AN ELECTRICAL METHOD FOR THE IDENTIFICATION OF SANDS.

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ABSTRACT. Sorting and angularity, as clues to the method of deposition of sands, are discussed. A method of measuring angularity is described, and a means of graphic representation is given. Formulae, for the extension of the various curves, are listed.

SORTING is a characteristic of sands which often enables the geologist to determine the agency responsible for the deposition of any given sample. It is common knowledge that histograms of wind-blown sands show one maximum, whereas histograms of water-borne sands show two maxima separated by one or more minima. This method of identifying sands has been carried to a fine point; it is now often possible to determine, by an examination of a histogram, from which spot on a dune,[1] on a beach,[2] or possibly on a valley flat, any given sample was taken. The method admits of very little error. Sorting is such a positive characteristic, indeed, that sands originally transported by one agency may be very briefly rehandled by another, and yet give a histogram indicative of the latter.

Soils, originally deposited by streams, and then blown short distances, give wind-blown histograms. Yet, accurately speaking, they are not entirely eolian. Most of their fragmentation, transportation, and consequent rounding was carried on by water rather than by wind. They owe the majority of their characteristics to water handling; nevertheless, a histogram will classify them as wholly eolian.

Many clastic sediments doubtlessly are handled by more than one agent of transportation, yet they are usually assigned to that agent which determined their final (and often least important) characteristic—sorting. If the mode of final deposition is unknown, histograms can usually solve the problem. But if the geologist wishes to determine what agency influenced the individual grains most during their history of transportation, he must turn to some other method.

Since the problem last mentioned is an important one in areas

[1] Sidwell, Raymond, and Tanner, W. F.: Sand Grain Patterns of West Texas Dunes, This Journal, 1939.

[2] Krumbein, W. C., and Pettijohn, F. J.: Manual of Sedimentary Petrography, p. 202, 1938.

where the wind is as powerful as the streams, geologists actually need a method of determining the agent which caused the greatest amount of rounding. The angularity of the individual grains, under the microscope, can be estimated, but it is now known that water, as well as wind, currents can produce rounding in any size of sand. There is one difference, however: sand grains are relatively more buoyant in water, and the ratio of rounding between the large and small grains is therefore smaller than is the case with wind-blown sands. This difference can be determined electrically.

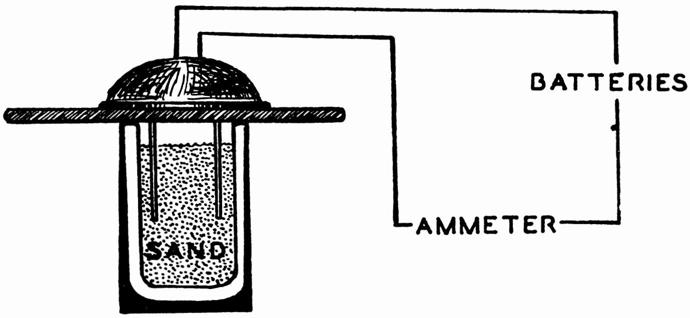

Fig. 1. Wiring diagram for electrical measurements.

Necessary equipment includes batteries, wire, a sensitive ammeter, some plywood, an electric plug, and half a dozen glasses about one and one-half inches high. The two metal prongs of the plug serve as electrodes, and the plywood, inserted under the plug, prevents the electrodes from being moved too far into the sample. The method is simply to measure the conductivity of the water in the spaces between the grains. The procedure is almost equally simple. After sieving (or elutriation), each glass is filled to a uniform, predetermined line, with the sand of one subsample. The sand is then saturated 100 per cent, no more, no less, with water, and the electrodes are introduced. The value for the specific grain size may then be read on the ammeter. When all of the subsamples have been measured, the results are conveniently plotted on semilogarithmic paper, the vertical scale being used for diameters, in millimeters, and the cyclic logarithmic scale being used horizontally for ammeter readings.

In general, if the resulting curve is concave, the sand was transported by water; if convex, by wind. Points to the right represent increasing angularity (or, decreasing distance of transportation). In eolian sands, curves toward the bottom indicate greater length of time in handling. Glacial sands have not been measured, but it is expected that they will give some line other than a smooth curve.

Experiments were made with several beach sands, but the results are probably not representative, inasmuch as the sands were collected from a beach in front of a wave-cut cliff, along a

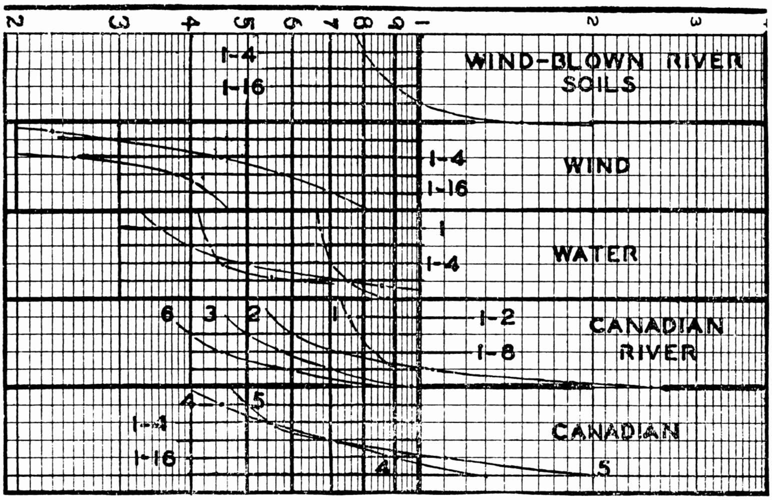

Fig. 2. Curves for twelve sand samples. Angularity increases to the right. The vertical scale, as indicated by the fractions, is calibrated in millimeters.

shoreline of emergence in equilibrium. The resulting curves were convex, and rising to the right, indicating the greatest rounding to be in the smaller grain sizes. How much of this condition is due to the abundance of shell fragments, and how much due to the location of the sand, was not determined.

During the preliminary experiments, measurements were made of wind-blown soils which originally had been water-rounded. The resulting curve was definitely of the concave or "water" type.

A series of samples, taken along the Canadian River, was measured. As a rule, the downstream samples were definitely more to the left (rounded) than the upstream sands. The exceptions occurred where large tributaries introducing angular grains caused the curve to shift, temporarily, to the right (angularity). It was noted that distances as short as fifty miles made a decided difference in the degree of rounding.

Measurements were also made of river sands from humid regions. The results seem to indicate that, for quartz, running water rounds each size toward a certain relative limit, regardless of the climatic conditions.

The accuracy incident to the application of electrical measurements depends largely upon the constancy of all variables except the two used in plotting the final curve. For this reason, fresh batteries, clean sands, uniform containers, and standardized amounts of sand must be used. Small containers (one inch high and three-quarters of an inch in diameter, approximately) are desirable, for they permit readings from screens where the lesser sizes lodge. Containers smaller than this hold too little sand and water for differences to be accurately determinable.

MATHEMATICS.

The choice of semilogarithmic paper, for plotting the curves, was made after considerable experimentation. The curves are of value primarily to the geologist, and secondarily to the mathematician or statistician. Semilogarithmic paper was chosen accordingly, for it tends to emphasize the differences between wind and water curves.

On coördinate paper, wind curves often plot as straight lines, and, since parts of water curves may do the same, there is an opportunity for error when only a few screen sizes are available.

Any equation representing a curve is more conveniently written as a progression, wherein each segment must be determined within the equation before the curve can be extended to the next point. Such progressions have been determined.

When

A is angularity (horizontal axis)
G is grain size within limits (1/64-2 mm.) (vertical axis)
m is "increase value" for water curves
n is "increase value" for wind curves

Then

$$(1) \quad G_3 = G_1/8 + G_2/4, \text{ within limits.}$$

This equation represents the progression along any vertical axis. If any two points (G_1 and G_2) are given, a third point (G_3) may be determined, in relation to the vertical axis.

$$(2) \quad A_3 = m(A_2 - A_1) + A_2, \text{ within limits.}$$

This is the equation of the progression along any horizontal axis, provided the sand grains were rounded by river action. "m" is determined experimentally, or may be found by solving the progression for any curve where three points are available. "m" is usually 2 or 2 and a fraction.

$$(3) \quad A_3 = A_2 + n, \text{ within limits.}$$

This equation, like (2), deals with the horizontal axis, but only in cases where the sand grains were rounded by the action of the wind. "n" increases by addition, whereas "m," noted above, increases by multiplication. It is this fundamental difference that determines the type of curve.

$$(4) \quad A_3 = m(A_1 - A_2) + A_2, \text{ within limits.}$$

This progression, also along the horizontal axis, is true only of certain beach sands. Again "m" increases by multiplication, but the change in position of the A_1 and A_2 in the parentheses results in a convex rather than a concave curve.

For the determination of additional points (G_3, A_3), the following equations are recommended:

1. For river sands: $\dfrac{A_3 = m(A_2 - A_1) + A_2}{G_3 = G_1/8 + G_2/4}$

2. For eolian sands: $\dfrac{A_3 = A_2 + n}{G_3 = G_1/8 + G_2/4}$

3. For certain beach sands: $\dfrac{A_3 = m(A_1 - A_2) + A_2}{G_3 = G_1/8 + G_2/4}$

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