Lognormal Components in Natural Polymineralic Associations

LOGNORMAL distributions are commonly encountered in Nature[1] and are applicable to a wide range of variables. The distribution was early used to describe the size distribution characteristics of detrital sediments[2], the variable in these instances being either a diameter determined by screening or direct microscopic measurement, or some function of shape, weight and projection area operative in methods utilizing settling velocities. Departures from lognormality are commonly met with, and recently an attempt has been made to extract from polymodal distributions lognormal components which are meaningful in terms of natural processes[3].

A common source of polymodality in size distribution plots is the inhomogeneity of the grain population with respect to density and shape. Density in particular must be taken into consideration when size analysis is carried out by screening. It is clear from considerations of hydraulic equivalence[4] that under a given set of hydraulic conditions grain-size associations will be partly determined by the range of densities involved, and the fact that small, dense grains will accompany larger, less-dense varieties has often been demonstrated[5].

We recently had an opportunity to test the validity of the lognormal distribution of individual mineral species in polymineralic shallow marine sediments collected on the shelf north-west of Cape Town, the results of which are recorded here. The sediment yielded, after dry screening, the polymodal size distribution cumulative reproduced in Fig. 1. Microscopic examination showed that the material consisted of a mixture of whole shells (mostly Foraminifera) which frequently enclosed some foreign material, shell fragments, quartz and glauconite (glauconite is a green pellet-like mineral, with a composition, in this case, similar to illite—a clay mica), the latter making up about 65 per cent of the whole. The grain population was thus markedly inhomogeneous with respect to density and shape, so that lognormality of grain diameters as determined by screening would not be anticipated.

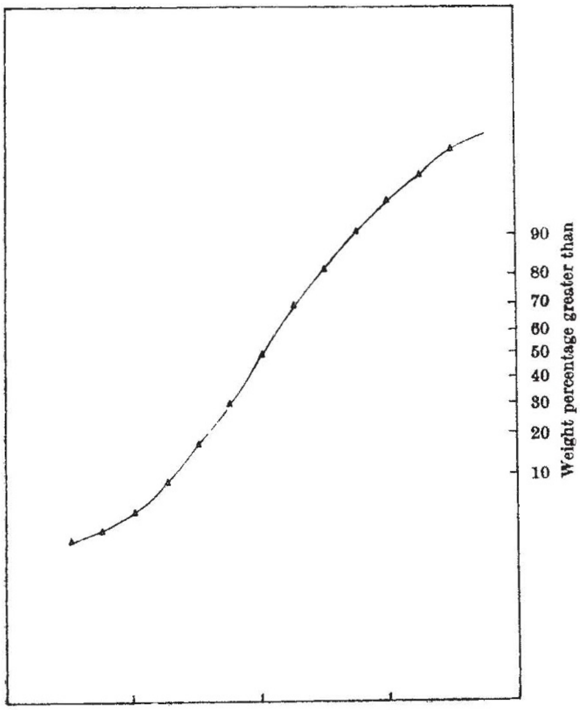

Fig. 1

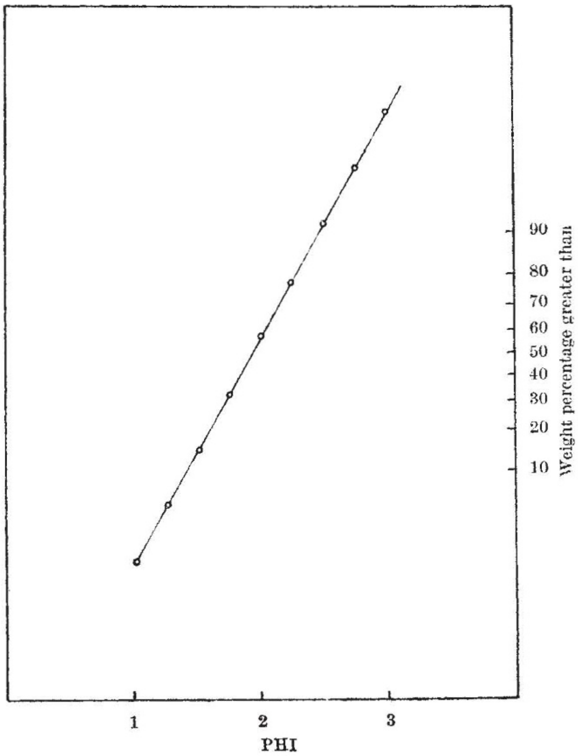

Fig. 2

The glauconite component was removed by magnetic, followed by heavy liquid separation, and screened. The resulting cumulative curve is shown in Fig. 2. It is strikingly lognormal. Attempts to analyse the size-distribution characteristics of the remaining components were unsuccessful due to separation difficulties. In addition the range of shell forms present made it impossible to define a homogeneous shell population. The quartz fraction could easily be recovered, but additions from the interiors of hollow shells during treatment could not be accounted for, and undoubtedly influenced the results.

It is of particular interest that the lognormality of the diameter distribution of glauconite has not been interfered with by the presence of an admixture of other grain types.

The glauconite does not appear to have inherited its size characteristics from original growth patterns. A log–log plot of length against breadth for the mineral did not yield a straight line which so often occurs in materials influenced by growth or decay[6]. The area in which the sample was collected is washed by strong currents, and it is likely that purely mechanical processes were involved in the development of the textural features of the sediment.

It is tempting to go further and speculate that each mineral component in a mixed sediment will, under shallow marine conditions at least, tend to develop the lognormal form displayed so well by the glauconite here. Accessory minerals such as zircon and ilmenite are characteristically lognormal in a variety of environmental settings, but it remains to be seen whether or not all the major components will behave in the same way.

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