Maritime Sediments, Vol. 5, No. 2, August, 1969, pp. 40-43.

Reports

Sampling of Laminated Beach Sands*

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Introduction

Two basically different sampling techniques can be used to obtain samples of layered beach sands.

a) Sampling across the layers. This technique will produce a so-called channel sample, which, providing that it represents a random sample of the population, will yield unbiased, consistent estimators of the population characteristics (Griffiths 1967).

b) Stratified random sampling (Cochran 1953; Krumbein and Graybill, 1965). This technique is concerned with such subpopulations as are present in strata, beds, layers, and lamina.

The sampling procedure has to be carried out in such a way to assure independent samples from one stratification unit only. In this case, with appropriate weighting (say, by the magnitude of the layers) it is possible to obtain an adequate estimate of the population mean and the variance. From the individual-layer, statistical estimators and a knowledge of the within- and between-layer variation can be derived (Griffiths 1967).

The principle of both channel sampling and stratified sampling is shown and described by Griffiths (1962; 1967). The following paragraph concerning this problem is a direct quote from Griffiths (1962, p. 608).

"It should be noted that to achieve an efficient estimate of the population mean and variance a channel sample across the entire deposit would serve the purpose at all stages, but a very large amount of important geological information may thereby be lost. It is not inconceivable that the mean sizes of quartz grains in many beach sands and glacial tills are similar and the population variances may also not be very different; the fundamental difference is that the fill is homogeneous, whereas the beach sand is finely layered and in the distribution pattern of means and variances among and within samples lies the clue to fundamental environmental differences. Finally, it should be realized that in many cases it cannot be decided, without performing the measurements on samples, whether the population is stratified or not and channel samples are inadequate for this purpose; indeed grid samples which are so placed that they intersect several layers and/or parts of layers are equally misleading and unless it can be guaranteed that the sampling programme follows the recommendations first proposed by E. T. Apfel and G. H. Otto, the objective of the experimental investigation may be completely defeated."

Both Apfel (1938) and Otto (1938) recommended stratified sampling of layered deposits, i. e. the sampling of separate "phases" (Apfel) or separate "sedimentation units" (Otto). Earlier, Thompson (1937) had demonstrated that the grain-size distribution of samples of beach sand representing a mixture of several laminae was distinctly different from the grain size distribution of the laminae when sampled individually. Emery and Stevenson (1950) reported that median diameters of sand in the individual laminae range from much coarser to much finer than the median diameter of the entire sand sample, whereas the sorting coefficients in the individual laminae are generally smaller than for the whole sample. Of six beach sands investigated by them, five showed the presence of laminae near the surface of the beach (p. 223). In conclusion they state (p. 223): "This study verifies the belief that the median grain-sizes and the sorting coefficients determined by ordinary mechanical analyses of scoop samples of sand are composites." Ehrlich (1964) stresses the importance of a homogeneous unit in sampling schemes for sediments and refers to earlier recommendations by Apfel (1938), Otto (1938) and Griffiths (1962), which he states "have not made much of an impression on sampling procedures during the past 24 years."

Sampling designs and patterns for beach sand were developed by Krumbein (1953) and McIntyre (1959). Krumbein collected fairly large cylindrical samples of two to three inches in

*Manuscript received April 15, 1969.

diameter and depth. The beach sands investigated by him had an average bed thickness of about 2. 2 inches. McIntyre, who was sampling thinnly laminated beach sands, retrieved approximately 2 ml of sediment material at each sampling location.

The vast difference in sample size of the above designs touches upon the size of the sampling unit in general. What size should it have in order to assure adequate representation of the population under investigation? To this Griffiths (1967, p. 21) states "No satisfactory definition of the size and shape of the primary sampling unit has yet been offered. In some sedimentary rocks having layers or lenses that are very small, i. e. microscopic, the definition of a primary unit is extremely difficult. "

McIntyre (1959) suggested that the lamina, at the field- or macro-level, is the unit which must be sampled. However he adds that "it is more than likely that it is made up of smaller microlaminae of no more than a few grains in size. "

It stands to reason that, for practical purposes, macrolaminae are the thinnest units which can be sampled in the field. "They are distinguished as entities on the basis of change in texture and (or) composition. While their boundaries may be transitional, they can nevertheless be operationally defined. " (McIntyre 1959, p. 279). The term microlamina, as defined by McIntyre, appears to be synonymous with the term lamina defined by Otto (1938).

In this paper the term lamina is synonymous with the term field- or macrolaminae as defined by McIntyre (1959).

Describing the actual sampling technique he mentions that the size of his sampling grid (4 x 9 feet) was dictated by the areal behaviour of the B layer (a macrolamina), this being the maximum area over which it retained a homogeneous character without pinching out or merging with other heavy mineral layers (McIntyre 1959).

In order to investigate the feasibility of obtaining independent, comparatively large samples from specific laminae a simple device was built. It consists of a metal frame which is 200 cm long, 40 cm wide and 15 cm high. A pan, 42 cm wide, equipped with a guiding plate on each side fits across the width of the frame. In Figure 1 the frame is shown lowered "flush" into the intertidal sands of the fore-shore of a high energy beach near Corona del Mar, California. At each corner of the frame a metre stick was forced into the sand to a depth of approximately 30 cm. They serve as markers to control the increments of penetration of the frame during the sampling. The frame is forced into the sand by carefully tapping it with a mallet until it has penetrated to its full depth (15 cm). Once this is accomplished the sand outside of the frame is removed to a depth of about 5 - 10 cm thus exposing the metal walls of the frame. From this point the frame is forced deeper into the sand by further tapping. As soon as the upper edge of the frame coincides with a bedding plane the sampling pan is placed at one end of the frame and moved towards the other (Fig. 1). This procedure will yield a sample of the subpopulation of the top layer, providing that the sampling plane coincides over its entire surface area with the bedding plane which separates the top layer from the layer underneath.

In Figures 2, 3, 4 and 5, a sampling location north of Oceanside (Camp Pendleton) California is shown. In order to evaluate properly the lamination of the beach sands, a ditch about two feet deep and 10 feet long was dug into the beach sands downslope from the sampling frame (Figs. 2, 3, and 4). In Figures 3 and 4, the lamination of the beach sand is clearly visible. It consists of a sequence of rhythmically alternating light and dark laminae with two conspicuous units in which the dark laminae (heavy minerals) are predominant. Numerous bedding plane irregularities are shown in Figure 4. In Figure 5, the result of the intersection of the sampling plane with the lamination is depicted. The ornamentation on the sampling plane is readily explained by the fact that the sampling plane is planar as opposed to the bedding planes, which are highly irregular. It stands to reason that the sand sample which was retrieved at this location is a channel type i. e. a composite sample. Laminated beach sands as shown in Figures 3 and 4 are very common. It is probably safe to assume that most high energy beach sands are laminated even in cases where the laminae are not readily discernible. If this is true stratified sampling of beach sands presents a very serious problem.

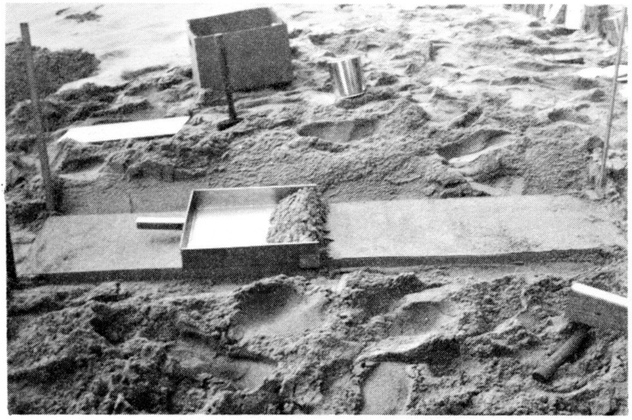

FIGURE 1 - Frame lowered into inter-tidal sands of the high energy beach near Corona del Mar, California, U.S.A.

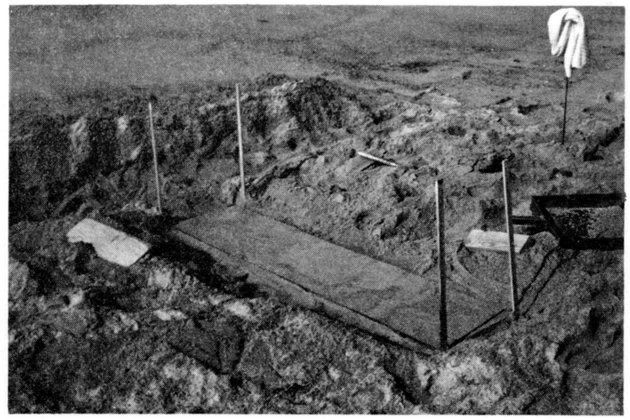

FIGURE 2 - Frame lowered into inter-tidal sands of the high energy beach near Oceanside, California, U.S.A.

FIGURE 3 - Ditch dug into beach sands downslope from sampling frame, near Oceanside, California, U.S.A.

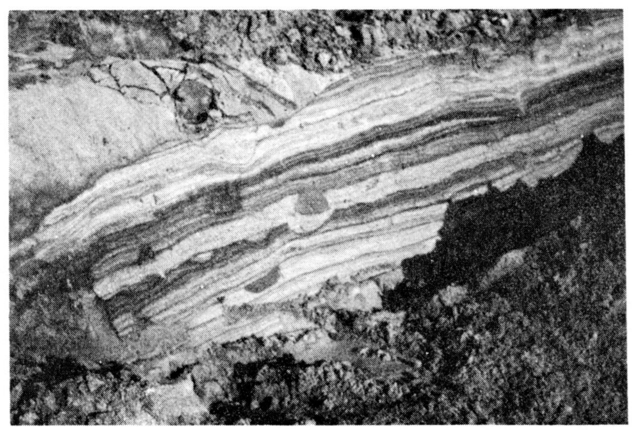

FIGURE 4 - Close-up of part of Figure 3 showing rhythmically alternating light and dark laminae.

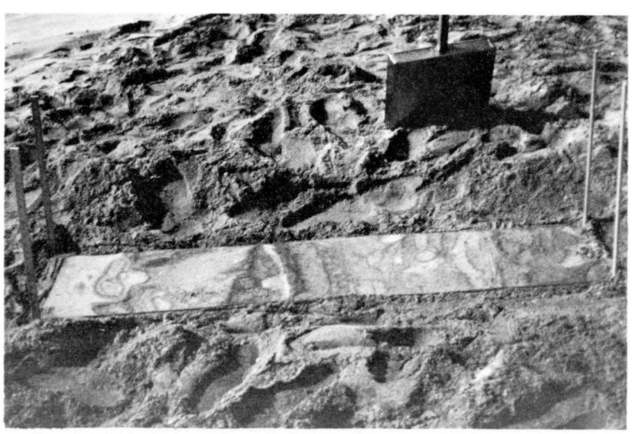

FIGURE 5 - Intersection of sampling plane with laminations (location as for Figures 2, 3, 4).

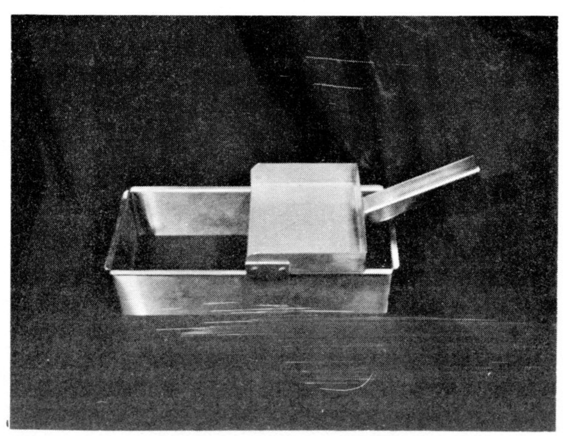

FIGURE 6 - New sampling device used in study of Nova Scotia beaches.

Conclusion

The sampling device which was used for this survey proved to be too large and impractical for stratified beach sand sampling. However it brought to light that stratified sampling of beach sands may be very difficult to accomplish. The writer does not rule out the possibility that many beach sand samples, which are said to be subpopulations representing one sedimentation unit only, are in fact composite samples. This problem may become very serious when grain size parameters of beach and dune sands are compared and statistically analysed. The stratification of aeolian sands is more regular and consistent, and lends itself more readily to stratified sampling. The outcome of such an endeavour may be the comparison of a composite sample of beach sand and a stratified sample of dune sand. Figure 6 shows the sampling device which is presently used by the writer; it is much smaller, 12 x 5 x 3 inches. Beach sands are usually sampled in a somewhat selective manner. Shallow ditches are dug into the foreshore slope, until a location is found where the lamination is "regular". The samples are subsequently taken by the procedure described above. Selecting a suitable sampling spot may not completely satisfy the requirements of random sampling. However what does one do if one has the choice between two evils?

Acknowledgement

The author is indebted to the management of the Union Oil Company of California for giving permission to publish the above data.

References cited

APFEL, E. T., 1938, Phase sampling of sediments, Jour. Sed. Pet., v. 8, p. 67-68.

COCHRAN, W. G., 1953, Sampling techniques, John Wiley & Sons, Inc., New York, 330 p.

EHRLICH, R., 1964, The role of the homogeneous unit in sampling plans for sediments, Jour. Sed. Pet., v. 34, p. 437-439.

EMERY, K. O. and STEVENSON, R. E., 1950, Laminated beach sand, Jour. Sed. Pet., v. 20, p. 220-223.

GRIFFITHS, J. C., 1962, Statistical methods in sedimentary petrography, in Milner, Sedimentary Petrography, v. 1, p. 565-617, 1962 (4th ed.).

________________, 1967, Scientific methods in analysis of sediments, McGraw - Hill, New York.

KRUMBEIN, W. C., 1953, Statistical designs for sampling beach sand; Am. Geophys. Union Trans., v. 34, p. 857-868.

KRUMBEIN and GRAYBILL, 1965, An introduction to statistical models in geology. McGraw - Hill, New York.

McINTYRE, D. D., 1959, The hydraulic equivalence and size distributions of some mineral grains from a beach, Jour. Geol., v. 67, p. 278-301.

OTTO, G. H., 1938, The sedimentation unit and its use in field sampling, Jour. Geol., v. 46, p. 569-582.

THOMPSON, W. O., 1937, Original structures of beaches, bars and dunes, Geol. Soc. Am., Bull., v. 48, p. 723-752.