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University of Nevada

Reno

Differentiation of Lake Lahontan Sediments in Western Nevada by Grain Size Parameters

A thesis submitted in partial fulfillment of the
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by

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ABSTRACT

Textural parameters of Pleistocene sediments from the Lake Lahontan Basin were studied from outcrops in the Truckee River Canyon, Carson Valley, Rye Patch Dam, and Wadsworth areas. Two stratigraphic sections of Lake Lahontan strata, including Eetza, Wyemaha and Sehoo formations were measured and sampled near Wadsworth. Parameters calculated from the grain size data, partially based upon statistical equations established by Folk and Ward (1957), include mean diameter, standard deviation, skewness, kurtosis, and the coarsest 5 percent.

These parameters, in conjunction with field observations, are used to differentiate the following depositional environments: aeolian, subaerial, fluviatile, beach, shallow-water nearshore, transitional shoreline to offshore, offshore, and turbidite. Where no single parameter can be used to discriminate environments, a combination of parameters could be used. Graphs of mean diameter versus coarsest 5 percent, mean diameter versus standard deviation, and mean diameter versus skewness are most indicative of environment in lacustrine settings. Kurtosis is of little value. Sorting generally is poor within water-laid sediments, and no sediment studied has better than moderate sorting.

INTRODUCTION

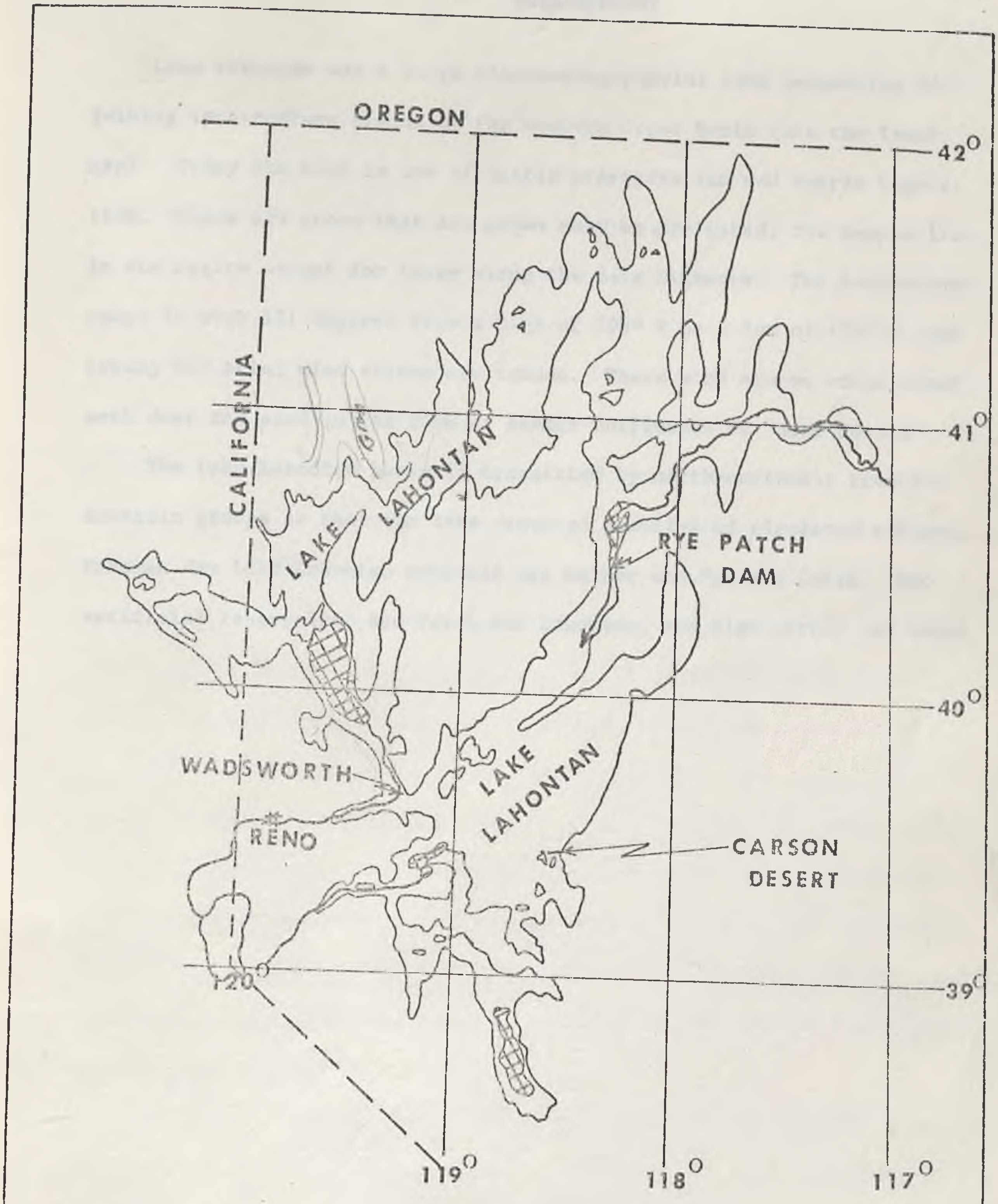
In recent years more data have become available relating sedimentary environments to various textural parameters. Recent work has contributed much information on the depositional processes which determine the grain size distributions in different marine environments; however, little information has been made available on the lacustrine environments.

The characterization of environments by the sediments deposited in them was achieved by collecting samples from different known environmental settings in the Truckee River Canyon, Carson Desert, Rye Patch Dam, and Wadsworth areas. Two detailed stratigraphic sections were measured and sampled near the latter areas for comparison with former lithologic observations. Statistical measures were applied to the size frequency distribution of these samples. Each sediment was then described in terms of mean diameter, standard deviation, skewness, kurtosis, and coarsest 5 percent based upon the statistical equations established by Folk and Ward (1957).

The purpose of this investigation is to study the nature of particle-size distributions in sediments which are deposited from different sources and under different transporting processes in a general lacustrine environment. The late Pleistocene Lahontan Lake Basin in Nevada was chosen for its widespread lacustrine influence and its varied source materials.

Former work done on the stratigraphy and the climate of the Lake Lahontan Basin includes reports by Russell (1885), Antevs (1925), Jones (1925), and Morrison (1961 and 1964).

This writer expresses his appreciation to the following people who have aided in preparation of this paper: Mr. Steve Born, University of Wisconsin, who suggested the topic and assisted in the initial field survey reconnaissance; Mr. George Brogan who suggested methods of approach for laboratory analysis and statistical comparison; and Doctors Larson and Firby of the University of Nevada for helpful, critical suggestions on the presentation of the material.


OREGON
CALIFORNIA
LAKE LAHONTAN
RYE PATCH DAM
WADSWORTH
RENO
LAKE LAHONTAN
CARSON DESERT
42°
41°
40°
39°
120°
119°
118°
117°

INDEX MAP

PHYSIOGRAPHY

Lake Lahontan was a large fluctuating pluvial lake inundating adjoining intermontane basins of the western Great Basin (see the Index Map). Today the area is one of little precipitation and sparse vegetation. Since all crops that are grown must be irrigated, few people live in the region except for those along the main highways. The temperature range is over 131 degrees from a high of 106° F to a low of -25° F, and strong but brief wind storms are common. These wind storms often carry much dust and sand in the form of summer whirlwinds or "dust devils".

The Lake Lahontan Basin is transected by north-northeast trending mountain groups so that the lake occupied a series of elongated valleys. Present day Lake Lahontan remnants are Walker and Pyramid Lakes. Two artificial reservoirs, Rye Patch and Lahontan, are also within the basin.

STRATIGRAPHY

In this study, particular attention was paid to the outcrops of late Pleistocene Eetza, Wayemaha, and Sehoo formations exposed in the banks of the Truckee River north of Wadsworth, Nevada. These Lake Lahontan sediments overlie the Quaternary alluvial gravels of the Paiute formation which was deposited locally by an ephemeral stream that supplied many of the sediments to the lake basin. The formations of the Lake Lahontan Valley group were named after their type sections in the Carson Desert by R. B. Morrison (1961). The following is a brief description of these formations from the oldest to the youngest.

The Eetza formation was described as a lacustrine gravel to clay unit of up to 90 feet in thickness (Morrison, 1961). It is the lowest member of the Lake Lahontan Valley group. The type section of the flanks of Eetza Mountain in the Carson Desert is 15 feet thick (Morrison, 1964). Russell (1885) estimated that the thickness may reach 150 feet.

The Wayemaha formation is comprised of eolian sands and alluvium up to 100 feet thick (Morrison, 1961). This formation lies conformably or slightly disconformably upon the Eetza formation. The type section of the Wayemaha formation is in the Wayemaha Valley near Eetza Mountain and obtains a thickness of 6-17 feet. At the top of this formation is the distinctive Churchill soil. This is the best developed soil horizon in the Lake Lahontan Valley group.

The Sehoo formation (Morrison, 1961) disconformably overlies the Wayemaha formation and is composed of lake sediments. This formation is subdivided into three members: lower Sehoo, dendritic Sehoo, and upper Sehoo. Since only the lower Sehoo is exposed in the Wadsworth outcrops, it is the only member discussed in this paper. The lower member of the type section attains a thickness of 12 feet in the Wayemaha Valley of the Carson Desert.

SEDIMENTATION

Procedure

Samples were collected and classified as to environment of depositions by use of stratigraphy and sedimentation morphologies according to the criteria of Potter (1967). This allows a certain amount of interpretation by the author, but as most of the samples were of relatively easily identifiable types, no appreciable error in classification is expected.

To avoid post-depositional alterations, the top four or five inches of sediments were removed before sampling. One to two kilograms of relatively undisturbed sediment were then collected with larger samples being taken for coarser sediment sizes. By using this technique, 10 eolian, 15 sub-aerial, 29 fluviatile or fluviatile mixed, 17 beach, 22 land to nearshore transition, 29 nearshore, 35 offshore, and 3 turbidity-type environments of deposition were sampled. Sub-aerial deposits are considered here as those moved by both wind and water under continental conditions although the water does not reach the turbulence of a river.

In the laboratory the samples were carefully weighed, disaggregated using a rubber cork and porcelain mortar, and sieved for 25 minutes in a Ro-Tap machine. The sample was passed through ½ Ø interval Tyler screens from -5 Ø to -1 Ø. The pebbles and granules were thus removed and each fraction was weighed to 0.01 grams. The sand and finer portions were then split to a 100-200 gram portion and resieved for 25 minutes into ½ Ø intervals between -1 Ø and 4 Ø. Each size fraction was then weighed to 0.01 grams and examined under a binocular microscope for the presence of aggregated particles. The amount of aggregate was deducted

(Folk, 1968) from each size fraction and the corrected weight recorded. The silt and clay size particles were subdivided by pipette analysis into intervals of phi diameters from 4 Ø through 10 Ø.

In the pipetting procedure, 12-14 gram samples were mixed in 1000 ml of distilled water with a couple of drops of ammonium hydroxide and a small amount of "calgon" to prevent flocculation within the sample. After complete mixing, 25 ml samples were withdrawn from various measured depths at given time intervals and placed in beakers to be dried and weighed. The cumulative amount of silts and clays at any given phi interval was calculated by deducting the amount of silts and clays remaining from the original sample.

The cumulative percentages were then determined and plotted on arithmetic graphs against the phi diameter. From the distribution curve, the following percentages were recorded to the nearest 0.01 Ø: 5, 9, 16, 25, 50, 75, 84, and 95 (see Appendix).

Statistical Parameters

For many years geologists have attempted to extract environmental information from the grain-size analyses of sediments. Since it has always been noted that general similarities exist between samples taken from the same environments, the determination of environmentally sensitive parameters seems to be the next logical step.

Much of the earlier work was inconclusive due to the lack of coordination between the many workers in the field. The early work was accomplished by utilizing different equations which were based on different percentiles. The system of quartiles was the most widely accepted of these systems, and of the quartile systems, the most common coefficients presented were those of Trask (1930). Inman (1952) suggested that statistical approach to sedimentation be standardized, and he presented a set of parameter equations to be used.

Krumbein (1936) introduced the Ø as a symbol for the negative logarithm of grain diameters to the base 2. Folk and Ward (1957) presented modifications of Inman's equations in order to include a larger portion of the tails (the ends of the sediment curve). These modifications allowed for inclusion of sediments of multi-modal or skewed natures which apparently comprise the vast majority of the sediment samples. Many workers have since demonstrated that multi-modal and skewed samples are quite common in sediment curves (Fuller, 1961; Kloven, 1966; Moss, 1963 and 1964; Passega, 1957; Spencer, 1963; and Visher, 1965 and 1969). A good review of the advantages and disadvantages for the various parameters is presented by Moiola and Weiser (1968).

The present investigation has been carried out using the equations of Folk and Ward (1957) because they consider all the factors of the sediment caused by depositional variations and because of the possibility of comparison with the results obtained by other present day workers.

The statistical parameters (mean size, standard deviation, skewness and kurtosis) are calculated using selected percentiles in phi sizes from the distribution curve as follows:

Mean Diameter $$\frac{16\,\phi + 50\,\phi + 84\,\phi}{3}$$

Standard Deviation $$\frac{84\,\phi - 16\,\phi}{4} + \frac{95\,\phi - 5\,\phi}{6.6}$$

Skewness
$$\frac{16\ \phi + 84\ \phi - 2(50\ \phi)}{2(84\ \phi - 16\ \phi)} + \frac{5\ \phi + 95\ \phi - 2(50\ \phi)}{2(95\ \phi - 5\ \phi)}$$

Kurtosis
$$\frac{95\ \phi - 5\ \phi}{2.44\ (75\ \phi - 25\ \phi)}$$

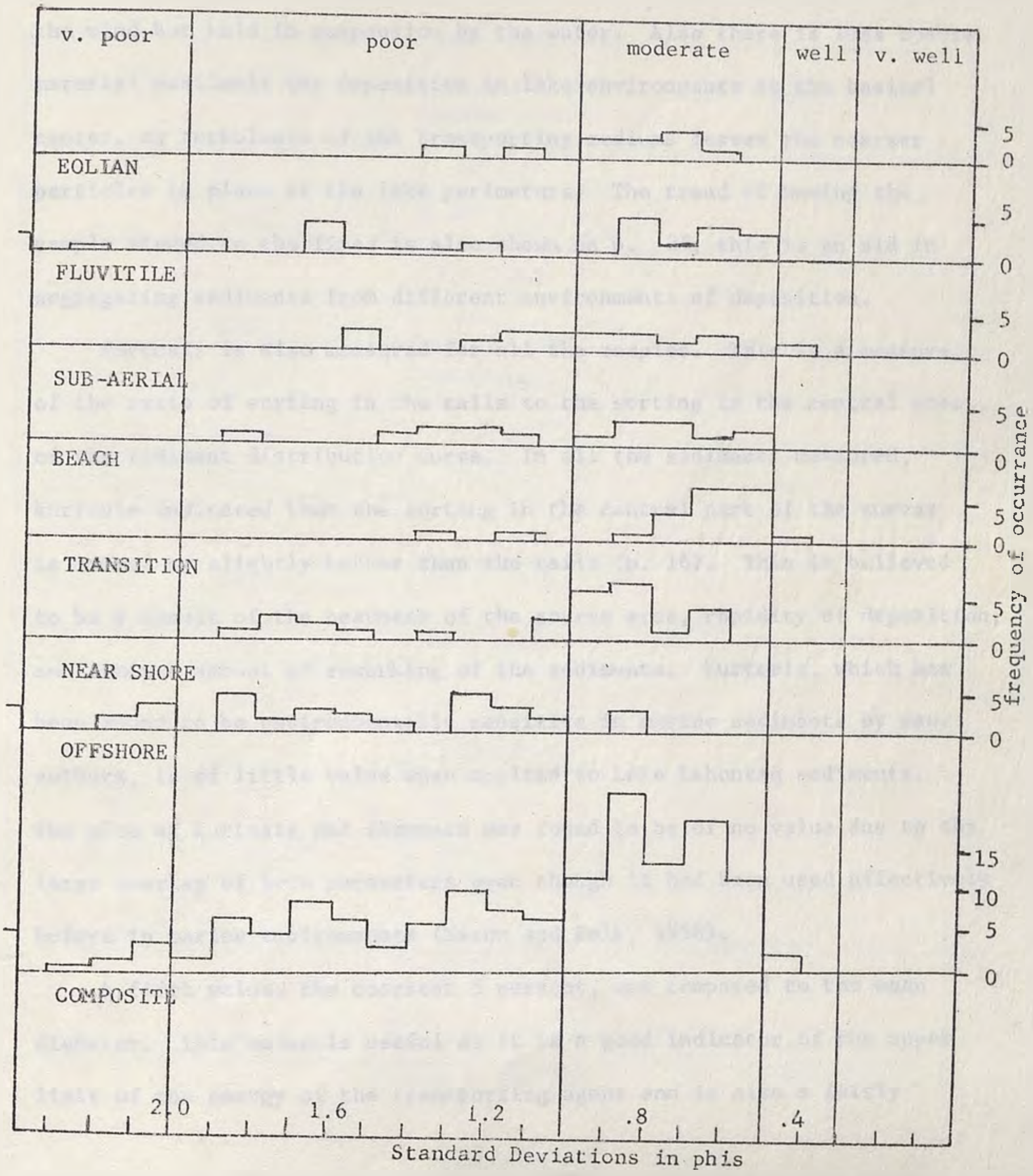
Mean diameter is a competent measure of sediment environment of deposition because it considers the tails as well as the center fractions of the distribution curve for each sample. In comparison median measures are quite misleading, as they are measured only at the 50th percentile on the sediment curve, thus ignoring the important tails of the usually skewed distribution curves. Since the median is not necessarily characteristic of the whole sample, the mean diameter is more likely to reflect the characteristics of the sediment sample, and thus should reflect the environment of deposition. Mean diameter can also reflect distance from the source area as well as the energy of the transporting agent, and is the best single parameter for identifying lacustrine sediments.

Standard deviation is a measure of the distance between standard percentiles calculated statistically from a normal curve. The equation of Folk and Ward (1957) considers the averages of the distances for both the 2 standard deviation and the 3.3 standard deviation measurements; thus the central tendencies as well as the tails are noted. This is necessary because, as the energies of transporting agents vary, so do the effects of the amount of sorting in the sediments deposited. Only by using calculations taken from both the tails and the central zone is it possible to compare the sorting in a nearly normally distributed sample to that of a sample with a multi-modal or skewed nature.

In the case of turbidity current deposits, sorting is a distinct characteristic as the sediments are of such an extremely bimodal nature. In all the other environments of deposition the ranges of sorting show overlap although characteristic concentration points occur (p. 13). It should be noted that deposits in strictly aqueous environments have a tendency to be less well sorted than those in environments where transportation is accomplished, at least in part, by wind. (p. 25). This is due to the suspended particles which are winnowed out and removed by wind but which remain in the water medium and settle out slowly among the coarser fractions as turbulence is reduced. This is evidenced in most sediments, and is the reason Inman (1949) stated that once the sediment attains a critical diameter and continues to get finer it will "round the corner" on the curve and sorting will worsen with further transport.

The next statistical parameter examined is skewness, a measure of the asymmetry of the sediment curve. This parameter is sensitive to the effect that deposition has on the tails of the sample. Values obtained only from one comparison with the central zone of the distribution curve may fail to detect a sediment with an abrupt termination of one tail. Therefore, skewness is calculated using the distance between two sets of percentiles on the sediment curve and comparing them individually with the median (Folk and Ward, 1957). Positive values indicate a tail of fines while negative values indicate a tail of coarse particles. Values for a sample between -.10 and .10 indicate a nearly symmetrical sediment sample.

Histogram 1: Standard Deviation (Sorting)

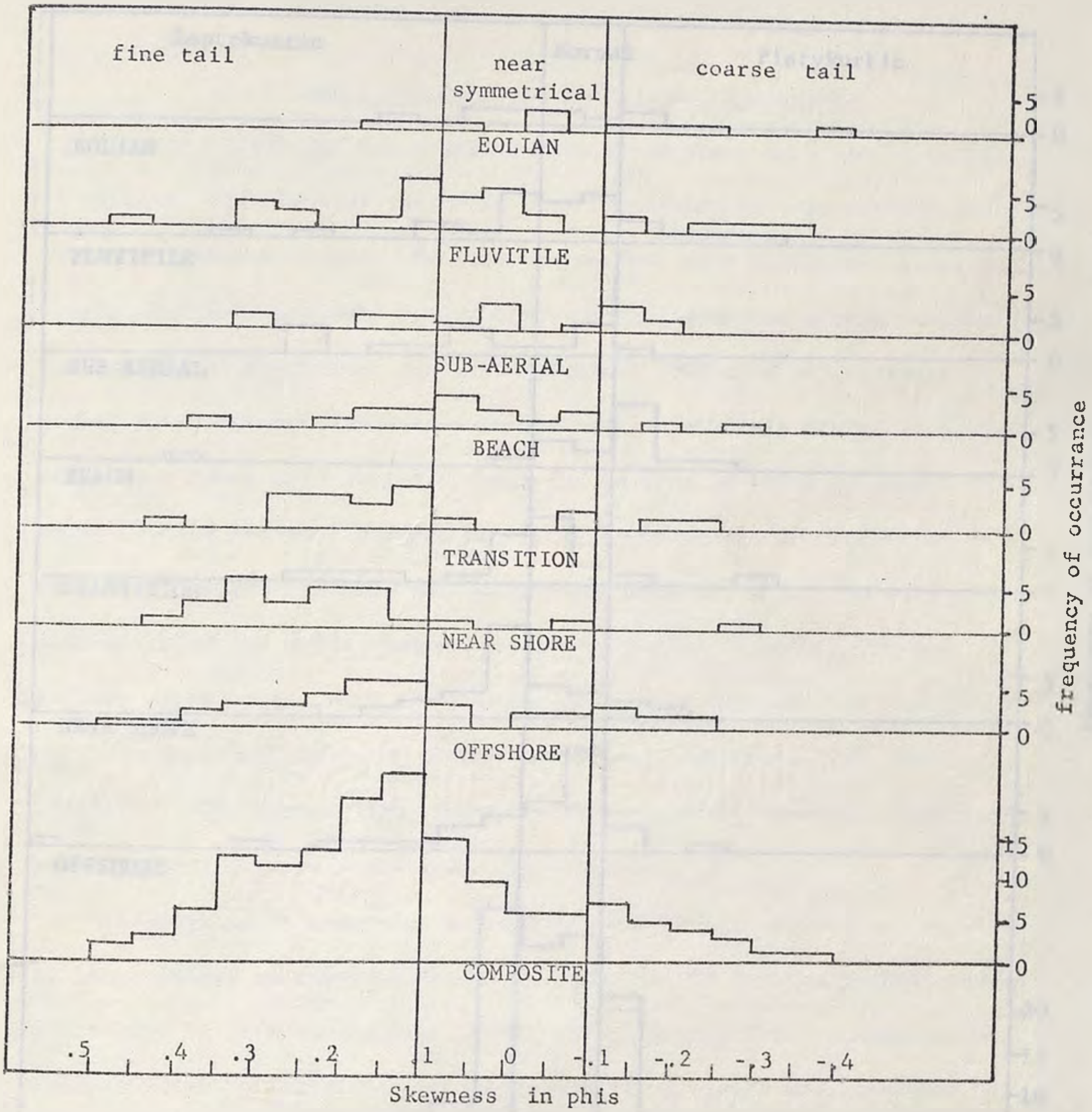


While it is not possible to segregate environments of deposition by means of skewness measurements, it is possible to recognize characteristic trends (p. 15). These trends are for tails of fines in water-laid deposits and tails of coarse material in eolian deposits. The difference is due to the energy of the environments since the fines are removed by the wind but held in suspension by the water. Also there is less coarse material available for deposition in lake environments at the basinal center, as turbulence of the transporting mediums leaves the coarser particles in place at the lake perimeters. The trend of having the sample skewed to the fines is also shown on p. 26; this is an aid in segregating sediments from different environments of deposition.

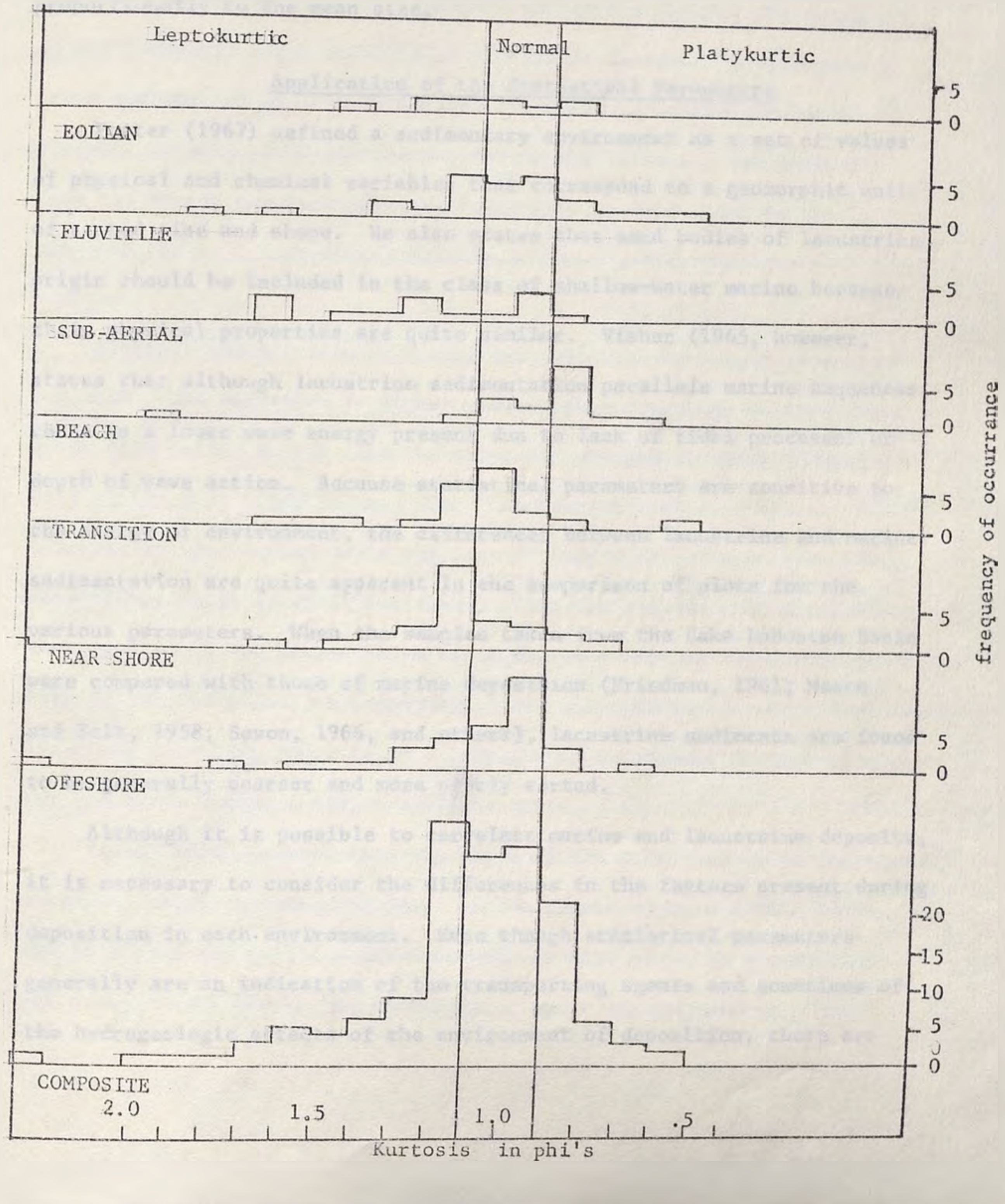
Kurtosis is also measured for all the samples. This is a measure of the ratio of sorting in the tails to the sorting in the central zone of the sediment distribution curve. In all the sediments measured, kurtosis indicated that the sorting in the central part of the curves is normal or slightly better than the tails (p. 16). This is believed to be a result of the nearness of the source area, rapidity of deposition, and limited amount of reworking of the sediments. Kurtosis, which has been found to be environmentally sensitive in marine sediments by many authors, is of little value when applied to Lake Lahontan sediments. The plot of kurtosis and skewness was found to be of no value due to the large overlap of both parameters even though it had been used effectively before in marine environments (Mason and Folk, 1958).

A fifth value, the coarsest 5 percent, was compared to the mean diameter. This value is useful as it is a good indicator of the upper limit of the energy of the transporting agent and is also a fairly

Histogram 2: SKEWNESS



Histogram 3: KURTOSIS



accurate indication of the distance from the source. Since much of the material in the Lake Lahontan sediments is derived locally, the coarsest 5 percent is particularly sensitive to the environment of deposition. When plotted against mean diameter, this parameter forms a fairly straight line (p. 27) indicating that the coarsest fraction decreases proportionally to the mean size.

Application of the Statistical Parameters

Potter (1967) defined a sedimentary environment as a set of values of physical and chemical variables that correspond to a geomorphic unit of stated size and shape. He also states that sand bodies of lacustrine origin should be included in the class of shallow-water marine because their physical properties are quite similar. Visher (1965, however, states that although lacustrine sedimentation parallels marine sequences, there is a lower wave energy present due to lack of tidal processes or depth of wave action. Because statistical parameters are sensitive to the energy of environment, the differences between lacustrine and marine sedimentation are quite apparent in the comparison of plots for the various parameters. When the samples taken from the Lake Lahontan Basin were compared with those of marine deposition (Friedman, 1961; Mason and Folk, 1958; Sevon, 1966, and others), lacustrine sediments are found to be generally coarser and more poorly sorted.

Although it is possible to correlate marine and lacustrine deposits, it is necessary to consider the differences in the factors present during deposition in each environment. Even though statistical parameters generally are an indication of the transporting agents and sometimes of the hydrogeologic effects of the environment of deposition, there are other factors which also influence the values of statistical parameters and cause variations in the plots. These factors include source types, distance to the source areas, rate of supply, and depositional rate.

The source for the Lake Lahontan sediments is primarily plutonic material from the Sierras to the west, and various mostly volcanic ranges to the east, or local highlands within the basin. The sediments of the Wadsworth area, which is of particular interest in this paper, are a combination of locally derived fragments of volcanic rock and plutonic material from glacial outwash in the Sierras. The distance from the source of the sediments to the site of deposition in the Lake Lahontan Basin is, therefore, relatively short and is considered to be constant.

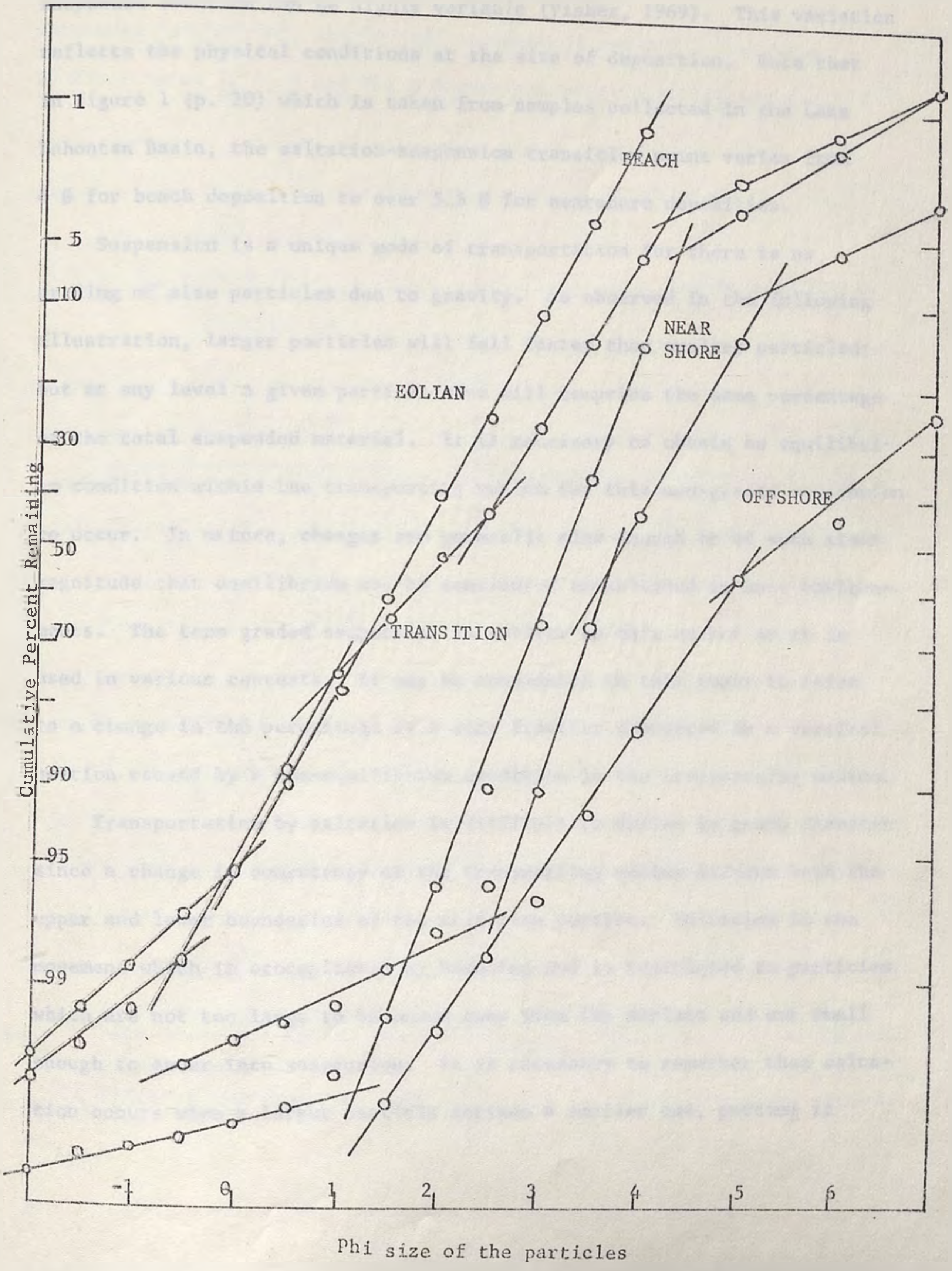
Although the distance is a constant, the rate of supply is quite variable. The variation is rather uniform throughout the basin at any given time period as the lake was primarily changed by climatic cycles. Only at times of rapid changes over local extent such as a glacial dam breakage in the Sierras would the rate of supply of sediment particles vary within local parts of the basin. Thus the statistical calculations when applied to the entire basin would depend mainly on the depositional rate of the individual environments, since the type of sediment, distance to source material, and rate of supply remain relatively constant throughout the basin during a single climatic cycle.

It has been observed that the shape of the particles is an important physical factor in sedimentation. In the papers by Moss (1962, 1963), the role that the particle shape as well as size plays in determining the energy exhibited by the transporting agent was emphasized. The shape is critical in determining the turbulence necessary to move a particle. The sediments deposited in the Lake Lahontan basin are of relatively uniform shape and are classified in a general group of sub-angular to sub-rounded according to the Powers Roundness Scale (1953). Since the shape does not vary from area to area, the same turbulences will produce the same characteristics when statistical parameters are applied.

Since the type of material deposited is dependent on the type supplied, it is necessary to study the transporting agents to understand the segregation that appears in plots using statistical parameters. The three basic modes of transportation by any agent are surface creep, suspension, and saltation. The particle shape determines the amount of energy necessary to move a given particle. For example, a particle with corners may resist the force of a stream while a rounded particle of equal size and mass would roll along the stream bottom when the same amount of energy is applied. Since particle shape is relatively uniform, the energy of the transporting agent is indicated by the percentage of the total sample carried in one of the three basic modes of transport and by the size that is represented within the boundaries of an individual mode (p. 20). Thus the textural parameters which vary as the transporting agents vary indicate the mode of transportation under which any given size particle moves. The limits of these various modes must be known in order that the energy of the transporting agent can be gauged against the other agents. The following is a general list of what may be expected for the various modes of movement.

The size of a particle that can be held in suspension is dependent

Figure 1
Phi Size of particles vs the Cumulative Percent Remaining



on the turbulence of the environment and the shape of the particle. Consequently, the transition point between the saltation fraction and the suspended fraction can be highly variable (Visher, 1969). This variation reflects the physical conditions at the site of deposition. Note that in figure 1 (p. 20) which is taken from samples collected in the Lake Lahontan Basin, the saltation-suspension transition point varies from 4 0 for beach deposition to over 5.5 0 for nearshore deposition.

Suspension is a unique mode of transportation for there is no grading of size particles due to gravity. As observed in the following illustration, larger particles will fall faster than smaller particles; but at any level a given particle size will comprise the same percentage of the total suspended material. It is necessary to obtain an equilibrium condition within the transporting medium for this non-graded suspension to occur. In nature, changes are generally slow enough or of such minor magnitude that equilibrium can be considered established in most environments. The term graded suspension is unclear to this author as it is used in various contexts. It may be considered in this paper to refer to a change in the percentage of a size fraction deposited in a vertical section caused by a non-equilibrium condition in the transporting medium.

Transportation by saltation is difficult to define by grain diameter since a change in competency of the transporting medium affects both the upper and lower boundaries of the saltation portion. Saltation is the movement which is accomplished by bouncing and is restricted to particles which are not too large to be moved away from the surface and not small enough to enter into suspension. It is necessary to remember that saltation occurs when a larger particle strikes a smaller one, putting it

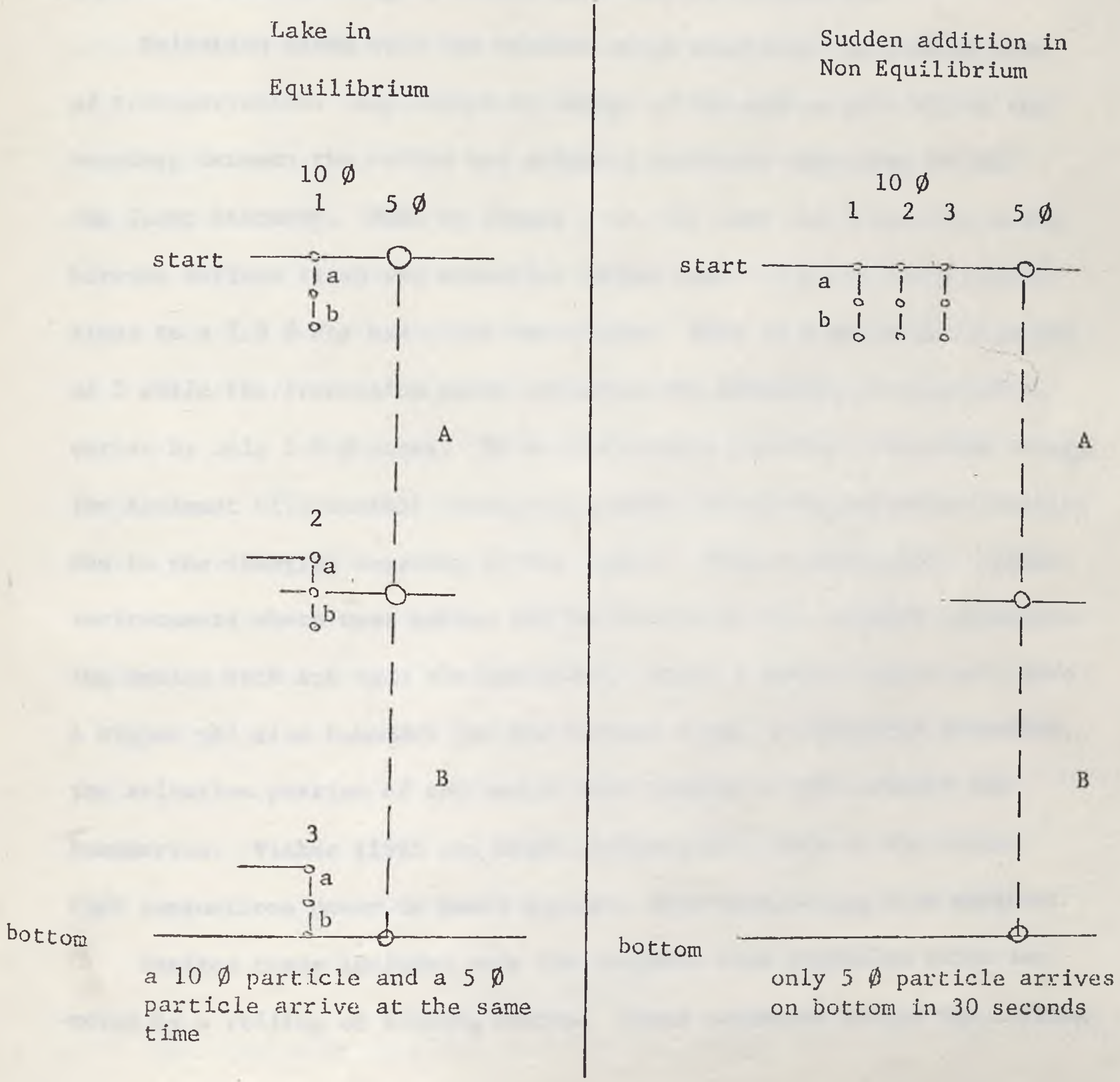
Rate of Particle Settlement in Equilibrium Conditions

distance 5Ø particle moves in 15 seconds

distance 10Ø particle moves in 15 seconds

distances "a","b","A", and "B" all indicate 15 seconds of settling

10 Ø particles 1, 2, 3 and the 5 Ø particle start similtaneously



a 10 Ø particle and a 5 Ø particle arrive at the same time

only 5 Ø particle arrives on bottom in 30 seconds into motion; and if the energy is the same over a period of time, the size of the saltating particles will be gradually reduced since a smaller particle never starts a larger one bouncing. Application of this principal causes one of the distinct characteristics of motion by saltation: graded bedding. Harris (1957) shows that finer particles will be removed by saltation leaving a bed of coarser particles. As this process is continued without interruption, the deposit will tend to become finer although a coarse tail will be maintained.

Saltation along with the surface creep comprises the bedload form of transportation. Any change in energy of the medium will affect the boundary between the rolled and saltated particles more than it will the finer boundary. Note on figure 1 (p. 20) that the transition point between surface creep and saltation varies from -.5 0 for beach depositions to a 2.5 0 for nearshore deposition. This is a phi size deviation of 3 while the truncation point variation for saltation to suspension varies by only 1.5 0 sizes. In an environment that has a variable energy, the sediment will exhibit transition points within the saltation fraction due to the changing capacity of the medium. This is evidenced in beach environments where wave action and the action of the original transporting medium both act upon the particles. Since a weaker medium will have a higher phi size boundary for the surface creep to saltation interface, the saltation portion of the sample will exhibit a break within its boundaries. Visher (1965 and 1969) believes that this is the reason that laminations occur in beach deposits with alternating size mediums.

Surface creep includes only the coarsest size particles which are moved by a rolling or sliding motion. These sediments exceed the lifting capacity of the transporting medium. Since these particles are usually the index of the upper capacity to the transporting agent, they often form mean and sorting parameters separate from the other fractions of the sample (Folk and Ward, 1957; Passega, 1957; and Visher, 1969). While the saltation fractions and suspended fractions often grade into each other, the surface creep interface is usually sharply defined.

All sediment particles deposited in any environment are transported in one of the above manners. It is necessary to remember that these modes of transportation occur together so that a sediment sample is composed of an admixture of material transported by all three mechanisms. The statistical parameters of a sediment represent the total energy of the medium in which it is deposited.

Passega (1957) recognized that textural parameters represented the transportation rather then the environments in general. He also stated that examples from several environments show that the coarse fraction is invariably the most representative of the depositional agent. The development of "CM" patterns was an application of this principal (Passega, 1957). The success shown by plotting the coarsest 5 percent versus mean diameter graph (p. 27) demonstrates this observation also is true for sediments in the Lake Lahontan Basin.

Using the sedimentation properties outlined above, there are eight environments of deposition in the Lake Lahontan Basin which are subdivided by the use of statistical parameters. The segregation of these environment populations are shown on figures 2, 3, and 4 on the following pages.

Eolian Environment

The deposition resulting from aerial transportation have the coarsest

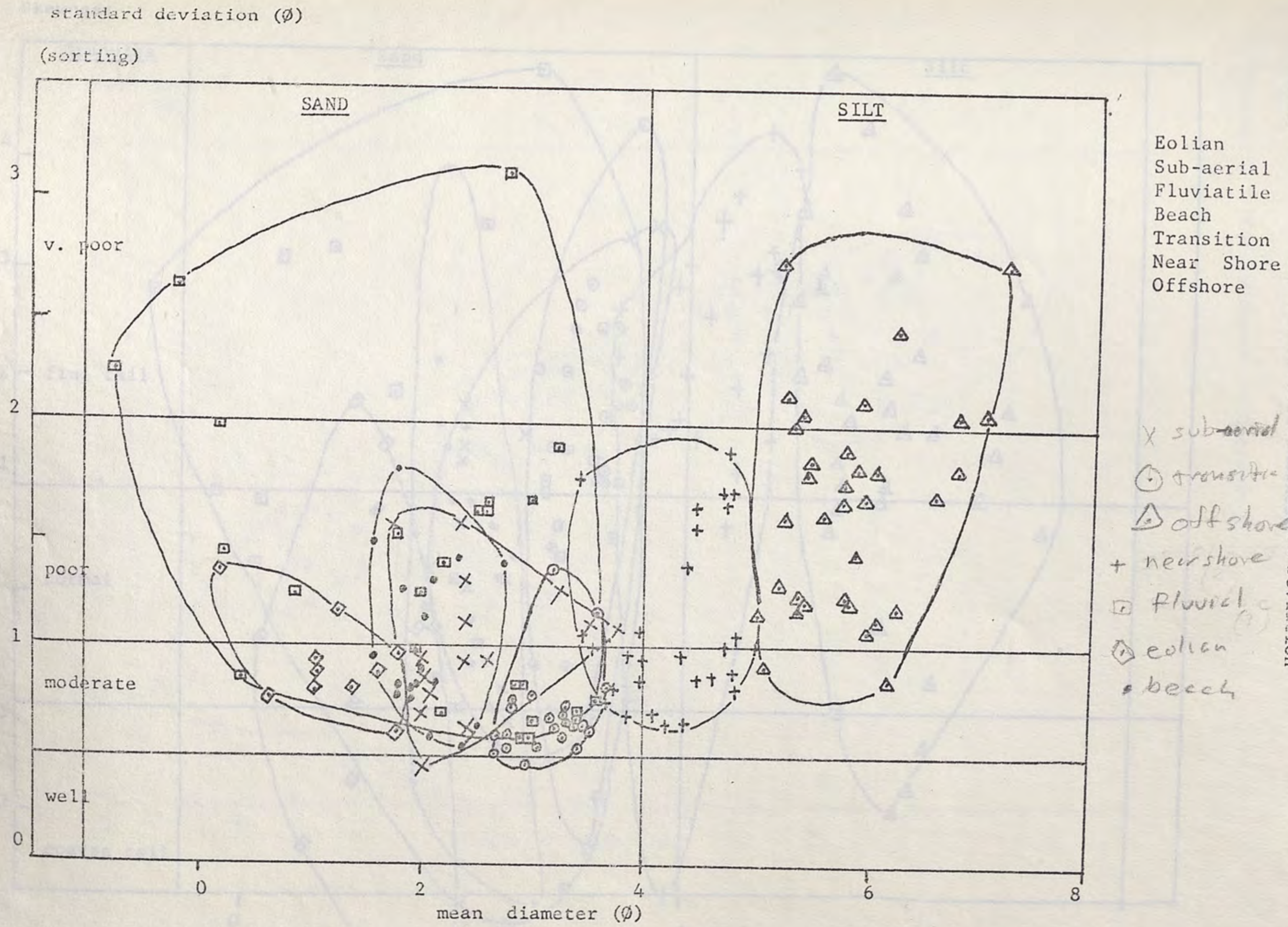


Figure 1 Mean Diameter vs Standard Deviation

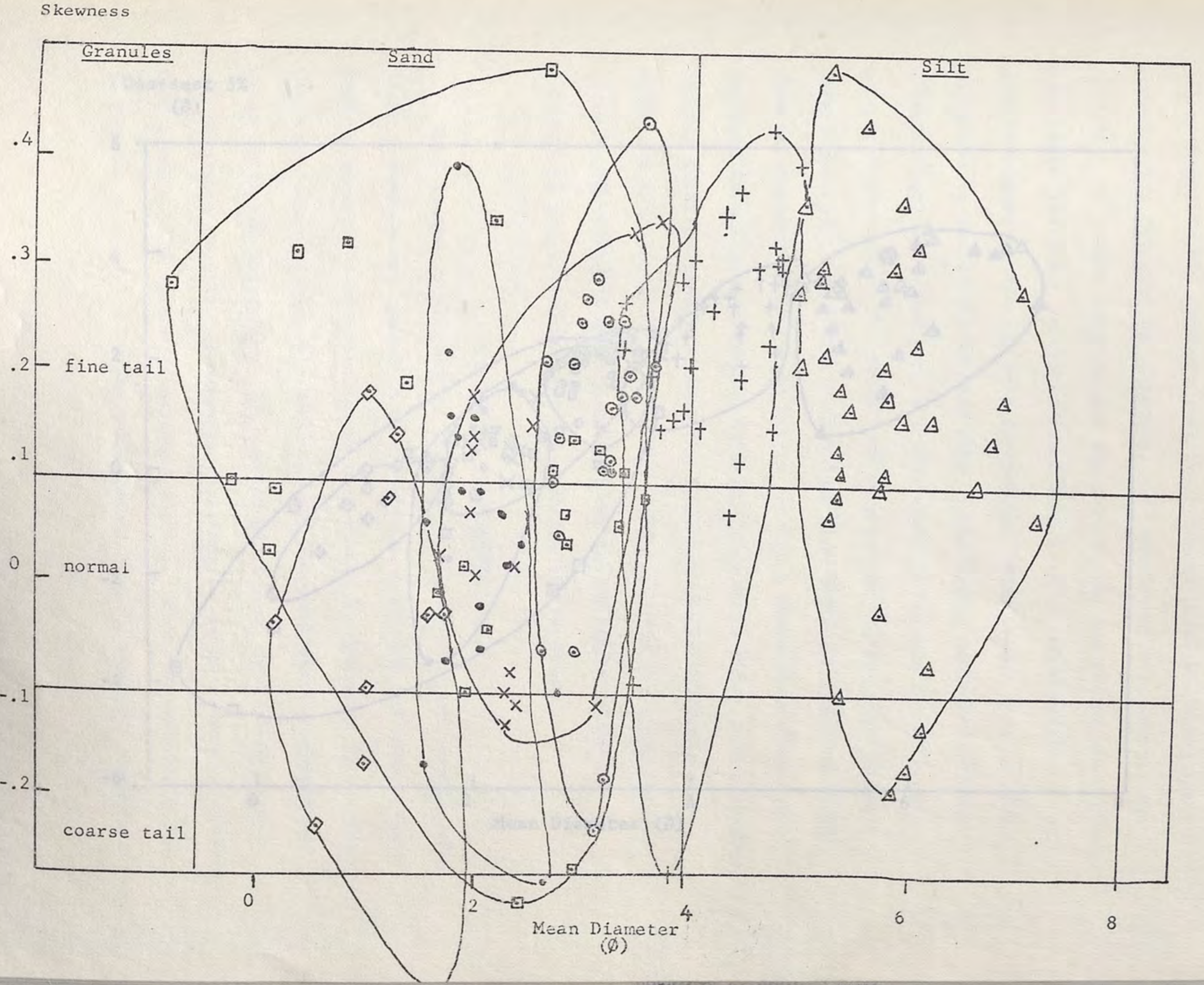
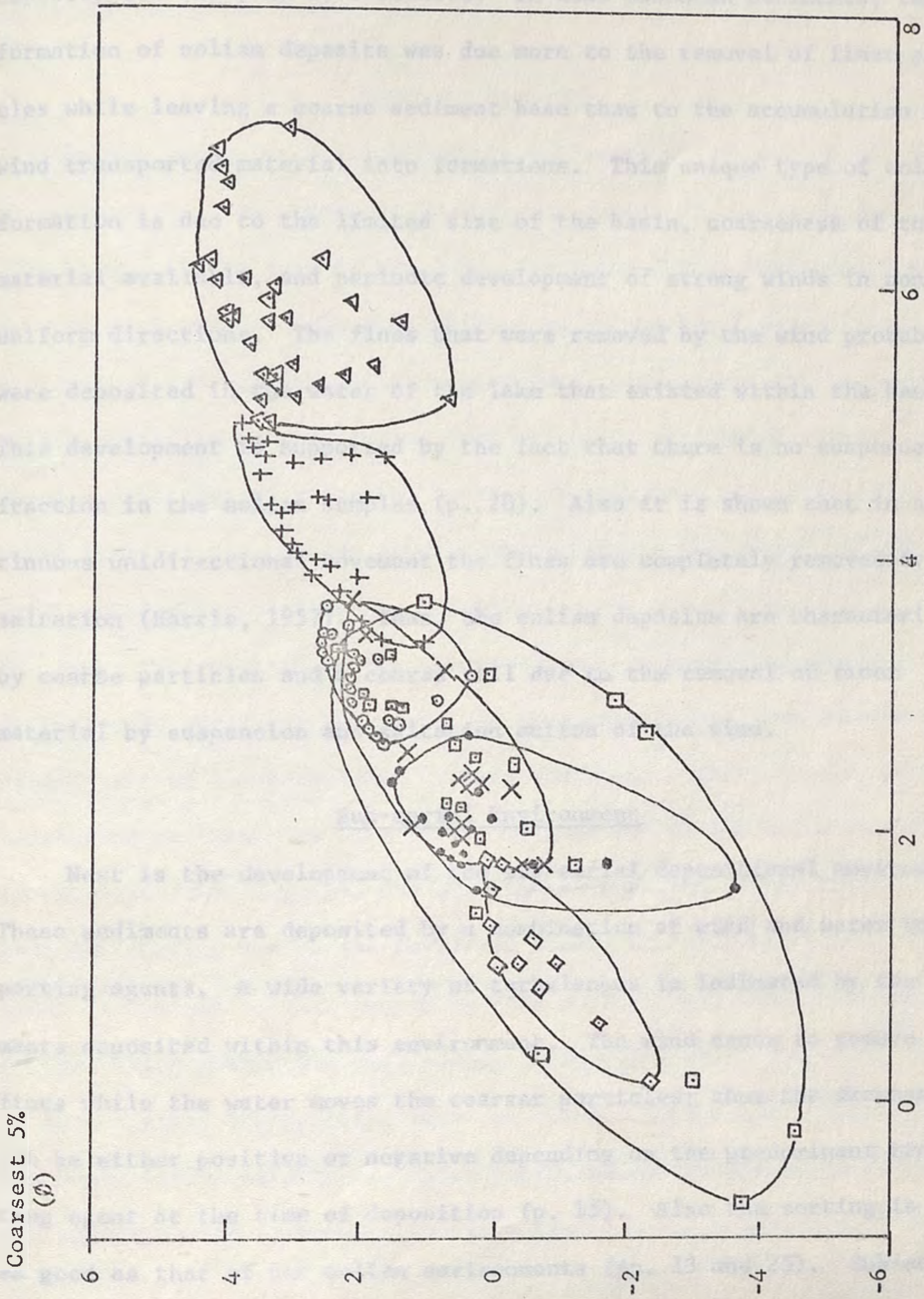


Figure 2 Mean Diameter vs Skewness

Figure 3 Mean Diameter vs Coarsest 5%



mean diameter. Also the tails of the distribution curves of these sediments are skewed negatively (p. 15). Under a general marine environment eolian deposits are commonly positively skewed; thus the upper limit of capacity for the wind is indicated. In Lake Lahontan sediments, the formation of eolian deposits was due more to the removal of finer particles while leaving a coarse sediment base than to the accumulation of wind transported material into formations. This unique type of eolian formation is due to the limited size of the basin, coarseness of the material available, and periodic development of strong winds in non-uniform directions. The fines that were removed by the wind probably were deposited in the water of the lake that existed within the basin. This development is supported by the fact that there is no suspended fraction in the eolian samples (p. 20). Also it is shown that in a continuous unidirectional movement the fines are completely removed by saltation (Harris, 1957). Thus, the eolian deposits are characterized by coarse particles and a coarse tail due to the removal of finer material by suspension and saltation action of the wind.

Sub-aerial Environment

Next is the development of the sub-aerial depositional environment. These sediments are deposited by a combination of wind and water transporting agents. A wide variety of turbulences is indicated by the sediments deposited within this environment. The wind tends to remove the fines while the water moves the coarser particles; thus the skewness can be either positive or negative depending on the predominant transporting agent at the time of deposition (p. 15). Also the sorting is not as good as that of the eolian environments (pp. 13 and 25). Sub-aerial sediments are a refinement of the eolian deposits with the coarser particles being regrouped by the higher energy capacities of the water medium while the finer particles are held in suspension and slowly deposited among the coarser particles.

Beach Environment

As the particles are continually subjected to the action of the wind and water, they progress towards the center of the basin and the lake body. At the edge of the lake, sediments form a laminated unit in a beach environment. The only difference in the beach depositional environment and the sub-aerial depositional environment is the reworking of the particles by wave action from the lake. The beach samples contain three populations of saltation because of this wave action (p. 20). The upper limit of the coarser population represents the energy of the environment which carries the particles to the site of deposition while the finer two populations are the result of the reworking of these particles by swash and backwash. As discussed before, the development of well sorted beach material by wave action does not occur in these lacustrine sediments as wave action is weak and is far below the energy of the agent that deposits the material at the site of the beach. Note that the sorting due to the saltation within the original transporting agent is similar to that caused by wave action, only the upper capacity for saltation within the wave medium is at 2.5 Ø while the upper limit of the original transporting agent is -.5 Ø. This would indicate that the waves influence only the finer particles on the beach; therefore, the sorting would be poorer than in a general marine environment of deposition. The skewness would also tend to be positive since the suspension fraction would encompass a smaller range of particles leaving more fines within the beach zone. The stronger wave action with marine beaches would winnow out much of this finer fraction leaving a negatively skewed deposit. Also the rate of supply of sediments to the beach environment exceeds the ability of the wave action to rework them.

While eolian and sub-aerial deposits are unidirectional, beach sediments are deposited in a two-directional manner. Friedman (1961) states that unidirectional flow of a medium tends to result in positive skewness in marine deposits again emphasizing the differences between beach and eolian deposits of marine and lacustrine depositional environments.

Another indication that the wave action is weak in comparison to the original forces that brought the sediments to the edge of the lake is the obvious over-lap of the values for the graphs that are used to segregate the other environments (figures 2, 3, and 4). The mean diameter, skewness, standard deviation, and even the coarsest 5 percent are extremely similar between the beach and sub-aerial environments of deposition. In fact, the two environments are not separable by the use of statistical parameters alone. The only difference noticed is in the lithologic appearance.

Fluvial Environment

Another mixed environment is the fluvial class. This sedimentary environment is a wholly water transported one in an ideal situation. In an actual environment, these particles are alternately transported and deposited as the climatic factors vary. These changes in velocity also cause extreme changes in the statistical parameters calculated from the samples. Note the wide variation in the mean diameters of the fluviatile deposits (figures 2, 3, and 4). The mean diameter was found to be a good diagnostic feature of all the other depositional environments. Also in the histograms it is noticed that besides turbidites, fluviatile samples have the highest standard deviation values although many samples fall within the moderate sorting range (p. 13). The skewness (p. 15) shows that the samples tend to be positively skewed indicating that the suspended fraction is included although most of the samples fall in or near the nearly symmetrical zone of the chart. This symmetry is probably an indication of the inclusion of a coarser tail due to periodic high energy levels within the transportation medium. This wide variability makes the use of statistical parameters on fluvial deposits impossible although it is noted that none of the fluvial samples lie within the ranges of nearshore or offshore deposits on the comparison graphs (figures 2, 3, and 4).

Turbidity Environment

The only other coarse grained deposit results from transportation in turbidity currents. Deposits of this type were found only within the Truckee River Canyon where nearly vertical cliffs formed the edges of the lake. These turbidity current deposits are characterized by standard deviations over 3.00 (see data cards in the index). Since no other deposit has standard deviations that approach this poor a sorting, standard deviation is the only parameter needed to identify the environment. The curves of the sample show an extreme bimodal nature since the gravels and granules were added to nearshore or offshore environments of deposition of clays and silts.

Transitional Environment

There are three other aqueous environmental divisions possible: transitional, nearshore, and offshore. All of these are affected by a continual deposition of suspended particles from an overlying body of water that is in an equilibrium state. By equilibrium this author means that the lower layers of water contain approximately the same percentage of any phi size particle in suspension as is present in the upper layers. This equilibrium therefore results in uniform and non-graded deposition of finer particles. In addition, particles move into the depositional environment along the slope of the lake to be admixed with the finer suspended particles.

The transitional environment is in shallow water off the beach. The sediment particles that waves removed from the beach by traction plus the particles that are fine enough to be moved across the beach by the original transporting agent, are deposited within the transition zone. The sorting is better than the beach since the energy levels are less and only finer material is transported from the beach (p. 20). Only in the fraction of the depositional curve caused by suspended particles do the transitional environment sediments appear more abundantly than those in the beach environment. The skewness is positive due to the addition of the suspended particles during the depositional process (p. 15).

Nearshore Environment

In slightly deeper water, there is a zone that receives only particles that are fine enough to move by creep or saltation through the transition zone. These particles are of such small quantities that the deposition from the lake in the form of slowly subsiding suspended particles may nearly equal it; thus forming two distinct populations, one composed of coarser particles that creep into the depositional environment and another composed of suspended particles. These two particle populations have a transitional boundary within the saltation fraction, for as energy levels are reduced, former suspended particles become saltated particles. The coarser particles are usually of only slightly larger diameters than those in suspension and the large addition of suspended material skews the distribution curves positively (p. 15). The sorting ranges from poor to moderate (p. 13) indicating that the material derived from the suspended population is of a uniform composition and poorly sorted throughout.

Offshore Environment

Offshore deposits appear towards the basin center and compose a zone of deposition almost completely from suspension. On figure 1 (p. 20), the offshore sample shows a saltation population and a suspended population. The saltation population is composed primarily of particles that no longer remained in suspension under the reduced turbulence conditions that are present in the deeper lake environments. The lack of any surface creep population supports this conclusion as it suggests that the particles must arrive within the water medium and not along the surface. Note that both nearshore and offshore saltation material contains particles that must have been suspended in more turbulent environments.

The offshore deposits were found to be quite fine with all but three of the samples being composed of 75 percent or more of silts and clays. These fine deposits lead to a varved nature in the sediments which is often observed in the deeper lake environments. Also the distribution curve is skewed toward the fines (p. 15). Note also that the standard deviation indicates poor sorting (p. 13) caused also by the predominant deposition from the uniform suspension environment.

The environments of deposition can be segregated by the use of statistical parameters (figures 2, 3, and 4). However, when marine and lacustrine environments are compared, several differences in the statistical parameters are noted within a single depositional environment. These differences are explicable when the modes of transportation are considered since the transporting agents vary in influence between marine and lacustrine areas.

CONCLUSION

The application of statistical parameters for the determination of paleo-environments within the Lake Lahontan sediments is an aid to stratigraphic mapping of the lake basin. The statistical limits placed on the boundaries of the various environments are slightly flexible but vary little throughout the region. The samples were collected in such a manner as to cover any variances that may have occurred in more restricted depositional areas such as the Truckee River Canyon; however, the bulk of the samples were collected from two stratigraphic sections near Wadsworth, Nevada. These sections allow this author to compare the results of the statistical parameters to those of stratigraphic studies.

Type of Deposition at Wadsworth

Morrison and Frye (1965) felt that the outcrops of Lake Lahontan sediments in the Wadsworth area were anomalously thick and were caused by deltaic deposition at the mouth of the Truckee River. The present author believes that the outcrops are not anomalously thick but instead reflect a typical sequence of sediment deposition within the central part of the Lake Lahontan Basin.

The differences in the thicknesses of the formations of the Wadsworth area as compared to their type sections are in part caused by the location of the type sections on the extreme edges of the lake basin. Well logs taken in the central part of the Carson Desert (Morrison, 1964) show a thick sequence of clays under the Wyemaha formation. Some of these sediments are undoubtedly pre-Lake Lahontan; however, it is not unlikely that the thickness of Eetza age sediments exceed those deposited in the Wadsworth area at the same time. In the well which furnishes most of the water for the Fallon area, 217 feet of unidentified clays lie between the Wyemaha formation and the basalts of the Rattlesnake Hill formation of lower Quarternary age (Morrison, 1964). This thickness seems to be that of lower Lake Lahontan sediments (Eetza formation); thus the formation is thicker than the 130 plus feet that appear in the Wadsworth area.

Another consideration is the type of deposition that occurred in the Wadsworth area. If the deposition was deltaic, any transgressive phase of the lake would be indicated by a marked rapid variation of depositional types. This writer failed to find evidence to support this type of variation except for the first transgression of the lower Sehoo formation (see correlation chart). Most of the transgressive phases were of a gradual transition of environments of deposition. Also the common deltaic lithologic features such as topset, foreset, and bottomset cross bedding were not common in the outcrops.

At times during the lake history, there was periodic deltaic deposition in the Wadsworth area. Today, Pyramid Lake, into which the Truckee River flows, is an example of such a deltaic development. As the lake level rose, the mouth of the Truckee River would pass through the area. Birkeland (1965) places the edge of the Lake Lahontan water as far up the Truckee Canyon as Mustang during the higher lake stands; therefore, it does not seem feasible to consider the Wadsworth area one of total deltaic development. This writer concludes that the Wadsworth area represents a typical development of lake sediments and is comparable with the sediments from any part of the basin.

Comparison of Stratigraphic and Statistical Results

At the site of the Wadsworth sections, Morrison, Mifflin, and Wheat (1965) subdivided the Eetza formation into 15 units defined by lithologies and the same number was defined by statistical parameters (see correlation chart). These units show that there are six distinct lake cycles which are represented by the units: 2, 4, 6, 10, 12, and 14. It is also possible that the lower part of unit one and unit eight are representative of other lake transgressions. The combination of stratigraphic information and depositional environments furnishes good control on the formation.

The Eetza and Sehoo formations represent periods of high water in the lake basin while the Wyemaha formation represents a low water level. The Eetza formation can be subdivided into two main lake cycles with an intervening lake recession (Morrison, 1961). The division of these cycles is based upon a tongue of sub-aerial sediments developed in the Carson Desert between layers of lacustrine sediments which had been classified by the development of shore lines. Later refinements of this work (Morrison and Frye, 1965) indicate that at least six major inter-Eetza lake recessions exist which is in agreement with the results of the statistical parameters.

The outcrops in the Wadsworth area exhibit a disconformity between the Eetza and Wyemaha formations (see correlation chart). This contact is easily recognized as an erosional surface; and due to its wide extent, this contact was chosen as the datum plane for stratigraphic correlation. The other contact within the Lake Lahontan Valley group exposed in the area is a paraconformity between the Wyemaha and Sehoo formations. The

Churchill soil horizon lies directly underneath this contact and appears in both sections, although it is poorly developed in the section towards the center of the basin. Also, the Wyemaha formation thins towards the basin (see correlation chart). According to Morrison (1964), the subaerial sediments of the Wyemaha formation extend to the lowest parts of the Lahontan Basin where they are intercalated with the shallow-lake sediments. This author believes that the formation is similar to a tongue which is thick on the edges of the basin but which thins towards the center where there was continuous deposition of lake sediments. Evidence for this conclusion is that the Sehoo formation directly overlies the Eetza formation in some areas. One example is the area just north of the sections at Wadsworth as shown on the geologic map of the area (Morrison, Mifflin, and Wheat, 1965).

Only the lowermost part of the Sehoo formation crops out in the Wadsworth area. The higher portions were eroded and covered by later formations. In the part that is exposed only one transgressive phase is present.

In summary, the stratigraphic work done on the sediments near Wadsworth correlates well with results obtained by the use of statistical parameters. Environments of deposition can, therefore, be used as a means of correlating outcrops throughout the basin and provide additional information on the sedimentation as well as stratigraphy of the Lake Lahontan sediments. This information can help clarify existing problems in the literature on the development of the lake.

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EOLIAN

sam	MD	Skew	SD	K	5%	9%
24	1.77	-.39	.61	.82	.80	.90
29	1.01	.18	.79	1.02	-.80	.02
33	1.03	-.10	.87	1.21	-.25	0
46	.60	-.23	.76	1.53	-1.58	-.92
63	1.02	-.17	.93	1.04	-.93	-.48
64	1.59	-.03	.88	1.13	.05	.39
65	1.77	-.03	.96	.97	.04	.47
102	1.21	.08	1.14	.89	-.60	-.34
103	.17	-.04	1.33	1.24	-2.39	-1.79
148	1.32	.14	.79	1.19	.09	.32

SUB-AERIAL

23	3.70	.34	1.08	1.44	2.20	2.60
25	2.31	-.10	.90	1.34	.40	.97
28	3.45	.33	1.09	1.64	2.00	2.30
66	2.01	.01	.76	1.34	.55	.94
67	2.36	.02	1.11	.99	.54	.82
68	1.98	.13	.93	1.14	.54	.76
69	2.00	.07	.83	.98	.60	.85
98	1.71	.03	1.54	.92	-.69	-.36
99	2.30	-.13	1.54	.89	-.20	.14
100	3.18	-.11	1.23	1.60	.75	1.28
128	1.99	.14	.69	1.23	.71	1.08
145	2.55	.15	.83	1.26	1.34	1.56
147	2.35	-.08	1.28	.99	.27	.58
149	2.40	-.16	.62	1.66	.40	1.43
151	2.00	.18	.44	1.03	1.25	1.51

16%	25%	50%	75%	84%	95%
1.10	1.40	1.80	2.20	2.40	2.80
.25	.50	.95	1.60	1.83	2.65
.25	.50	.95	1.60	1.90	3.00
-.14	.18	.66	1.08	1.29	1.79
0	.38	1.11	1.72	1.94	2.46
.68	1.02	1.63	2.18	2.45	3.25
.72	1.08	1.78	2.49	2.80	3.38
.02	.34	1.14	2.08	2.46	3.19
-1.18	-.70	.20	.95	1.48	2.62
.58	.79	1.27	1.81	2.10	3.04

2.80	2.95	3.50	4.15	4.80	6.40
1.40	1.73	2.33	2.93	3.20	3.97
2.60	2.80	3.30	3.90	4.45	6.90
1.25	1.56	1.99	2.49	2.80	3.37
1.21	1.59	2.36	3.16	3.52	4.32
1.09	1.39	1.93	2.60	2.92	3.92
1.15	1.42	1.95	2.62	2.90	3.92
.10	.59	1.73	2.90	3.31	4.50
.57	1.06	2.52	3.44	3.82	4.92
1.95	2.61	3.30	3.83	4.29	5.52
1.35	1.57	1.91	2.44	2.72	3.38
1.77	2.01	2.51	2.99	3.38	4.35
.94	1.42	2.48	3.22	3.62	4.63
1.79	2.06	2.42	2.84	2.99	3.56
1.58	1.68	1.94	2.33	2.48	2.91

FLUVITILE and FLUVITI

sam	MD	Skew	SD	K	5%	9%
1	2.73	.11	3.12	1.25	-2.25	-1.50
16	.17	.03	1.98	.85	-3.00	-2.50
21	2.93	.14	.57	1.08	2.05	2.20
22	3.33	.11	.69	.92	2.35	2.50
26	2.87	.04	.82	1.16	1.42	1.70
31	-.77	.28	2.24	1.08	-3.70	-3.40
32	2.95	-.27	1.66	2.49	-1.80	-1.00
34	-.20	.10	2.62	1.18	-4.60	-3.80
43	2.53	.00	1.61	.61	.28	.52
45	2.17	.34	1.32	.72	.54	.67
47	.38	.31	.85	1.40	-.70	-.48
48	1.37	.19	.80	1.44	.28	.52
60	3.29	.01	.78	1.95	1.53	2.10
61	3.38	.06	.59	1.02	2.57	2.65
82	3.17	.13	1.90	1.35	.10	.61
84	.82	.32	1.23	1.14	-.70	-.46
88	.20	.09	1.42	1.27	-1.77	-1.45
92	2.48	-.30	1.60	.92	-.27	.04
95	1.98	-.20	1.24	1.01	-.48	.05
96	1.94	-.10	.96	.91	.25	.56
97	1.73	-.01	1.50	1.07	-1.20	-.51
101	2.79	-.10	.82	1.74	.78	1.41
110	2.87	.07	.58	1.22	1.81	2.05
118	2.56	.14	.62	1.11	1.59	1.72
124	2.17	-.04	.69	1.22	.61	1.08
127	1.91	.02	.80	1.21	.42	.75
129	2.98	.25	.66	1.20	2.04	2.16
144	3.57	.08	.75	1.10	2.36	2.57
152	2.64	.48	1.64	1.05	.63	.98

ILE MIXED

16%	25%	50%	75%	84%	95%
-.20	.95	2.60	4.70	5.80	9.20
-1.95	-1.40	.15	1.80	2.30	3.60
2.40	2.55	2.90	3.35	3.50	4.15
2.60	2.80	3.30	3.80	4.10	4.60
2.05	2.35	2.85	3.40	3.70	4.40
-2.80	-2.20	-1.10	.75	1.65	4.10
1.60	2.50	3.15	3.75	4.10	5.80
-2.80	-2.00	-.40	1.20	2.60	4.60
.69	.90	2.46	4.02	4.44	4.94
.88	1.11	1.86	3.38	3.78	4.58
-.33	-.16	.27	.81	1.19	2.62
.68	.88	1.40	1.81	2.04	3.54
2.73	2.91	3.32	3.70	3.83	5.42
2.78	2.97	3.41	3.80	3.95	4.64
1.44	1.92	3.07	4.11	4.99	7.30
-.24	.02	.65	1.66	2.05	3.87
-1.14	-.68	.08	.96	1.67	3.31
.56	1.37	2.91	3.70	3.98	4.95
.58	1.07	2.16	2.86	3.20	3.93
.88	1.25	2.02	2.71	2.93	3.49
.03	.57	1.78	2.91	3.37	4.91
2.05	2.43	2.81	3.28	3.52	4.38
2.32	2.55	2.84	3.28	3.46	3.98
1.96	2.13	2.51	2.94	3.20	3.79
1.51	1.68	2.16	2.62	2.85	3.41
1.11	1.42	1.88	2.41	2.73	3.34
2.39	2.57	2.89	3.38	3.66	4.42
2.79	3.03	3.53	3.98	4.38	4.92
1.25	1.54	2.04	3.72	4.62	6.23

BEACH

sam	MD	Skew	SD	K	5%	9%
17	1.55	-.17	1.47	2.07	-3.62	-2.10
30	1.57	.06	.92	.91	.20	.39
38	1.74	.22	1.80	1.19	-1.75	-.49
40	1.98	.16	1.12	.83	.37	.60
42	2.27	.07	1.37	.78	.25	.56
44	1.80	.39	1.25	1.23	.47	.57
49	1.86	.14	.73	1.03	.73	.96
70	1.80	.16	.80	.99	.60	.76
71	1.97	.13	.89	.97	.76	1.00
72	2.06	-.06	.81	.91	.66	.90
93	2.70	-.28	1.36	.95	.45	-.59
94	2.07	-.02	1.29	.90	.07	.34
111	2.36	.02	.53	1.10	1.53	1.64
117	2.43	.04	.63	1.06	1.44	1.59
125	1.90	.09	.79	1.12	.61	.85
143	1.77	-.07	.76	.91	.57	.70
150	2.08	.09	.57	.96	1.08	1.24

TURBIDITY

1	-.03	.68	4.16	.67	-4.20	-4.00
8	1.35	-.17	4.91	.78	-5.60	-5.20
9	1.30	-.39	3.27	.63	-3.95	-3.60

16%	25%	50%	75%	84%	95%
.40	.85	1.50	2.30	2.75	3.70
.60	.80	1.56	2.16	2.55	3.22
.17	.58	1.40	3.12	3.66	5.60
.81	1.08	1.85	2.83	3.27	3.91
.80	1.12	2.24	3.45	3.78	4.67
.71	.88	1.29	2.20	3.40	4.43
1.13	1.34	1.80	2.36	2.64	3.30
1.01	1.20	1.71	2.31	2.67	3.27
1.18	1.41	1.92	2.57	2.82	3.51
1.18	1.49	2.10	2.71	2.90	3.38
1.11	1.78	3.06	3.70	3.92	4.91
.68	1.08	2.14	3.05	3.39	4.40
1.84	2.03	2.33	2.72	2.91	3.38
1.80	2.04	2.43	2.88	3.05	3.62
1.12	1.38	1.86	2.40	2.73	3.40
.93	1.24	1.84	2.35	2.55	3.04
1.51	1.64	2.02	2.48	2.71	3.05
-3.70	-3.40	-2.20	3.90	5.80	7.80
-4.60	-3.20	2.05	4.30	6.70	8.60
-3.00	-2.25	2.40	4.00	4.50	5.60

TRANSITION NEARSHORE T

sam	MD	Skew	SD	K	5%	9%
36	3.37	.25	.53	1.26	2.60	2.75
37	3.53	.43	1.13	1.57	2.20	2.45
39	3.24	-.18	.69	1.02	1.86	2.19
40	2.78	.05	.72	1.00	1.52	1.72
59	3.17	.11	.62	.98	2.10	2.35
91	3.13	-.23	1.33	1.77	.38	.86
106	2.95	-.06	.77	1.63	.88	1.72
107	3.41	.20	.63	1.14	2.60	2.68
109	3.49	.18	.61	1.18	2.61	2.71
112	2.64	-.06	.50	1.31	1.72	1.95
113	2.91	.21	.46	1.15	2.13	2.27
114	3.02	.27	.53	1.18	2.18	2.37
116	3.23	.25	.58	.68	2.54	2.60
119	2.72	.10	.53	1.27	1.90	2.05
120	3.35	.18	.63	1.10	2.53	2.61
121	3.28	.11	.70	1.21	2.12	2.44
122	3.26	.12	.65	1.27	2.10	2.51
123	2.66	.21	.59	1.17	1.75	1.95
126	2.77	.17	.56	1.18	2.01	2.09
141	3.12	.29	.66	1.24	2.17	2.36
142	3.67	.21	.81	1.14	2.55	2.67
146	2.79	.14	.74	1.25	1.60	1.82

O BEACH

16%	25%	50%	75%	84%	95%
2.90	2.95	3.30	3.60	3.90	4.60
2.65	2.80	3.30	3.95	4.65	6.60
2.51	2.72	3.30	3.76	3.90	4.45
2.05	2.26	2.73	3.27	3.55	3.98
2.57	2.70	3.12	3.65	3.82	4.36
1.77	2.66	3.38	3.86	4.25	5.56
2.22	2.54	2.92	3.42	3.70	4.38
2.82	3.01	3.37	3.81	4.03	4.82
2.93	3.09	3.45	3.86	4.10	4.82
2.13	2.34	2.68	2.94	3.12	3.64
2.51	2.60	2.84	3.21	3.39	3.84
2.55	2.65	2.92	3.34	3.58	4.16
2.69	2.83	3.18	3.56	3.81	4.57
2.19	2.38	2.70	2.99	3.27	3.79
2.76	2.94	3.32	3.78	3.96	4.78
2.63	2.81	3.26	3.75	3.96	4.89
2.66	2.81	3.23	3.67	3.90	4.77
2.10	2.26	2.58	3.01	3.29	3.89
2.22	2.40	2.73	3.06	3.35	3.91
2.55	2.68	3.01	3.51	3.79	4.68
2.90	3.12	3.57	4.12	4.53	5.32
2.09	2.34	2.73	3.24	3.54	4.34

						NEARSHORE
sam	MD	Skew	SD	K	5%	9%
5	4.70	.43	1.65	2.62	2.70	3.40
6	4.43	.12	.83	1.75	2.70	3.40
13	3.92	.29	1.06	1.32	2.60	2.80
14	4.73	.15	1.70	.90	2.20	2.65
15	3.82	-.27	.95	1.22	2.05	2.50
18	4.42	.20	1.63	1.45	1.95	2.50
20	3.97	.21	.94	1.30	2.75	2.94
52	4.42	.37	1.53	1.04	2.62	2.78
53	4.37	.07	.63	1.19	3.40	3.60
57	4.59	.30	.85	1.41	3.58	3.67
58	4.19	.26	.63	1.04	3.25	3.52
76	3.92	.17	.84	1.21	2.54	2.90
78	4.81	.31	.80	1.25	3.70	3.92
81	4.71	.23	1.89	1.07	1.07	2.48
83	3.39	.27	1.75	1.32	1.11	1.48
90	3.72	.15	.82	1.57	2.31	2.64
105	3.40	.23	1.05	1.20	1.80	2.12
108	4.77	.31	.87	1.21	3.62	3.76
130	3.51	-.09	.97	1.24	2.08	2.18
131	4.35	.60	1.36	1.23	3.04	3.12
136	4.96	.39	.99	1.20	3.76	3.95
137	4.08	.15	.68	.98	3.06	3.20
140	4.30	.35	.94	1.25	3.12	3.28
153	4.80	.30	1.03	1.19	3.52	3.66
155	4.01	.31	.80	1.18	3.02	3.12
156	3.65	.20	.73	1.20	2.53	2.68
157	3.82	.16	.66	.94	2.78	3.01
158	4.72	.32	.99	1.25	3.54	3.65
160	4.68	.54	1.70	1.11	3.10	3.29

16%	25%	50%	75%	84%	95%
3.80	3.90	4.50	5.20	5.80	11.00
3.80	3.90	4.40	4.85	5.10	6.75
3.00	3.25	3.80	4.50	4.96	6.60
3.05	3.40	4.60	6.10	6.55	8.10
2.85	3.20	3.85	4.40	4.75	5.60
3.00	3.60	4.30	5.40	5.95	8.40
3.20	3.40	3.85	4.55	4.85	6.40
3.05	3.38	4.11	5.44	6.10	7.83
3.76	3.98	4.39	4.81	4.95	5.80
3.84	4.03	4.49	4.92	5.44	6.66
3.61	3.73	4.09	4.66	4.87	5.61
3.15	3.40	3.84	4.49	4.78	5.77
4.10	4.25	4.66	5.21	5.66	6.64
3.01	3.30	4.43	6.03	6.69	8.85
1.79	2.40	3.16	4.34	5.23	7.34
3.01	3.19	3.66	4.04	4.50	5.57
2.43	2.66	3.25	3.96	4.51	5.62
4.01	4.18	4.62	5.24	5.67	6.76
2.37	3.08	3.58	4.02	4.58	4.91
3.28	3.46	3.86	5.01	5.92	7.71
4.14	4.30	4.76	5.56	5.99	7.45
3.42	3.60	4.02	4.58	4.79	5.41
3.53	3.68	4.14	4.83	5.24	6.64
3.90	4.13	4.66	5.41	5.85	7.25
3.31	3.54	3.90	4.55	4.82	5.94
2.94	3.14	3.53	3.97	4.47	4.97
3.14	3.32	3.73	4.28	4.59	4.99
3.85	4.07	4.58	5.24	5.72	7.10
3.34	3.55	4.21	5.83	6.48	9.30

sam	MD	Skew	SD	K	5%
2	6.00	-.17	1.08	1.48	3.40
3	5.90	.36	2.12	1.37	3.50
4	5.37	.11	1.20	1.03	3.40
7	5.40	-.10	1.78	.98	1.90
10	5.33	.09	1.17	1.15	3.40
11	5.23	.48	2.14	2.45	3.40
19	5.28	.07	2.01	.75	2.75
27	5.17	.30	2.73	1.85	.80
35	5.93	.16	1.66	1.00	3.45
50	6.77	.14	2.04	1.19	4.05
51	5.36	.13	1.21	1.13	3.60
54	7.00	.28	2.06	1.36	4.26
55	5.35	.19	2.07	1.03	2.39
56	6.02	.32	1.80	1.38	3.86
62	5.56	.43	1.59	1.09	3.77
73	5.75	.21	1.89	1.09	3.25
74	5.20	.22	1.58	1.14	3.10
75	7.19	.07	2.73	1.08	3.14
77	4.97	.28	.89	1.02	3.70
79	4.97	.36	1.15	1.60	3.55
80	5.73	.10	1.73	1.53	1.50
85	5.43	.17	1.84	.90	3.12
87	6.20	-.07	2.44	1.05	2.67
88	6.57	.10	1.69	1.06	4.14
89	5.88	-.19	1.81	.95	2.25
104	4.99	.21	.89	1.03	3.69
115	6.02	.23	1.11	1.22	4.27
132	5.76	.18	1.22	1.07	4.14
133	5.73	-.02	1.67	1.17	3.46
134	5.82	.30	1.41	1.05	4.13
135	5.78	.11	1.21	1.02	4.12
138	6.15	-.13	.84	1.22	4.51
139	5.16	.29	1.27	1.16	3.60
154	6.85	.18	1.80	1.21	4.19
159	6.20	.16	1.18	1.24	4.36

OFFSHORE

9%	16%	25%	50%	75%	84%	95%
4.25	4.90	5.35	6.10	6.60	7.00	7.90
3.95	4.25	4.56	5.65	7.20	7.90	12.00
3.85	4.20	4.45	5.30	6.20	6.60	7.80
2.60	3.40	4.20	5.60	6.80	7.20	8.10
3.95	4.20	4.50	5.30	6.10	6.50	7.90
3.70	4.00	4.20	4.80	5.80	6.90	13.00
2.85	3.05	3.45	5.30	6.80	7.50	8.80
2.10	3.20	3.70	4.80	6.40	7.50	13.00
3.94	4.30	4.70	5.80	7.10	7.70	9.30
4.26	4.68	5.60	6.68	7.88	8.96	10.68
3.85	4.18	5.60	6.68	7.88	8.96	9.30
4.70	5.21	5.66	6.74	7.98	9.06	11.95
2.74	3.34	3.73	5.30	6.66	7.40	9.69
4.16	4.52	5.00	5.80	7.30	7.75	10.60
4.01	4.20	4.44	5.18	6.54	7.31	9.35
3.68	3.97	4.35	5.63	6.94	7.66	10.09
3.42	3.75	4.11	5.07	6.17	6.78	8.85
3.82	4.41	5.32	7.20	8.92	9.96	12.70
3.99	4.14	4.32	4.81	5.60	5.95	6.87
3.94	4.14	4.32	4.82	5.60	5.95	8.56
3.73	4.17	4.55	5.52	6.74	7.50	9.65
3.31	3.60	3.90	5.36	6.72	7.34	9.31
3.10	3.53	4.55	6.53	7.76	8.55	10.91
4.40	4.87	5.42	6.54	7.65	8.30	9.92
3.20	3.81	4.50	6.11	7.28	7.72	8.86
3.89	4.17	4.34	4.89	5.62	5.92	6.90
4.61	5.06	5.28	5.87	6.71	7.12	8.51
4.31	4.60	4.97	5.67	6.60	6.98	8.40
3.64	3.90	4.90	5.91	6.82	7.38	8.95
4.28	4.51	4.82	5.61	6.68	7.34	8.92
4.29	4.59	4.96	5.77	6.65	6.97	8.32
5.03	5.28	5.61	6.27	6.75	6.90	7.91
3.78	4.04	4.30	5.01	5.94	6.43	8.25
4.61	5.20	5.68	6.73	7.93	8.63	10.85
4.74	5.11	5.38	6.11	6.84	7.37	8.78