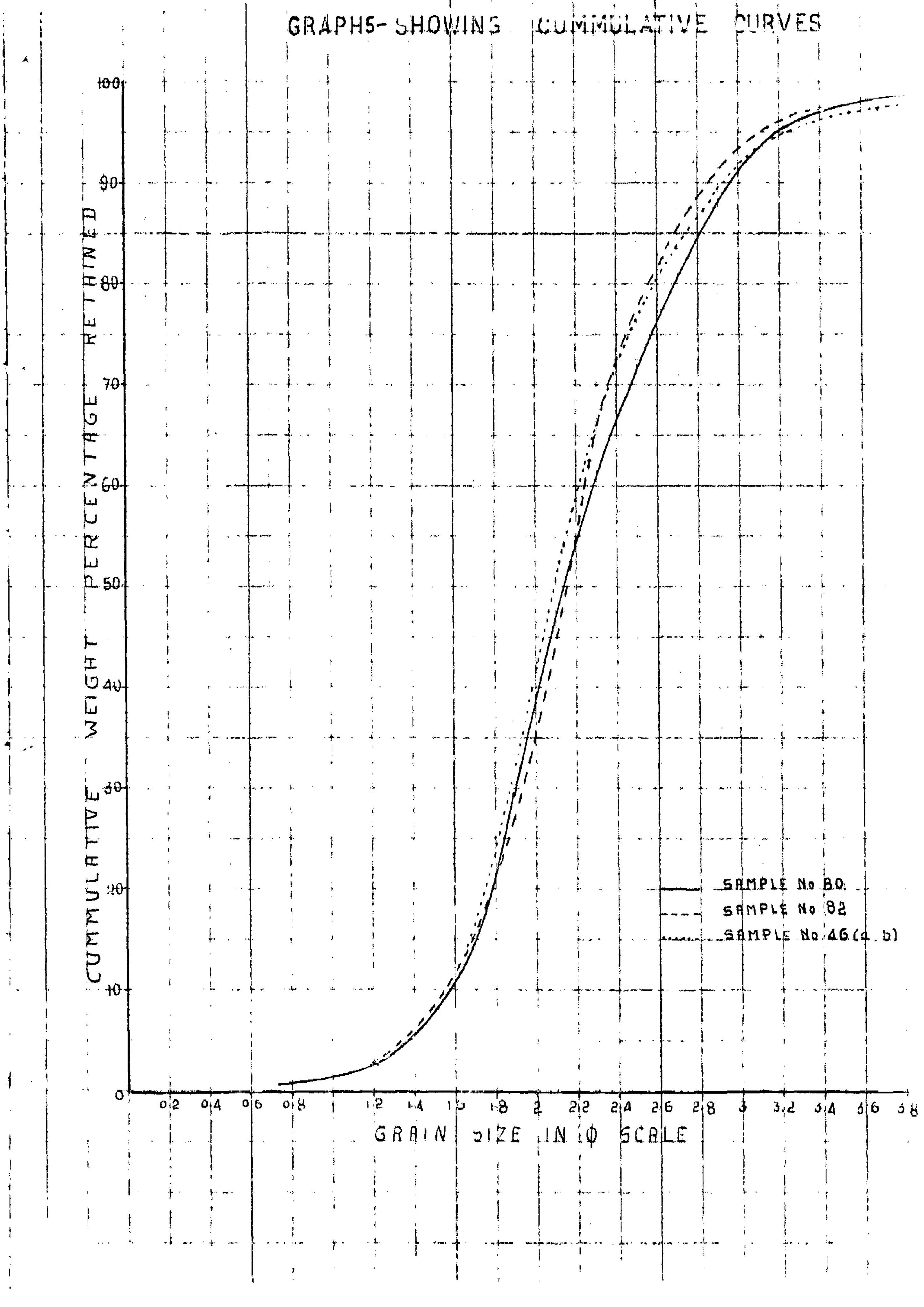

GRAPH1-SHOWING CUMMULATIVE CURVES
CUMMULATIVE WEIGHT PERCENTAGE RETAINED
GRAIN SIZE IN Ø SCALE
SAMPLE No 1c
SAMPLE No 3a
SAMPLE No 7b
0
10
20
30
40
50
60
70
80
90
100
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6



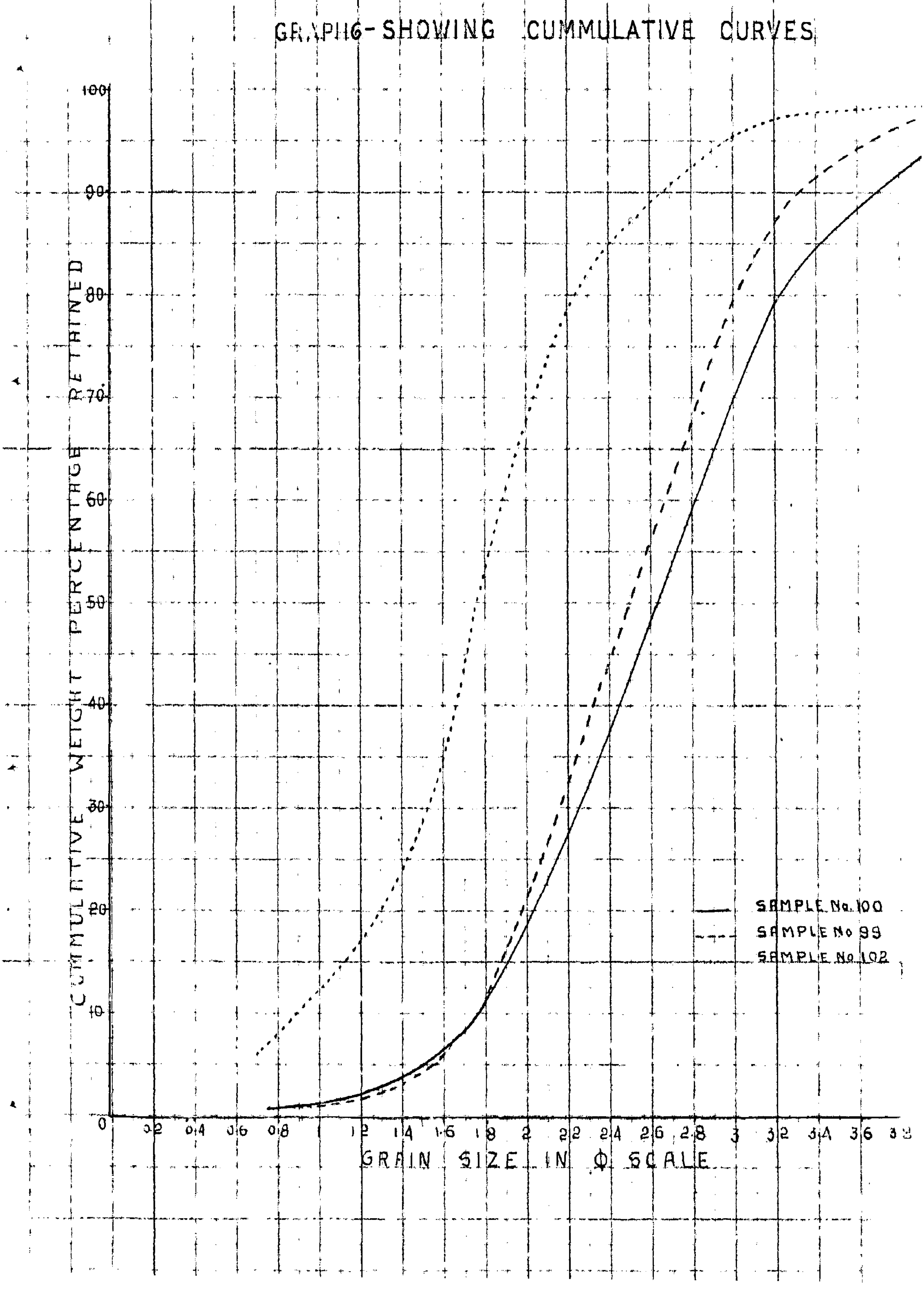
GRAPH 2- SHOWING CUMMULATIVE CURVES
CUMMULATIVE WEIGHT PERCENTAGE RETAINED
100
90
80
70
60
50
40
30
20
10
0
0.2
0.4
0.6
0.8
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
GRAIN SIZE IN ϕ SCALE
SAMPLE No 13
SAMPLE No 31
SAMPLE No 21


GRAPH3-SHOWING CUMMULATIVE CURVES
CUMMULATIVE WEIGHT PERCENTAGE RETAINED
0
10
20
30
40
50
60
70
80
90
100
0.2
0.4
0.6
0.8
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
GRAIN SIZE IN Φ SCALE
SAMPLE No.2A
SAMPLE No 18a
SAMPLE No. 3A

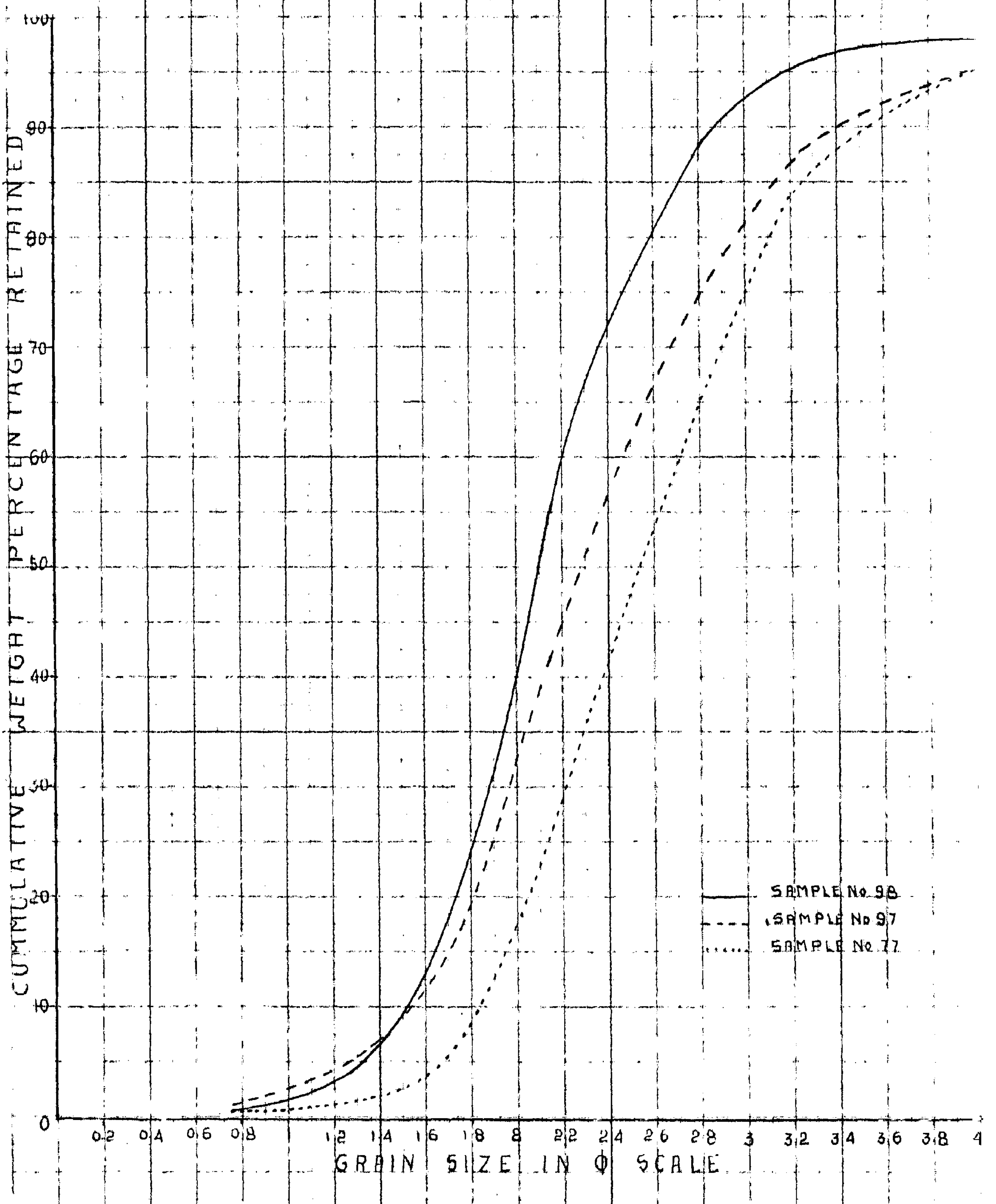

GRAPH4- SHOWING CUMMULATIVE CURVES
CUMMULATIVE WEIGHT PERCENTAGE RETAINED
GRAIN SIZE IN φ SCALE
SAMPLE No 51
SAMPLE No 42a
SAMPLE No 38
0
10
20
30
40
50
60
70
80
90
100
0·2
0·4
0·6
0·8
1·2
1·4
1·6
1·8
2
2·2
2·4
2·6
2·8
3
3·2
3·4
3·6
3·8



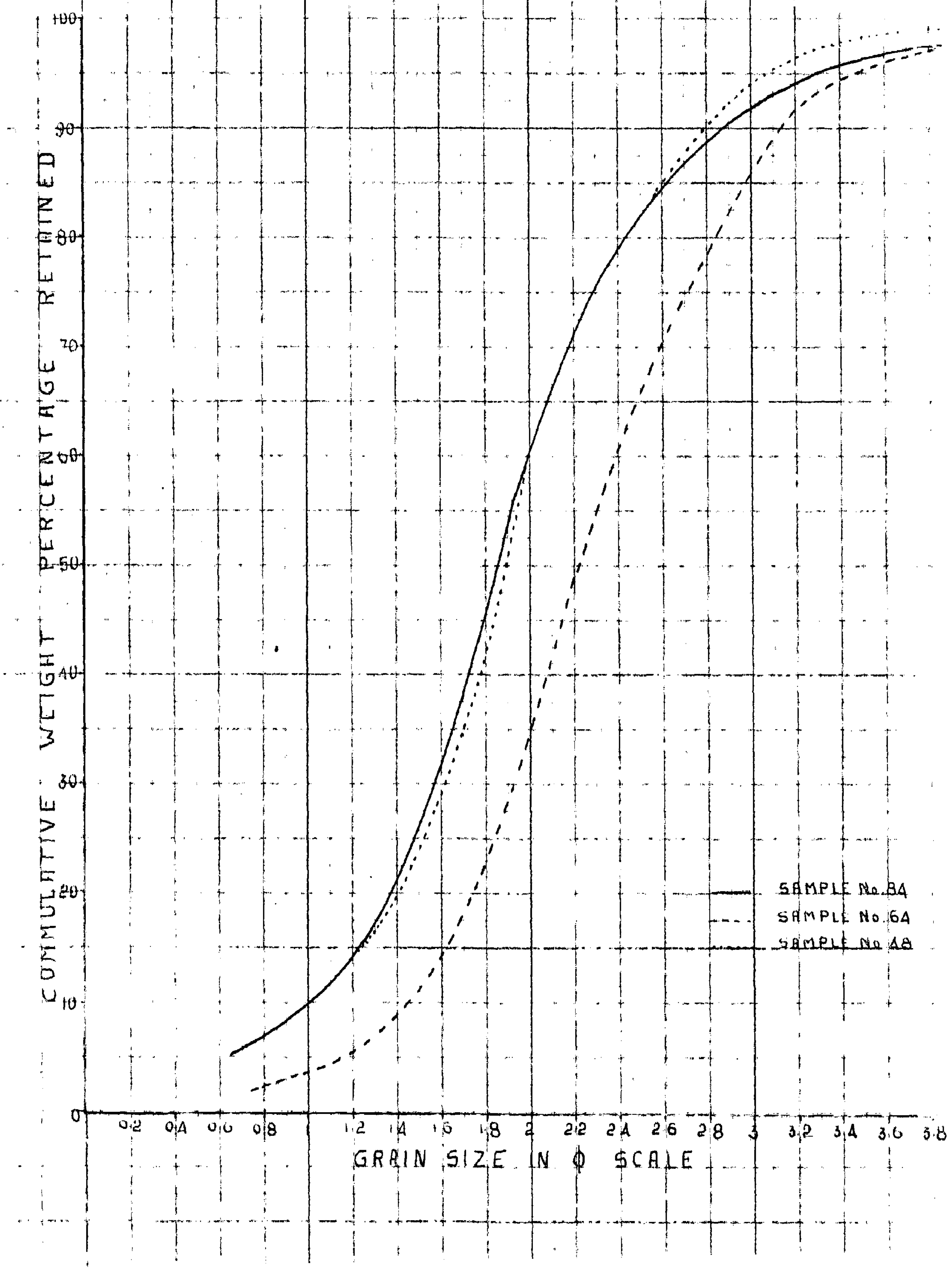
GRAPHS- SHOWING CUMMULATIVE CURVES
CUMMULATIVE WEIGHT PERCENTAGE RETAINED
GRAIN SIZE IN Φ SCALE
0
10
20
30
40
50
60
70
80
90
100
0.2
0.4
0.6
0.8
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
SAMPLE No 80
SAMPLE No 82
SAMPLE No 46(4.5)


GRAPH6-SHOWING CUMMULATIVE CURVES
CUMMULATIVE WEIGHT PERCENTAGE RETAINED
GRAIN SIZE IN Φ SCALE
SAMPLE No. 100
SAMPLE No 99
SAMPLE No 102
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
10
20
30
40
50
60
70
80
90
100

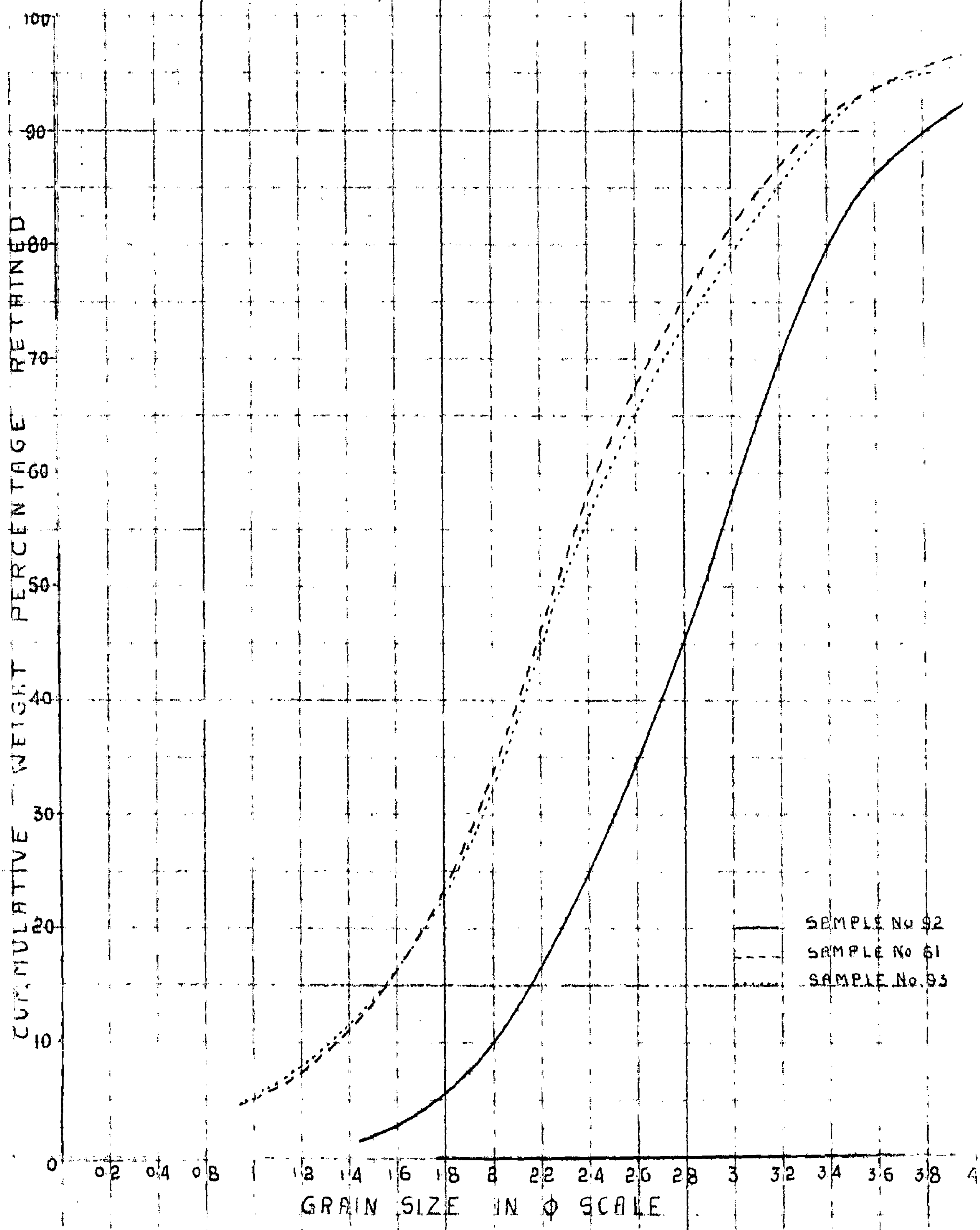
GRAPH 7- SHOWING CUMMULATIVE CURVES

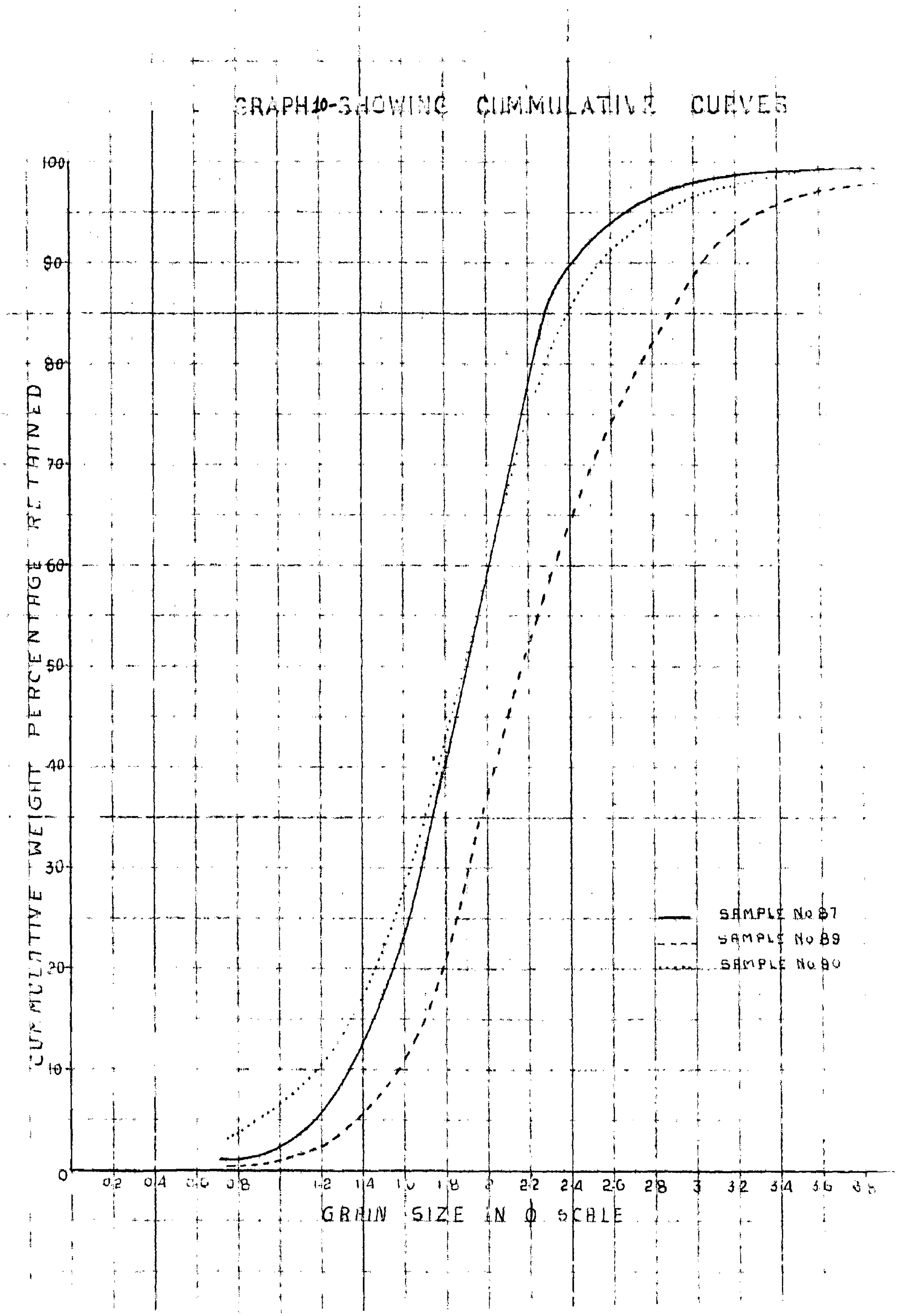


GRAPH 8- SHOWING CUMMULATIVE CURVES.

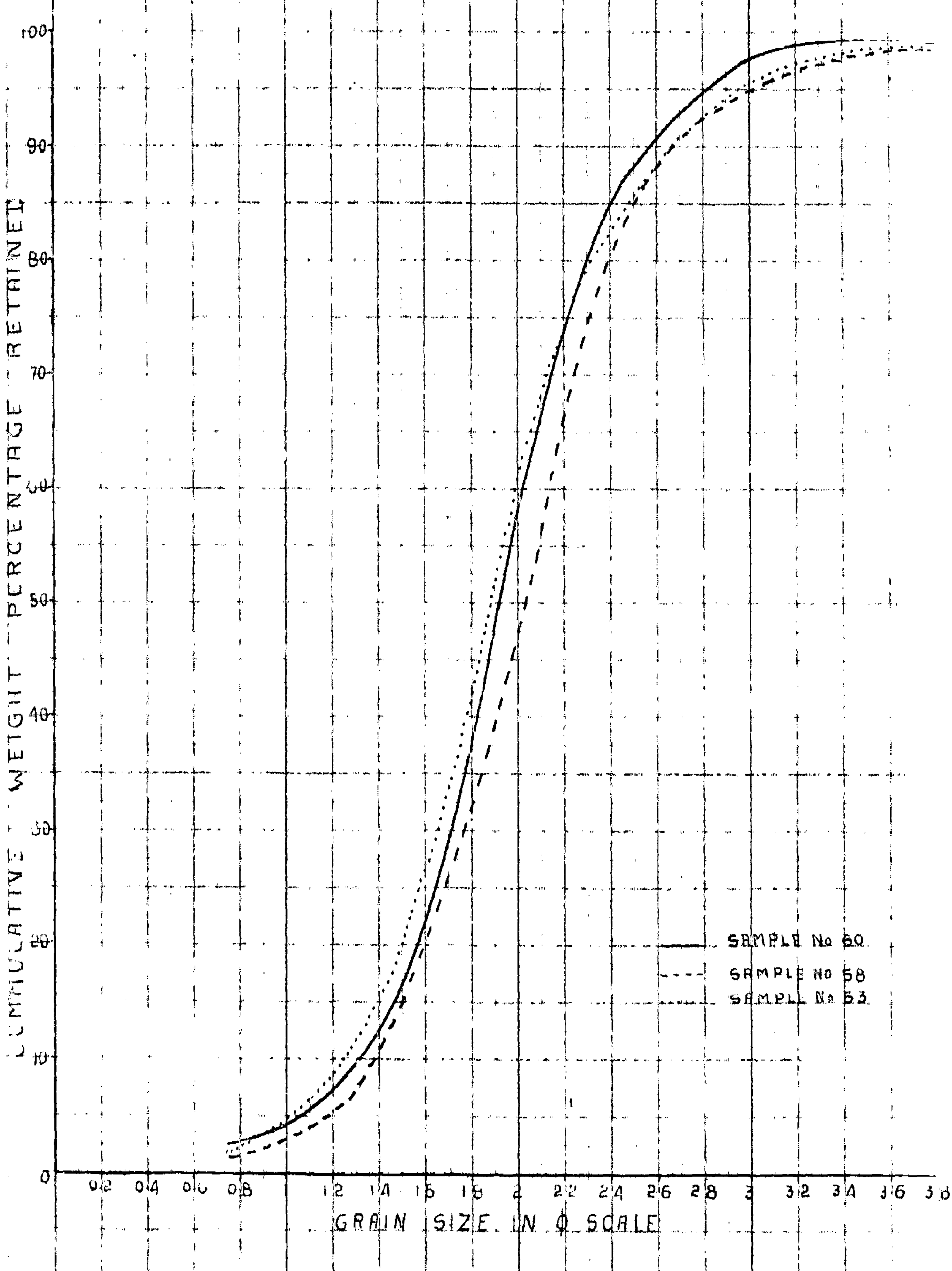


GRAPH9- SHOWING CUMMULATIVE CURVES




GRAPH 10 - SHOWING CUMMULATIVE CURVES
CUMMULATIVE WEIGHT PERCENTAGE RETAINED
GRAIN SIZE IN Ø SCALE
SAMPLE No 87
SAMPLE No 89
SAMPLE No 90
0
10
20
30
40
50
60
70
80
90
100
0.2
0.4
0.8
1.2
1.4
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6

GRAPH 11 - SHOWING CUMMULATIVE CURVES



GRAPH 12- SHOWING CUMMULATIVE CURVES